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PILOT STUDY OF DREDGING AND DREDGED MATERIAL DISPOSAL ALTERNATIVES

Superfund Site, New Bedford Harbor, Massachusetts

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Prepared by:

U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts

Mark J. Otis
Chief, New Bedford Superfund Project Office

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This document provides the detailed description for a pilot study of dredging and dredged material disposal alternatives to be carried out at the New Bedford Harbor, Massachusetts Superfund Site. It was prepared by the New England Division of the U.S. Army Corps of Engineers and submitted to the Environmental Protection Agency (EPA), Region 1. EPA is responsible for distributing this document to Federal, State and local agencies who have a role in determining if the proposed pilot project is in compliance with environmental laws and regulations. The decision on whether to proceed with this pilot study will be made by EPA after considering the comments received in response to this document.

EXECUTIVE SUMMARY

Testing of sediment from the northern portion of New Bedford Harbor has revealed that most of the area is contaminated by polychlorinated biphenyls (PCB). This area extends from the Coggeshall Street Bridge in New Bedford to the Wood Street Bridge in Acushnet. In August 1984 the Environmental Protection Agency (EPA) published a Feasibility Study of Remedial Action Alternatives for this area. This study proposed five cleanup alternatives, four of which dealt specifically with dredging the area to remove the contaminated sediments.

Comments EPA received on these dredging and disposal alternatives prompted them to ask the U.S. Army Corps of Engineers to perform additional studies to better evaluate the engineering feasibility of dredging as a clean up alternative. This study is a joint effort of the Corps New England Division in Waltham, Massachusetts and the Waterways Experiment Station in Vicksburg, Mississippi.

A pilot study of dredging and dredged material disposal alternatives is proposed to support this engineering feasibility study. This study would be a small scale field test of several dredging and disposal techniques carried out on site between December 1987 and June 1988. The need for such a study is particularly great at New Bedford due to our limited knowledge and experience in dredging and disposing of such highly contaminated sediment and where the data base for the impact of site specific factors on design is not available.

The study will evaluate three types of hydraulic dredges with the contaminated sediment being placed in two separate disposal sites. A confined disposal facility (CDF) will be constructed partially on land and partially in water. The CDF will cover approximately 250,000 square feet and will have dikes constructed around it. Material is dredged from the bottom of the estuary and is pumped into the CDF in a slurry consisting of 10 - 40 % solids. After solids are allowed to settle, excess water will be drained off the site and returned to the harbor. Approximately 5,000 cubic yards of sediment with PCB levels in the range of 100 parts per million (ppm) will be placed in the site initially. This sediment will then be capped with approximately 5,000 cubic yards of clean material dredged from the estuary.

The second disposal method is called Confined Aquatic Disposal (CAD). The area dredged in removing the initial 10,000 cubic yards of material will be used as the CAD cell. Approximately 2,500 cubic yards of contaminated sediment containing PCB levels in the 100 ppm range will be removed from a second dredging area and placed along the bottom of the CAD cell. This material will then be capped with approximately 2,500 cubic yards of clean sediment taken from this same dredging area.

The pilot study will be extensively monitored. The monitoring program is designed to obtain sufficient data to support the technical objectives of the pilot study and to insure that both public health and the environment are protected. The program involves monitoring the water quality throughout the harbor by checking both physical, chemical and biological parameters for changes that may be caused by the dredging and disposal activities. Air monitoring stations will also be set up around the operation. Pilot study operations will be modified or stopped if significant increases in the level of contaminants are detected at the Coggeshall Street Bridge.

1. INTRODUCTION

1.1 Site Description

New Bedford Harbor, a tidal estuary, is situated between the City of New Bedford on the west and the towns of Fairhaven and Acushnet on the east at the head of Buzzards Bay, Massachusetts. The site can be divided into two geographic areas. The most northern portion of the site extends from the Coggeshall Street Bridge north to Wood Street in Acushnet. The remainder of the site extends south from the Coggeshall Street Bridge through the New Bedford Hurricane Barrier and into Buzzards Bay. Geographic boundaries include the shoreline, wetlands and peripheral upland areas.

PCB contamination in New Bedford was first documented by both academic researchers and the Federal Government between the years 1974 - 1976. Since the initial survey of the New Bedford area, a much better understanding of the extent of PCB contamination has been gained. The entire area north of the Hurricane Barrier, an area of 985 acres, is underlain by sediments containing elevated levels of PCB's and heavy metals including copper, chromium, zinc and lead. PCB cocentrations range from a few parts per million (ppm) to over 30,000 ppm. Portions of western Buzzards Bay sediments are also contaminated, with concentrations occasionaly exceeding 50 ppm. The water column in New Bedford Harbor has been measured to contain PCB's in the parts per billion range.

1.2 Background Information

In August 1984 the Environmental Protection Agency (EPA) published a Feasibility Study of Remedial Action Alternatives for the upper Achushnet River Estuary above the Coggeshall Street Bridge. Sediments from this area of the New Bedford Harbor Superfund Project contain much greater PCB concentrations than the remainder of the harbor. The study proposed five alternatives for cleanup of the contaminated sediment. Four of these alternatives dealt specifically with dredging the estuary to remove the contaminated bottom sediments. Disposal options included an intertidal disposal site, partially lined for one option and fully lined for a second, disposal in an upland site, and disposal in cells constructed in the estuary and covered with clean material.

Public and interagency comment on these dredging and disposal alternatives prompted the EPA to ask the U.S. Army Corps of Engineers (USACE) to perform additional predesign studies for dredging and disposal alternatives in order to develop the technical information necessary to evaluate the engineering feasibility of these alternatives. The Engineering Feasibility Study (EFS) began in October 1985 and is scheduled to be completed in March 1988. It addresses two questions: (1) What are contaminant release rates from dredged material disposal alternatives and (2) what are contaminant release rates from dredging alternatives.

The technical approach used by the EFS to evaluate disposal alternatives is based on a USACE publication "Management Strategy for Disposal of Dredged Material: Contaminant Testing and Controls." This strategy incorporates findings of research conducted by the USACE, EPA,

and others over the past 10 years, and on world - wide experience in managing dredged material disposal. It consists of a suite of tests developed specifically for the unique nature of dredged material that, when applied to New Bedford Harbor sediment, will allow for site specific evaluation and conceptual design of available disposal alternatives.

The other part of the question for the EFS is evaluation of dredging alternatives, i.e., can the contaminated sediment be effectively removed from the estuary by conventional or specialty dredging equipment without unacceptable migration of contaminants to the environment? Unlike the disposal issue, testing protocols and a prescribed strategy have not been developed for estimating contaminant release from a dredging operation itself. The EFS addresses the questions of sediment resuspension and contaminant migration during the dredging operation by reviewing past studies of dredging projects, characterizing the hydraulic conditions in the Upper Estuary, performing flume tests to physically model sediment deposition and resuspension, estimating contaminants associated with suspended sediment based on limited laboratory tests, and incorporating the results into a numerical sediment migration analysis.

Much of the information needed to evaluate the design of proposed dredging and disposal alternatives for the New Bedford Harbor Superfund Site (above the Coggeshall Street Bridge) can and will be provided by the EFS. This information will be critical to the record of decision (ROD) for selection of the remedial action alternative. However, the EFS approach uses laboratory (bench-scale) studies, literature reviews, and desk top analyses to assess engineering feasibility and develop conceptual designs. The sound engineering approach for evaluation of alternatives and verification of design parameters is to perform pilot scale evaluations after laboratory studies and before final selection and design of a prototype system. This is particularly true for the New Bedford Project where dredging and disposal of highly contaminated sediment must be considered innovative application of alternatives, where dredging equipment must be evaluated without benefit of field - verified laboratory testing protocols, and where the data base for the impact of site specific factors on design is currently not available. A pilot study will reduce the uncertainty in the choice of alternatives for the ROD and in the final design and will allow smoother transition from alternative selection to final design and thence to construction. For these reasons, the EPA and the USACE are proposing that a pilot study be performed at New Bedford in order to evaluate proposed dredging and disposal alternatives in the field.

1.3 Pilot Study

This study will be a small scale field test carried out in the upper Acushnet River Estuary. Three dredges and two disposal techniques will be evaluated. The disposal techniques include a diked area called a confined disposal facility (CDF) and disposal in a trench or cell that will be created in the estuary bottom. This is called Confined Aquatic Disposal (CAD). Detailed descriptions of all phases of the Pilot Study are contained in Sections 2 and 3.

1.4 Study Objectives

The pilot study provides the opportunity to evaluate different dredges, dredge operating procedures, disposal methods and control techniques under the site specific conditions of New Bedford Harbor. The informatiion gathered during the pilot study will improve our ability to address the critical issues being evaluated by the Engineering Feasibility Study (EFS). Appendix 7 contains a detailed comparison between the information that will be provided by the EFS and the additional or improved information that can be provided by the pilot study. Listed below are the specific technical objectives of the pilot study.

a. Determine the efficiency of dredging for removal of PCB contaminated sediment from New Bedford Harbor.

b. Evaluate actual sediment resuspension and contaminant release during field conditions for selected dredging equipment, operational controls and turbidity containment techniques.

c. Refine and scale-up laboratory data for design of disposal/treatment processes for contaminated dredged material from the site.

d. Develop and field test procedures for construction of confined aquatic disposal cells for contaminated dredged material under site specific conditions.

e. Evaluate containment of PCBs in diked disposal areas and confined aquatic disposal cells filled with contaminated dredged material.

f. Assess solidification techniques for contaminated dredged material with respect to implementability.

g. Establish realistic cost data for dredging and disposal of New Bedford Harbor sediment.

1.5 Additional Benefits

a. Construction techniques for the CDF and the CAD can be tested in the field for site specific conditions.

b. Information on air emissions during dredging and disposal can be evaluated.

c. Other regulatory agencies and the public will become more involved in seeking a solution for cleanup of the site. Requirements for complying with other environmental laws and regulations will be addressed early on and allow smoother review and approval for the final cleanup action.

d. Experience gained with the pilot study will expand information on dredging and disposal alternatives and benefit evaluation of remedial action alternatives for the lower harbor as well as the upper estuary.

e. The pilot demonstration will reduce uncertainty in the ROD for selection of the final alternative by showing that dredging will or will not cause major environmental consequences. Without the pilot and the site specific evaluation it provides, the project could, at a tremendous cost, proceed through final design, contract award, contractor mobilization, and initial construction only to be stopped because of unforseen, undocumented adverse environmental impacts.

2. DETAILED DESCRIPTION OF PILOT STUDY DREDGING AND DISPOSAL OPERATIONS

2.1 Project Description

The pilot study will involve the evaluation of three types of hydraulic dredges and two disposal methods. Approximately 7500 cubic yards of contaminated sediment with PCB levels in the 100 part per million (ppm) range will be removed and disposed of during the study. The dredging and disposal process involves initially placing the contaminated sediment in the bottom of the disposal site and then capping it with a layer of clean sediment.

A confined disposal facility (CDF) and confined aquatic disposal (CAD) will be evaluated during the study. These disposal methods are described in detail later in this section.

An extensive monitoring program will be implemented to detect any contaminant releases during pilot study operations. This program is designed to obtain data to support the technical objectives of the study and to insure that public health and the environment are protected. Section 3 describes the monitoring program in detail.

2.2 Pilot Study Site

Dredging and disposal operations will be conducted in and adjacent to a small cove located just north of the Coggeshall Street Bridge on the New Bedford side of the Acushnet River. The general area is shown on Figure 1 with the dredging and disposal areas shown on Figure 2. Water depths in the cove are approximately 0.5 feet at Mean Low Water (MLW) and the mean tide range is 3.7 feet with the spring range being 4.6 feet. Tidal currents within the cove are negligible.

2.3 Description of Dredged Material

There will be two dredging areas located in the cove. Approximately 10,000 cubic yards of material will be removed from area 1 and 5,000 cubic yards from area 2 (see figure 2). Material from area 1 will be placed in the CDF. Area 1 will then be used as the CAD site and will receive the material from area 2.

Thirteen sediment cores and 7 grab surface samples have been taken from within the cove. The top two feet of each core was analyzed for PCBs. Levels in the 0 - 12 inch horizon ranged from 250 ppm to 1.70 ppm. PCB levels in the 12 - 24 inch horizon ranged from 105 ppm down to the detection limit.

The 7 grab samples which consist of the top six inches of material were combined to form a composite sample and a standard and modified elutriate test was performed on this material.

Wood Street Bridge
Acushnet
Pilot Study Site
Coggeshall Street Bridge
ACUSHNET RIVER
Brooklawn Park
Quarries
Playground
Cranberry Bog
HATHAWAY
Riverside Cem
Radio Towers (WBSM)
Ropes Island
Radio Tower (WBSM)
Marine Park
Driveon Theater
SCALE
0 1000 2000 3000 4000 Feet

FIGURE 1

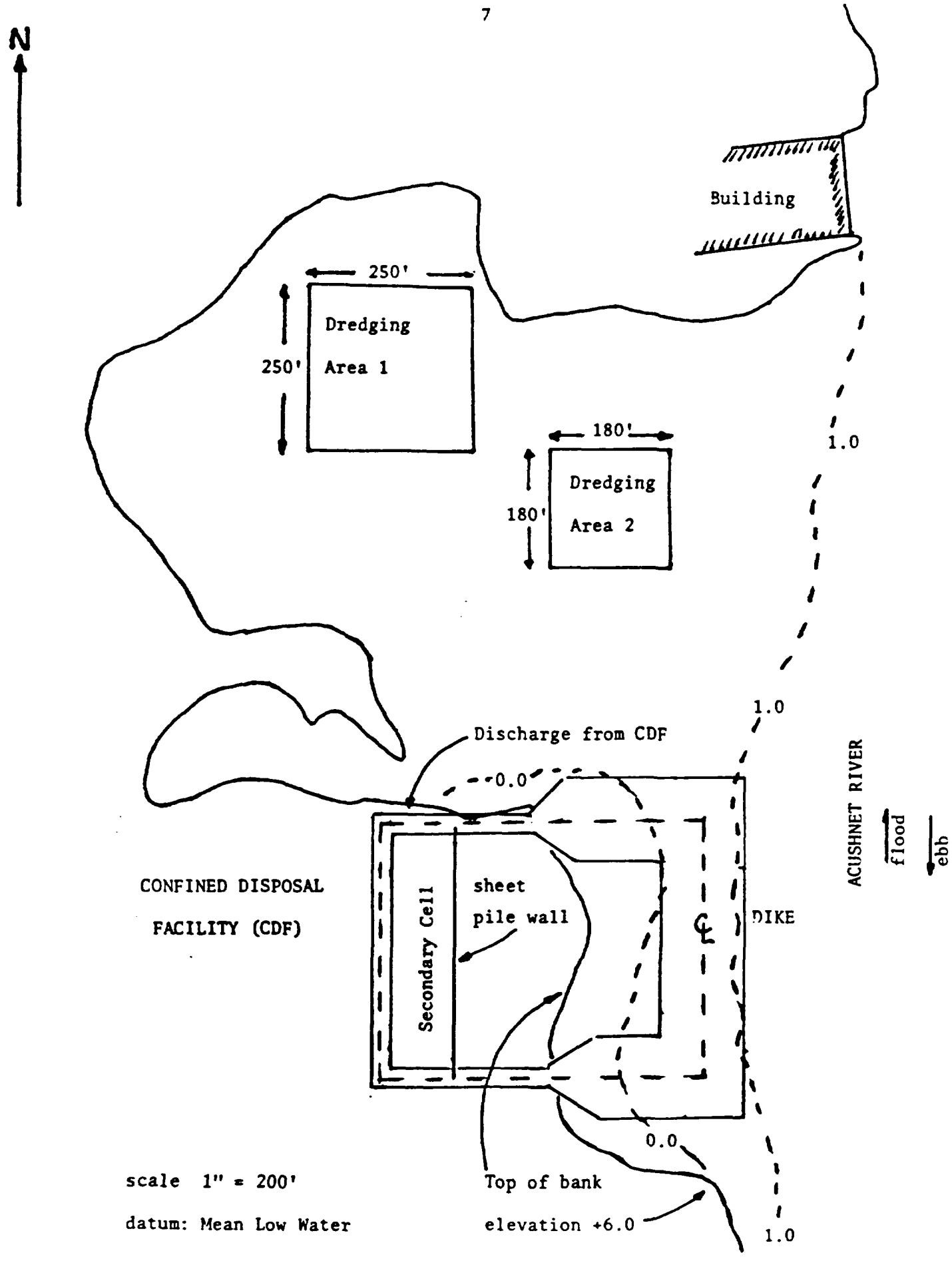

N
Building
250'
250'
Dredging
Area 1
180'
180'
Dredging
Area 2
1.0
1.0
Discharge from CDF
0.0
ACUSHNET RIVER
flood
ebb
CONFINED DISPOSAL
FACILITY (CDF)
Secondary Cell
sheet
pile wall
DIKE
0.0
scale 1" = 200'
datum: Mean Low Water
Top of bank
elevation +6.0
1.0

FIGURE 2

The results of all physical and chemical testing are contained in Appendix 6. Additional core samples will be taken from the dredging areas prior to the start of work. The number of cores and type of analyses are described in section 3, Monitoring Program.

2.4 Dredging Equipment

Three hydraulic dredges will be used during the Pilot Study; a hydraulic pipeline cutterhead dredge, a horizontal auger dredge known as a Mudcat and the hydraulic pipeline dredge with a special attachment called a Matchbox. These hydraulic dredges operate on the principal of the centrifugal water pump. A vacuum is created on the intake side of the pump and the atmospheric pressure acts to force water and sediments through the suction pipe. The dredged materials are then hydraulically pumped via pipeline to the disposal site in a slurry consisting of 15 - 40% solids.

These three pieces of equipment were selected based on their performance in the following critical areas:

1) They will be able to efficiently and effectively remove the layer of contaminated sediment.

2) They will minimize the resuspension of sediment while operating.

3) They will be able to operate in the shallow water which is prevalent in the upper estuary.

Appendix 3 contains a detailed description of this equipment, other equipment considered and a discussion of the equipment selection process.

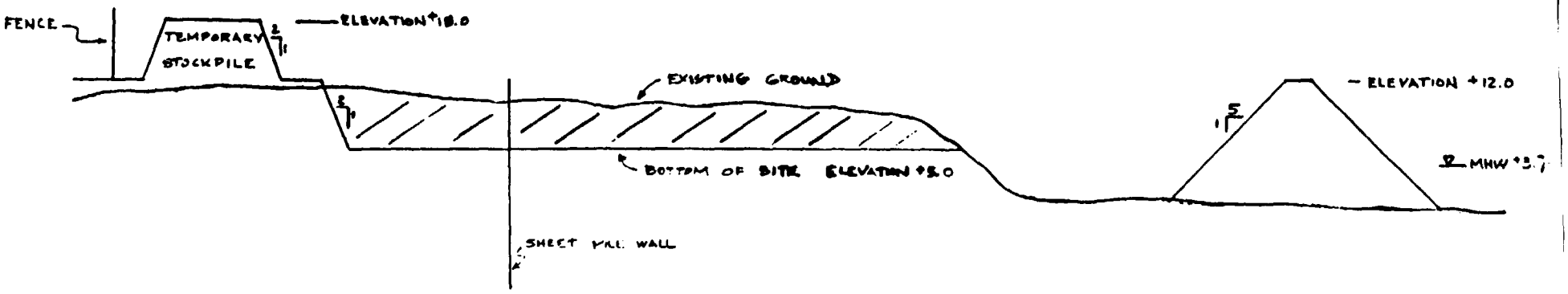
2.5 Disposal Facilities

Confined Disposal Facility (CDF): Refer to figures 3 through 7.

Physical Description:

Area below elevation +4.0 Mean Low Water	125,000 square feet
Upland area	120,000 square feet
Top elevation of dike	+ 12 MLW
Quantity of material excavated from site	17,500 cubic yards
Quantity of dredged material to be placed in site	10,000 cubic yards
Quantity of dike material	24,500 cubic yards

Site Construction: Approximately 24,500 cubic yards of material will be used in constructing the 1700 feet of dike that surrounds the site, 700 feet of which is located below the high water line. This 700 foot long section of dike will be constructed on a geotechnical fabric due to poor foundation conditions. The fabric is installed by placing it on the existing bottom along the dike alignment. Granular fill is then added in two foot lifts. A typical cross section of the completed dike is shown on figure 6. Some bottom material will be displaced and resuspended during the construction process; however, the quantity is expected to be small when compared to other pilot study operations. The monitoring program will be ongoing during this phase of the project and a silt curtain will be in place around the site.



CONFINED DISPOSAL FACILITY

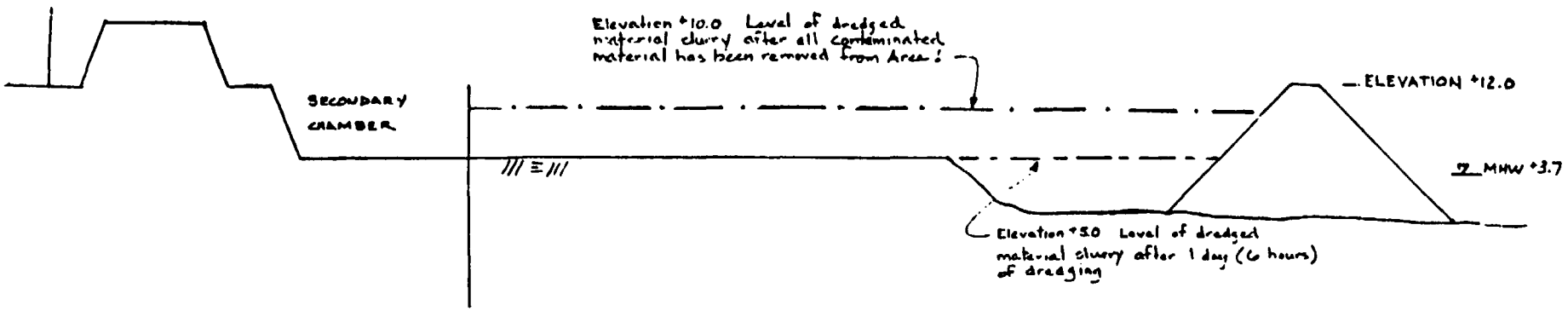
TYPICAL CROSS SECTION

SCALE 1" = 50' HORIZONTAL
1" = 10' VERTICAL

MATERIAL TO BE EXCAVATED

DATUM: MEAN LOW WATER

FIGURE 3



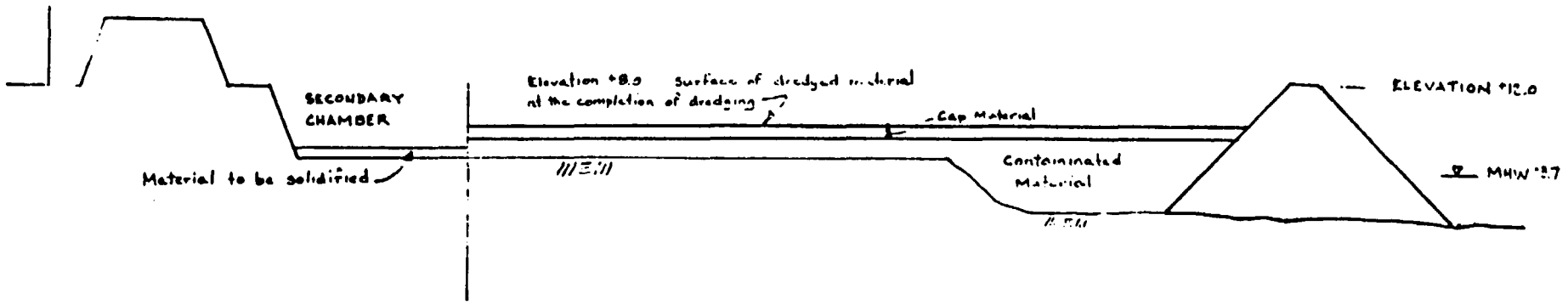
CONFINED DISPOSAL FACILITY

TYPICAL CROSS SECTION DURING DREDGING

SCALE: 1" = 50' HORIZONTAL
1" = 10' VERTICAL

DATUM: MEAN LOW WATER

FIGURE 4



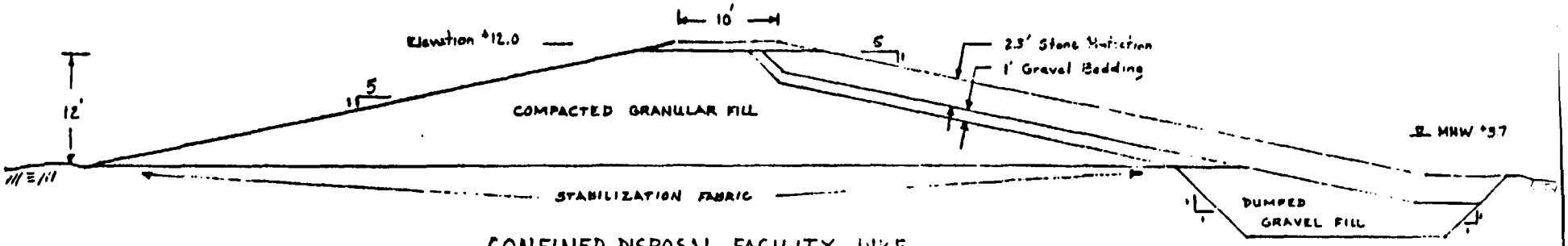
CONFINED DISPOSAL FACILITY

TYPICAL CROSS SECTION AT THE COMPLETION OF DREDGING

SCALE: 1" = 50' Horizontal
1" = 10' Vertical

DATUM: MEAN LOW WATER

FIGURE 5

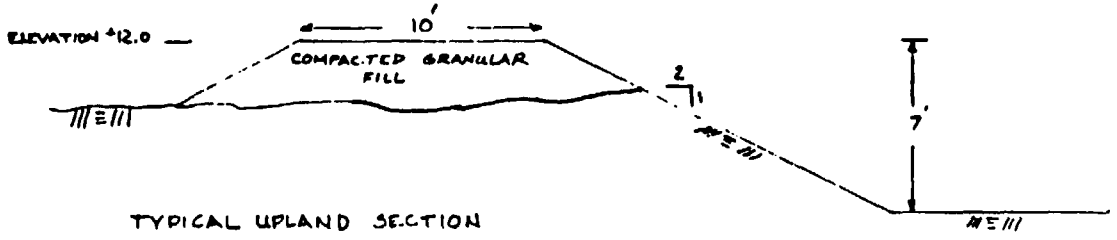


CONFINED DISPOSAL FACILITY DIKE

TYPICAL IN WATER SECTION

SCALE: 1" = 10'

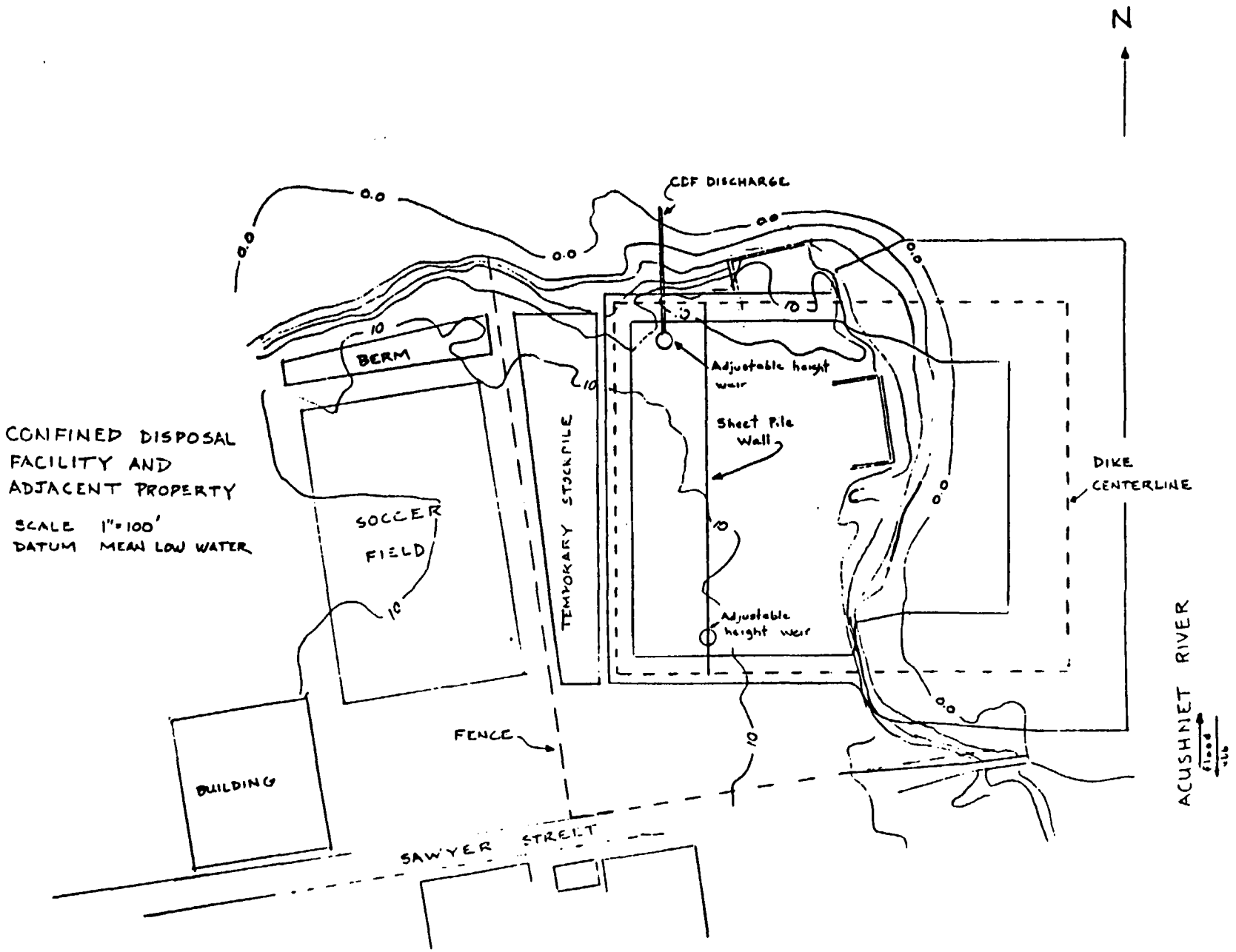
DATUM: MEAN LOW WATER



TYPICAL UPLAND SECTION

SCALE: 1" = 5'

FIGURE 6



CONFINED DISPOSAL FACILITY AND ADJACENT PROPERTY

SCALE 1" = 100'
DATUM MEAN LOW WATER

FIGURE 7

The construction of the CDF will also require the excavation of the upland portion of the site where existing elevations vary between +6 and +10 Mean Low Water (MLW). This area will be excavated down to elevation +5.0 MLW requiring the removal of approximately 17,500 cubic yards of material. This material will be tested for the presence of PCBs, metals and volitiles as well as suitability for use in dike construction. We anticipate being able to use some of the material in dike construction. The remainder would be used in reconstructing the athletic field with approximately 5,000 cubic yards being stockpiled on site and used as an additional cap for the CDF site.

Material to be used in dike construction would be brought to the site by truck. Truck trips should average 30 round trips per day during January, February and March. The choice of truck routes will be coordinated with the City of New Bedford to minimize impacts to the surrounding neighborhoods. Traffic control features such as signs, police and flagmen will be utilized throughout the work period.

Site Operation: The CDF is divided into a primary and secondary cell as shown in figure 3. The dredged material enters the primary cell in a slurry consisting of 10-40% solids. The slurry will be dischared through the submerged diffuser (Appendix 6) which will be attached to the end of the dredge pipeline. This device is designed to release the slurry parallel to the bottom of the site and at a reduced velocity. Here the solids are allowed to settle out and the excess water flows over a weir into the secondary cell. The primary cell has the capacity to hold approximately 25,000 cubic yards of slurry. We estimate that only 20,000 cubic yards of slurry will be produced in removing the 5,000 cubic yards of contaminated sediment from dredging area 1; therefore, it is possible to retain all slurry in the primary cell until all the contaminated sediment has been removed. This mode of operation will not provide the desired estimate of effluent quality for prototype facilities under typical operating conditions. Therefore, an adjustable height weir will be lowered to allow overflow into the secondary cell to allow monitoring during the latter stages of contaminated sediment dredging. Figure 4 shows the level of slurry in the CDF at several phases of the operation.

The excess water will be mixed with cationic polymer emulsions (Magnifloc 1586C and Nalco 7126) as it enters the secondary cell. Tests performed for the Engineering Feasibility Study indicate that as much as 82% additional suspended solids reduction can be achieved in the secondary cell following polymer flocculation. The secondary cell fills with water until elevation +9.0 MLW is reached then it flows over another weir structure back into the cove. We estimate that an effluent suspended solids concentration of 70 mg per liter can be attained (Appendix 1). A small portion (50 gal/min) of the water leaving the secondary cell will receive additional treatment. A portable filtration and carbon absorption system will be utilized to evaluate the feasibility of this type of treatment.

Figure 5 shows a typical cross section of the CDF at the completion of dredging area 1. Approximately 5,000 cubic yards of contaminated sediment will have been placed in the site initially. This material is

the top two feet of sediment from dredging area 1. This material will have been capped with an additional 5,000 cubic yards of clean sediment taken from the 2 to 6 foot layer of dredging area 1.

We estimate that a one foot layer of material with a sludge like consistency will be present in the secondary chamber at the completion of dredging. We plan to solidify this material in place by mixing it with Portland cement. This process will hydrate or lock in the pore water.

Appendix 1 contains estimates of contaminant release for all pilot study operations. Contaminant release from the CDF discharge during dredging operations is calculated directly from the dredge flow rate, settling test data, and the suspended sediment contaminant concentrations and dissolved contaminant concentrations observed in the modified elutriate test.

The CDF is being constructed on property owned by the City of New Bedford. EPA will lease the property from the city until a final decision is made regarding cleanup of the superfund site. The CDF is a temporary facility which may either be left in place, removed or incorporated into the overall clean up plan that is eventually chosen for the Superfund Site.

The remaining sections of the city property adjacent to the CDF will be modified during the construction process. These modifications are shown at figures 7 and 8. During the pilot study and for the duration of the lease the site will be fenced off and constantly monitored. EPA will be responsible for maintenance of and any repairs to the facility. The site will be capped with an additional layer of material in either late fall 1988 or spring 1989. This additional cap material will be obtained from the dikes surrounding the site, material stockpiled on site and from off site.

Confined Aquatic Disposal (CAD): Refer to figures 2 and 9.

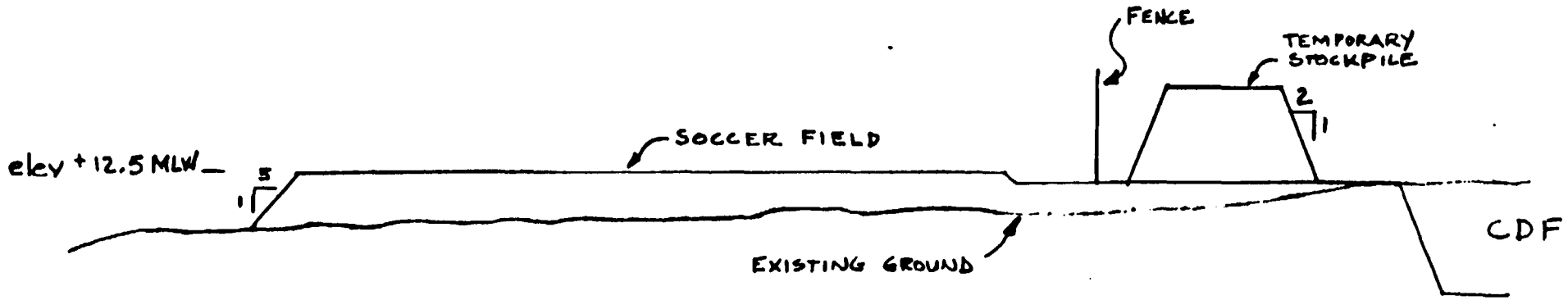
Physical Description:

Dimensions:	250 feet by 250 feet
Bottom elevation:	Approximately -6.5 MLW

Site Construction: The CAD cell will be created at dredging area 1 during the dredging that provides the material for the CDF.

Site Operation: Approximately 2,500 cubic yards of contaminated sediment from the top two feet of dredging area 2 will be placed along the bottom of the CAD cell. The material will be discharged through the submerged diffuser. The contaminated sediment will be placed in a two foot layer and then capped by a two foot layer of clean material removed from the 2-4 foot layer of dredging area 2.

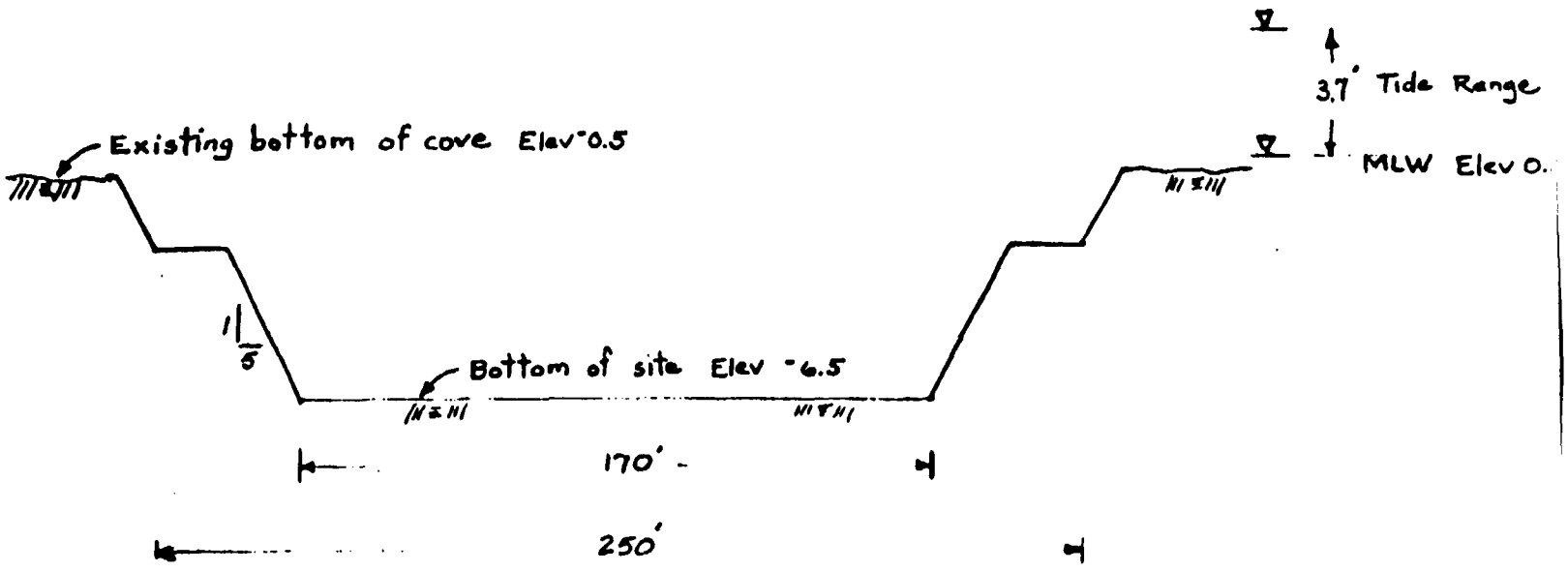
Testing conducted for the Engineering Feasibility Study determined that a cap thickness of 35 cm was an effective seal that chemically isolated New Bedford Harbor sediment from the overlying water column. This cap thickness is for a chemical seal only and does not include



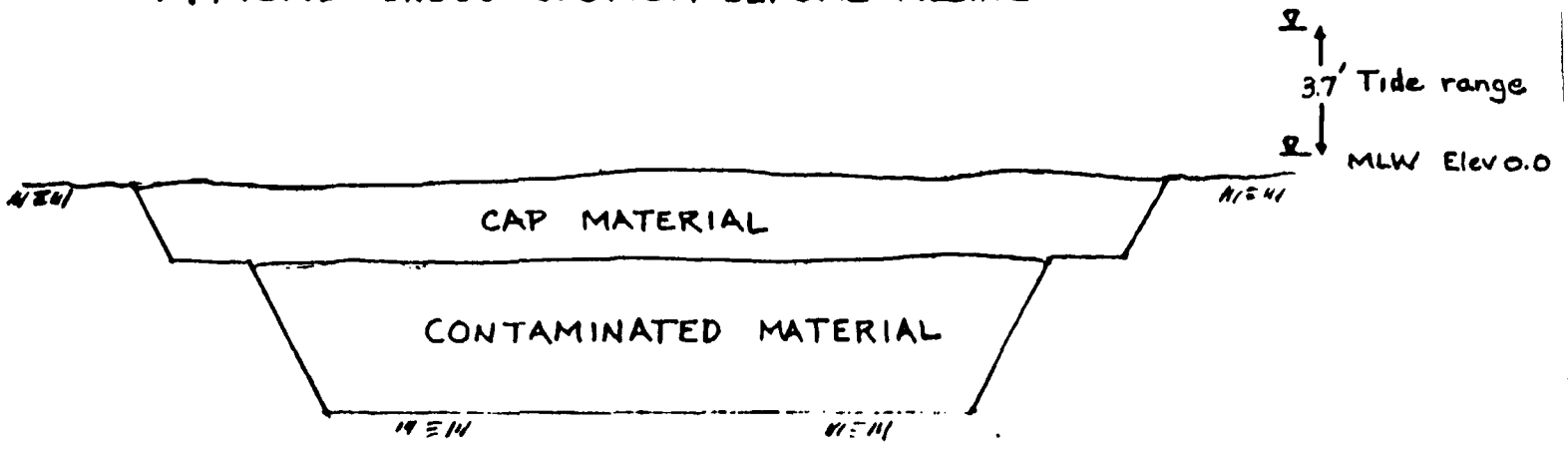
TYPICAL CROSS SECTION
SOCCER FIELD

scale: horizontal 1" = 50'
vertical 1" = 10'

FIGURE 8



TYPICAL CROSS SECTION BEFORE FILLING



TYPICAL CROSS SECTION AFTER FILLING

FIGURE 9

allowances for bioturbation by burrowing aquatic organisms. The prime interest in this phase of the pilot study is to evaluate our ability to place contaminated sediment in a CAD cell and cap it with clean sediment. The 24 inch (61 cm) cap planned for the pilot study is sufficient to allow for this evaluation of the CAD cell over the one year period that it will be monitored. Appendix 4 contains a complete discussion of the capping effectiveness laboratory testing.

Contaminant Release: Appendix 1 contains a discussion of contaminant release from all pilot study operations. Estimates made for the disposal into the CAD cell are based on the dredge flow rate and suspended sediment contaminant concentrations from the modified elutriate test and soluble concentrations observed in the standard elutriate test performed on the composite sample of cove sediment.

Studies of sediment loss during open water disposal of dredged material, generally reported where disposal depths were greater than 50 feet, have estimated sediment in the water column on the order of 1 to 5 percent of the original sediment mass. Material will be more efficiently placed in the bottom of the CAD cell with the submerged diffuser than with conventional open water disposal techniques. The excavated CAD cell also provides time and confinement for settling in much the same manner as the CDF. However, to be conservative for the estimate of contaminant release, a sediment loss of 1 percent was used in the calculations rather than using results from the settling test.

2.6 Sequence of Events: The CDF will be constructed first as described in section 3.5. This work is scheduled to begin in January 1987 and will proceed through March 1988. During this period monitoring of both air and water will be ongoing as described in section 3. Dredging is scheduled to begin in late March and will extend through May. Starting in dredging area 1, the top two feet of contaminated material would be removed and pumped into the CDF. It is estimated that 8-16 days will be required to remove the 5,000 cubic yards of contaminated material from this area. Each dredge would operate for a consecutive 4-5 day period with approximately one week downtime between operating periods. An additional two feet of clean material would then be removed from dredging area 1 and pumped into the CDF over an 8-16 day period where it will provide a cap for the contaminated sediment.

Dredging area 1 will now have been dredged to a depth of approximately six feet below its original depth of 0.5 feet at MLW and will be used as the Confined Aquatic Disposal site. The top two feet of contaminated material would be removed from dredging area 2 and pumped into the CAD site. An estimated 4-6 days will be required to remove the 2,500 cubic yards of contaminated material. An additional two feet of clean material will now be removed from dredging area 2, approximately 2500 cubic yards, and placed in the CAD site to provide a two foot thick cap over the contaminated sediment. The dredge determined to be the most effective during the dredging of area 1 will be used for this phase of the Pilot Study.

2.7 Controls During Operations

Construction of Confined Disposal Facility (CDF): A silt curtain will be deployed around the work area during the construction of the dike section located in the water. As an additional control, work could be restricted to the flood tide. Such a restriction would be imposed if monitoring detected elevated levels of contaminants during the operation.

Dredging and Confined Aquatic Disposal (CAD): All dredging and disposal into the CAD cell will take place within the cove as shown on figure 2. The discharge from the CDF will also be within the cove. A silt curtain and oil boom will be deployed across the mouth of the cove during the entire operation as shown on figure 2. Additional controls that will be implemented if needed involve restricting the various operations to flood tide periods. Additional down time could also be provided between operational periods (intermittent operations). The operation of the dredges can also be modified. The depth of cut, rotation of cutterhead and swing speed of the dredge ladder can all be reduced on the cutterhead dredge. The depth of cut, rotation of horizontal auger and rate of advance can all be reduced on the Mudcat.

The need to implement any of these operational controls will be determined by the monitoring that is ongoing during all phases of the project. Section 4 contains a detailed discussion of the decision criteria that will be used in evaluating the need for additional controls.

A detailed discussion of the silt curtain is contained in Appendix 6.

3. MONITORING PROGRAM

3.1 Objective

This monitoring program was designed by personnel from the Corps of Engineers Waterways Experiment Station and EPA's Environmental Research Laboratory in Narragansett, Rhode Island (ERLN). The objective of the monitoring program is to provide information that can be used to (1) evaluate the effectiveness of the dredging and disposal techniques employed, (2) predict the magnitude and areal extent of water quality impacts during a full-scale operation, (3) select optimum monitoring protocols, and (4) regulate pilot study operations. Results of this program will be used to evaluate the risks and potential benefits of a full-scale dredging and disposal operation relative to other proposed options for decreasing the contamination effects of PCBs and metals in New Bedford Harbor.

The level of effort described in this section is meant to acquire sufficient data to meet the four objectives listed above. However, the program is meant to be flexible. Monitoring of certain activities can be expanded if initial results indicate such a need. The program includes physical, chemical and biological evaluations of sediemnt, harbor water, effluent from the confined disposal facility (CDF) and leachate from the CDF. Air monitoring is not addressed in this section. ERLN has designed the biological monitoring that will be performed during the pilot study and these individual tests are described in the following paragraphs.

Ampelisca Toxicity Tests
Approach: The tube dwelling amphipod, Ampelisca abdita will be used to evaluate sediment contamination. This organism has been shown to be sensitive to contaminated fine-grained sediments. The toxic response will be mortality and emergence.

Replication: 3 chambers/treatment, 30 Ampelisca/chamber
Control Sediments: relatively uncontaminated sediments from Central Long Island Sound

Mussel Deployments

Approach: The mussel has been demonstrated to be a reasonable biological monitor whose sensitivity to chronic impact makes it an effective early warning system for other biological components of the marine ecosystem. Prior to construction, and at the initiation of each subsequent phase of the pilot study, mussels will be transplanted to four stations (see figure 10). Tissues will be analyzed chemically on mussels collected for transplants at time zero. Collections will be made three days following the initiation of each phase of the pilot study with the mussel tissue being chemically analyzed. The first biological measures (mortality, actual growth, scope for growth) will be made on mussels collected at day seven. Both chemical tissue analyses and biological indicators will be measured after 28 days of exposure.

Stations: (See figure 10) Four caged mussel stations; three in transect from Coggeshall Street Bridge to the Acushnet River Side of the hurricane barrier, one control station in Buzzards Bay.

Replication: Four replicates per station

Individuals per Replicate:
Scope for Growth: 10/cage
growth and survival (marked and measured individuals:10/cage)
bioaccumulation: 30/cage
total: 50/cage
redundancy: 50/cage

Sperm Cell Toxicity Tests
Approach: The sea urchin (Arbacia punctulata) sperm cell toxicity test is a proven, effective, indicator of ambient water toxicity. This test provides rapid estimates of toxicity. It will be used to evaluate the toxicity of various ambient waters north of the Coggeshall Street Bridge throughout the study and the effluents from the Confined Disposal Facility (CDF).

Receiving Waters: Whole (undiluted) receiving waters will be tested from each site.

Discharge waters: Discharge waters from the CDF will be tested as an effluent. There will be five experimental concentrations (diluted with site control water).

Replication: Three replicates for each receiving water sample or effluent concentration.

Control Water: Two controls will be selected for each test series: a site control (clean seawater collected at the south end of West Island, MA); and a Narragansett Bay seawater control.

2 and 7 Day Toxicity Tests

Approach: The 2-day red alga (champa parvula) reproductive test, the 7-day mysid (Mysidopsis bahia) reproductive, growth and survival test, and the 7-day sheeps head minnow (Cyprinoden variegatus) growth and survival test will be conducted during the Pilot Study to evaluate toxicity in either the receiving waters or the effluent discharge from the CDF.

Receiving Waters: Whole (undiluted) receiving waters will be tested from each site.

Discharge Waters: Discharge waters from the CDF will be tested as an effluent. There will be five expernmental concentrations. (diluted with site control water)

Replication: A minimum of two replicates will be provided for the

algal tests, three for the fish tests and a minimum of eight replicates wil be used for the mysid reproductive tests. Five plants, fifteen fish and five mysids will be used in each replicate.

Control Water: Two controls will be selected for each test series: a site control (clean seawater collected at the south end of West Island, MA); and a Narragansett Bay seawater control.

3.2 Program Description

The monitoring program is divided into four major tasks associated with evaluating impacts and measuring the success of the pilot project. Each of these tasks has two or more subtasks. The major tasks are as follows:

1. PRELIMINARY SAMPLING
   - A. Water Quality Characterization
   - B. Sediment Characterization

2. EVALUATION OF THE CDF
   - A. Effluent Water Quality
     - i. During active filling
     - ii. Storm run-off, post filling
   - B. Leachate Water Quality

3. EVALUATION OF CAD
   - A. Disposal into CAD Cell
   - B. Contaminant Migration

4. EVALUATION OF DREDGE TYPES/DISPOSAL TECHNIQUES
   - A. Removal Efficiency
   - B. Comparison of Dredge Types/Disposal Techniques
     - i. Plume extent
     - ii. Far-field water quality

3.2.1 Preliminary Sampling: Preliminary sampling will be used to refine the proposed techniques for this specific project area and determine the natural range of specified physical, chemical, and biological response variables which occur within the system. Data will also be collected to verify results of certain predictive tests or models (e.g. settling tests, elutriate tests, and plume behavior).

Water Quality Characterization: The basic sample component for water quality assessments will be hourly water samples taken over one tidal cycle and pooled into ebb and flood composites. Samples will be taken on five sample dates at four stations (see figure 10) and will be opportunistically chosen for normal and worst case conditions (e.g. spring tide-high discharge, storms). The Coggeshall Street bridge station is the focal point relative to the decision criteria described in Section 5. At this station stream discharge will be measured for each sampling event and samples will be composited proportional to flow

Wood Street Bridge
Acushnet
Pilot Study Site
Coggeshall Street Bridge
ACUSHNET RIVER
Ropes Island
Radio Tower (WBSM)
Radio Towers (WBSM)
Riverside Cem
Brooklawn Park
Quarries
Marine Park
Cranberry Bog
HATHAWAY
CONDANT
Doane Memorial Field
Cushman Park
SCALE
0 1000 2000 3000 4000 Feet
Monitoring Station

FIGURE 10

from 3 cross sectional sub areas and 3 water depths. Samples from the other stations will be taken at three depths where conditions allow. A sampling event will consist of ebb and flood composites of hourly samples at each station. These samples will be analyzed for:

- -suspended solids
- -temperature
- -salinity
- -whole water PCB (total, aroclors, congeners)
- -metals on 50% of samples
- -TOC on 10% of samples
- -filterable PCB (total, aroclors, congeners), metals on 25% of samples

Biological testing during this preliminary phase will include:

- -sperm cell test on all samples
- -sperm cell and physical/chemical tests on noncomposited hourly samples on two sample dates at Coggeshall St. station (2x6x2=24)
- - 2- and 7-day tests on expected "worst case" and expected "normal" conditions
- -mussel deployments for "worst" and "normal," sampled on days 0, 3, 28

Sediment Characterization: Six sediment cores will be taken to a depth of six feet below the surface from each area to be dredged. These cores will be split into samples representing six horizons (0-0.5', 0.5'-1.0', 1.0'-1.5', 1.5'-2.0', 2.0'-2.5', and 2.5'-3.0') (6 cores x 6 horizons x 2 areas to be dredged = 72). This effort is being done to determine the depth at which clean material is found. Physical and chemical parameters to be measured on these samples are:

- -water content, specific gravity
- -Atterberg limits, grain size
- -PCBs (aroclors, congeners), metals, TOC (one core per site on <64um fraction)
- -elutriate tests on composites - standard and modified

Biological tests will be:

- -*Ampelisca* toxicity on whole sediments
- -sperm cell tests on water from *Ampelisca* test

Elutriate tests: Composite one sample by depths of 0-1, 1-2, 2-4 feet for each dredging area. A modified elutriate test will be run on each sample to predict effluent quality from the CDF. A standard elutriate test will be run on each sample to predict soluble contaminant release from the CAD construction and the dredging operation. Each elutriate test will be run in triplicate. Makeup water for the elutriate tests should be collected from the upper Acushnet River Estuary.

3.2.2 Evaluation of the CDF: The confined disposal facility (CDF) will be evaluated for (1) the effects of different treatment techniques on the concentration of contaminants in the effluent and (2) the long term migration of contaminants within the leachate. Effluent treatment techniques will be evaluated relative to one another and to existing water quality standards and existing water quality conditions. Effects during construction of the CDF are addressed in Task 4 under operational evaluations.

The format used in sections 3.2.2, 3.2.3 and 3.2.4 consists of a statement of the question being addressed, followed by the appropriate null hypothesis. A sampling program designed to test each null hypothesis is then detailed complete with reccommended numbers of samples, stations, and statistical analyses.

A. Effluent Water Quality

i. During active filling

Question: Are techniques available that can be used to reduce contaminant concentrations in effluent from a CDF into which contaminated New Bedford Harbor sediment is disposed? (Secondarily, are observed treatment levels substantially different and economically practicable to justify full scale application of these techniques?)

Null Hypothesis: The concentration of specific contaminants in effluent and the toxicity of effluent from the CDF will be unchanged by treatment method.

Approach: CDF effluent will be treated by dividing the CDF into two cells, with primary settling in the first cell and chemically assisted clarification in the second cell. Effluent quality will be evaluated by chemically analyzing both filtered and unfiltered effluent to determine contaminant loadings in the suspended and dissolved phases. Relative toxicity of treated effluents will also be determined using bioassay techniques.

Sampling Design: Effluent contaminant concentrations will be analyzed for the following treatments:

Treatment	Data to be Collected*
Primary cell - initial filling phase	1, 2
Primary cell - late filling phase	1, 2
Secondary cell - initial filling phase	2
Secondary cell - late filling phase	2,3
Filtered	2
Carbon treated	2

*Data Type
1. Suspended solids only - 24 hourly samples for five days
2. 10, 24 hour composites
   - -suspended solids
   - -whole water and filterable PCBs
   - -metals on 50% of samples

-TOC on 10% of samples
-sperm cell test on subset (some on chemically fractionated samples)

3. most sensitive of 2 and 7 day tests on final effluent

Data Analysis: Mean contaminant concentrations in effluent and toxicological response will be compared by treatment using ANOVA.

ii. Storm run-off, post filling

Question: What are the concentrations of any contaminants released to stormwater runoff?

Null Hypothesis: Contaminant concentrations in stormwater runoff are not elevated.

Approach: Following completion of disposal into the CDF and initial dewatering, effluent quality during storm run-off conditions will be determined.

Sampling Design: During a storm event collect effluent samples hourly until flow has peaked. For ten of these samples determine suspended solids, PCB (whole water and filterable), pH, salinity, and temperature.

Data Analysis: Data will be used to predict performance and effectiveness of the CDF for sequestering contaminants.

B. Leachate Water Quality

Question: What are the concentrations of any contaminants released to the leachate?

Null Hypothesis: Contaminant concentrations in leachate are similar to local ground water and do not increase with time.

Approach: Ten wells will be installed in and around the CDF (see figure 11). They will be sampled for background contaminant concentrations before dredged material is placed in the site. These wells will also be sampled periodically over the life of the CDF. Undisturbed core samples of dredged material will be taken from the CDF and the pore water analyzed.

Sampling Design: Monitoring wells will be sampled and samples analyzed at least 3 times prior to dredging. One sample will be taken immediately prior to initiating dredging. Samples from the wells will be collected three times per week while the CDF is being filled, and weekly for the first month after the CDF is filled. Six of the samples collected during that time period will be analyzed for PCB, TOC (10% of samples), pH, salinity, and metals (50% Of samples). The remainder of the samples will be archived and analyzed if necessary to characterize rapid changes in ground water quality. The wells will continue to be sampled quartely for 2 years.

In addition to the monitoring wells, sediment cores will be taken from the sediment in the CDF by a pattern similar to that shown on figure 11. Sediment and pore water from these cores will be characterized chemically and physically to include PCB, selected heavy metals, and water content. These cores will be collected after initial consolidation of the filled CDF and after drainage of free water from the surface of the CDF.

Data Analysis: Mean contaminant concentrations by well and sample date will be analyzed using ANOVA.

3.2.3 Evaluation of CAD: CAD will be evaluated for the ability of the operation to place a contaminated layer of material in the bottom of the excavated cell and cap this contaminated layer with a layer of clean material. Upward migration of contaminants within the completed CAD cell will be assessed by analyzing contaminant concentrations in sediment horizons approximately 50 and 400 days following CAD cell construction.

A. Disposal into the CAD Cell

Question: Can contaminated sediment be isolated by excavating a disposal cell, filling the bottom half with the contaminated material and filling the top half with a layer of clean material?

Null Hypothesis: Contaminants in the bottom layer of sediment in the completed CAD are greater than those in the cap material and similar to contaminant concentrations measured in surface (0-50cm) sediments before dredging.

Approach: Sediment core samples will be taken in the area to be dredged before construction and at the CAD site following construction and initial consolidation. The cores will be divided into sediment horizons and each horizon will be analyzed for contaminant concentrations and toxicological response.

Sampling Design: The following samples will be taken:

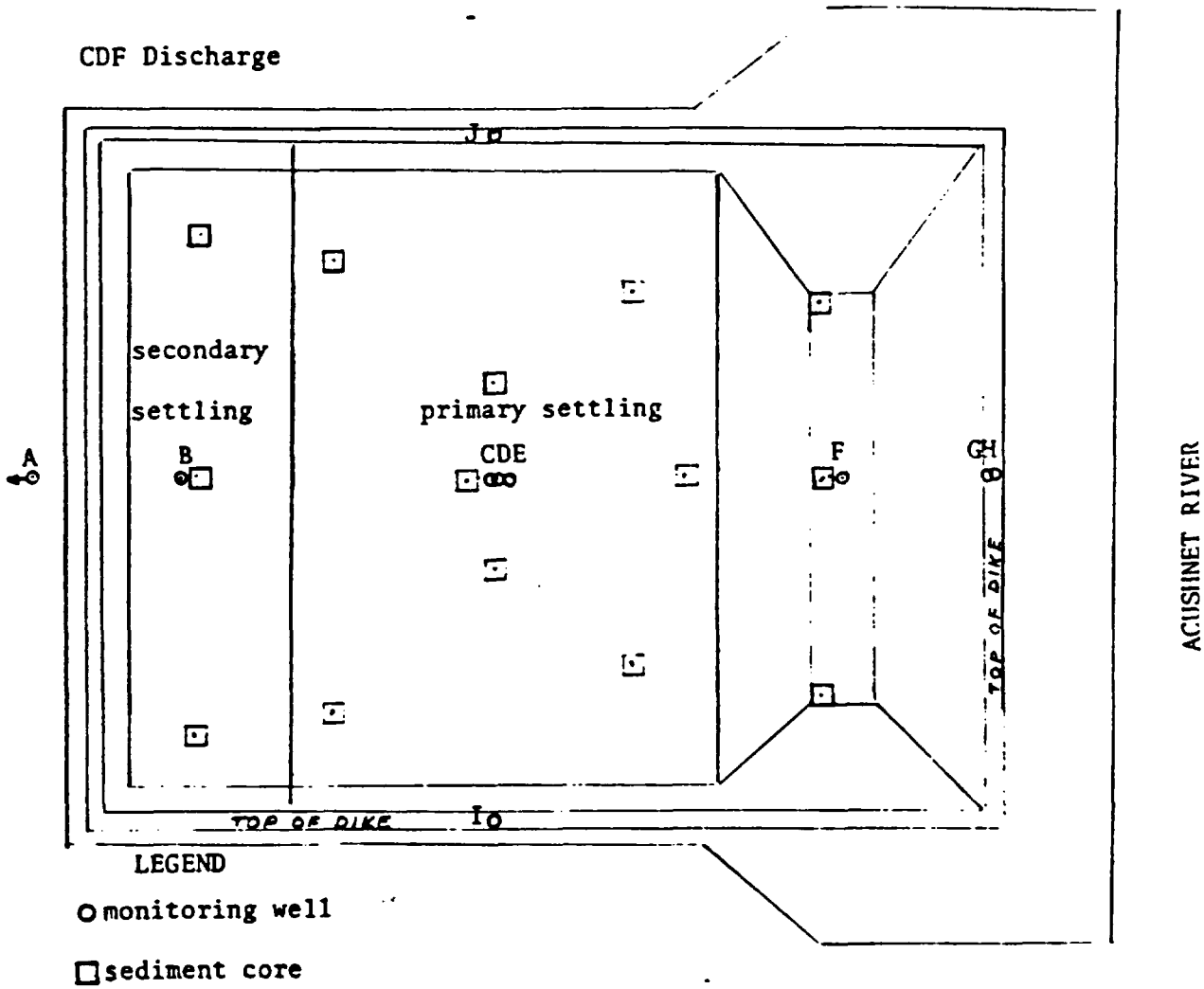
-Pre-dredging: 100 2' cores composited to 20 (taken to characterize contaminant concentrations of the material to be dredged)

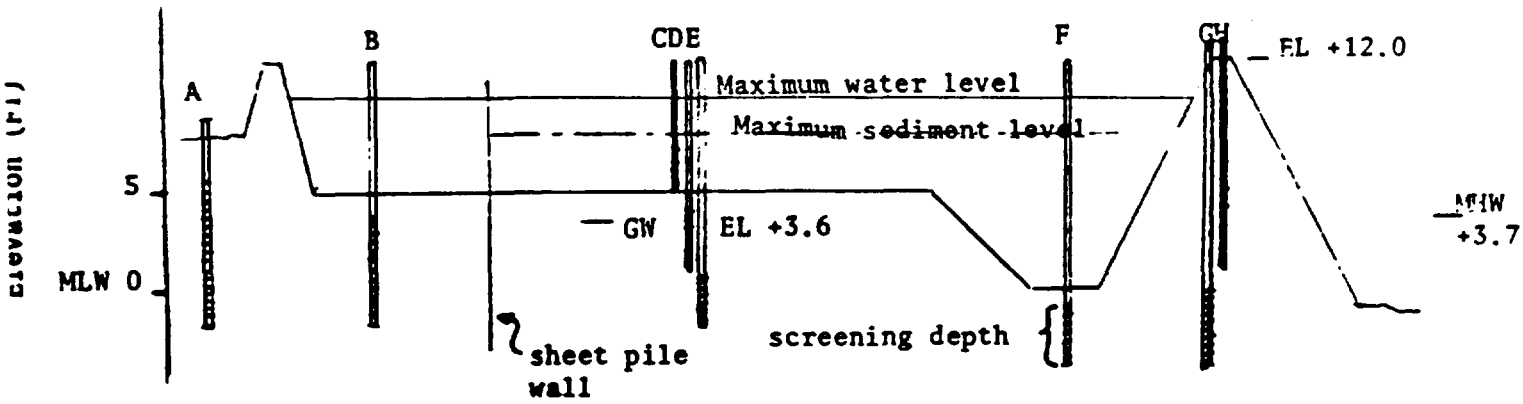
-Post CAD construction (~50 days post construction): 100 5' cores divided into 6" horizons and composited to 20 samples per horizon

-analyze each sample for PCBs, metals and *Ampelisca* toxicity

Data Analysis: Mean contaminant concentrations by location will be analyzed using ANOVA.

B. Contaminant Migration





CONFINED DISPOSAL FACILITY

Note: Exact screening depths to be determined during well drilling.

FIGURE 11

Question: Following construction of the CAD cell will contaminants from the contaminated bottom layer be transported up into the cleaner cap layer?

Null Hypothesis: Contaminant and toxicological response levels of sediment horizons down through the CAD remain unchanged through time.

Approach: Sediment core samples will be taken in the CAD site approximately one year following construction. The cores will be divided into sediment horizons and each horizon will be analyzed chemically and toxicologically for contaminant concentrations. Results of this subtask will be compared to that of the 50 day samples taken in the previous subtask.

Sampling Design:

Post CAD construction (~400 days post construction): 100 5' cores divided into 6" horizons and composited to 20 samples per horizon

-analyze each sample for PCBs, metals and *Ampelisca* toxicity

Data Analysis: Mean contaminant concentrations and toxic response by horizon and date (50 day vs. 400 day) will be analyzed using ANOVA.

3.2.4 EVALUATION OF DREDGE TYPES/DISPOSAL TECHNIQUES

Each type of dredging equipment and each disposal technique (CAD vs. CDF vs. no dredging) could behave differently with respect to its effects on water quality during construction and operation. Additionally the effectiveness of each dredge type may be different with respect to its ability to remove primarily contaminated sediment without substantial overdredging. Studies carried out in this task will assist in determining whether any equipment or technique should be preferred because of greater efficiency or relatively low water quality impacts.

A. Removal Efficiency

Question: Can optimum dredging depth be predicted and controlled with sufficient accuracy to remove the entire contaminated layer from a dredging area? What amount of over-dredging is necessary to meet this goal?

Null Hypothesis: Contaminant levels in sediment cores taken from the dredging area following dredging are the same as levels before dredging.

Approach: Sediment core samples will be taken in the dredging area immediately before and following the final dredge pass predicted to reach uncontaminated sediment. If substantial contaminated material still remains in the dredge area a deeper dredge cut will be made and the area retested until contaminant levels similar to reference levels are attained.

Sampling Design: Collect 10 3" cores from the dredging area and analyze (within hours) for total PCBs.

Data Analysis: Mean contaminant concentrations between sets of sediment cores will be analyzed using ANOVA.

B. Comparison of Dredge Types/Disposal Techniques

i. Plume extent

Question: Are any tested dredge types or disposal techniques preferred because of their ability to minimize water column suspended sediment plumes?

Null Hypothesis: Suspended sediment plumes are similar for each dredging or disposal activity.

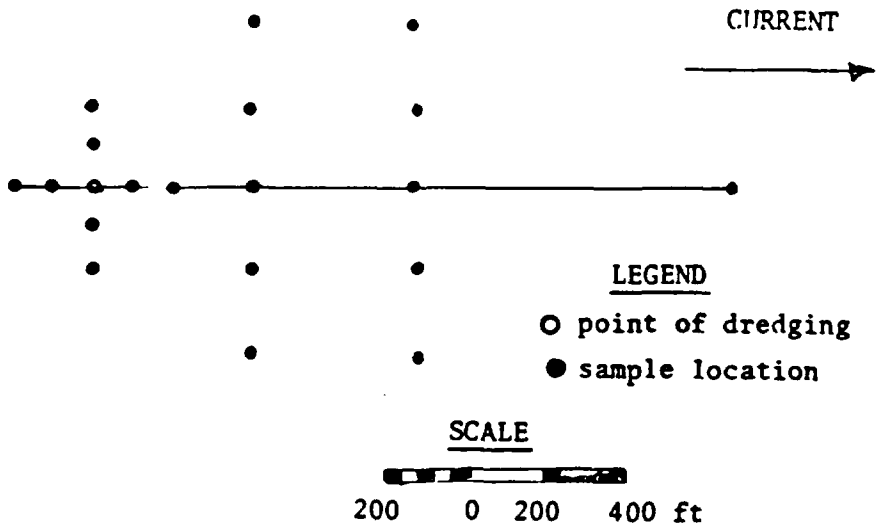
Approach: During operation of the three different dredge types and during disposal into the CAD cell the development and extent of plumes will be determined with suspended sediment samples.

Sampling design: A longitudinal transect will be established extending down current of the dredge or CAD cell. Samples should be taken along this transect in the center of the plume at distances of 50, 100, 400, and 800 feet from the dredge, as well as on either side of the silt curtain. Twelve additional sampling stations will be located along three perpendicular transects as shown on figure 12. Current measurements will be taken frequently. If water current magnitudes are not sufficient to move the plume in one general direction then a uniform sampling grid (figure 12) will be used. Sampling should stop when the limit of the plume is reached, except that one additional sample should be taken outside the plume. Plume sampling will be executed for at least 3 events for each type of dredging equipment. Discrete samples should be taken at hourly, or more frequent intervals, at middepth during the time period that the dredge is operating. The duration of sampling should avoid periods when dispersion of the plume will be interrupted by the silt curtain. Therefore, sampling will start soon after the dredge starts on a given day. Samples will be analyzed for suspended solids, PCBs, and metals (50% of samples only). In addition a transmissometer will be towed outside of the silt curtain at hourly intervals. Sampling stations will be located using electronic positioning equipment.

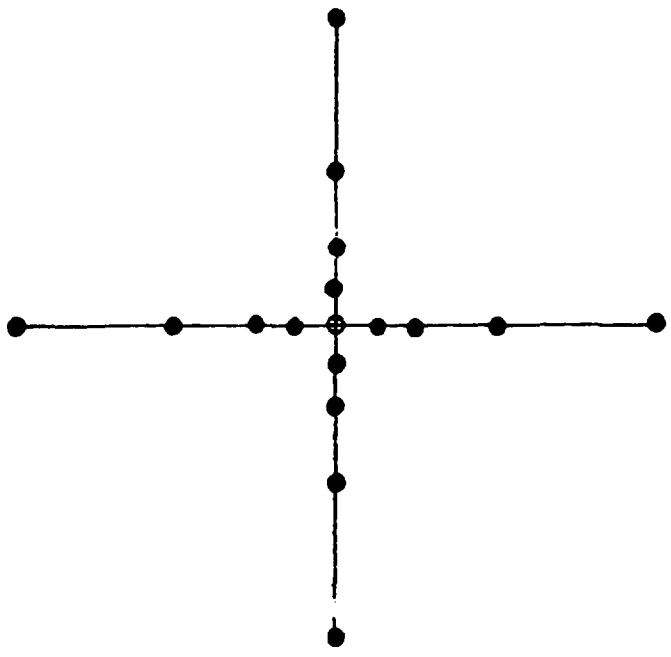
Plumes produced by the following activities will be measured:

- Dredge type 1
- Dredge type 2
- Dredge type 3
- Disposal into CAD cell

Dredge information: The following information will be recorded for each type of dredge: position of dredge, depth of water, pump power, pumping rate, slurry concentration, depth of cut, width of cut, speed of forward progress, and, where appropriate, cutterhead swing speed and rotation rate.



Plume Sampling Plan in the Presence of Significant Current Velocities



Plume Sampling Plan in the Absence of Significant Current Velocities

FIGURE 12

Dredge head sampling: An appropriate dredge head sampling apparatus will be installed on each of the dredges used. Selected samples from the dredge head will be analyzed for suspended solids, PCBs, and metals. These samples will be selected to represent differing dredging techniques and operating conditions and will be composited over an operating day.

Data Analysis: Analysis of plume data will yield a qualitative description of plume geometry and a quantitative measure of the rate of sediment resuspension from the dredge head. Sediment and contaminant concentration isopleths will be constructed to show the horizontal distribution of the sediment plume caused by each dredge type and operation technique. If current velocities are sufficient to transport the plume down current the product of the current velocity and the sediment and contaminant concentration distribution in a cross section of the plume will be used to calculate a mass flux rate. This mass flux rate can be used to calculate the rate of sediment and contaminant resuspension from the dredge. A correlation between dredge operation variables and the rate of sediment and contaminant resuspension will aid in specifying dredging methods to minimize contaminant release during dredging.

ii. Far-field water quality

Question: Are any pieces of dredging equipment or disposal techniques preferred because of their ability to minimize far-field water column suspended sediment and toxicological impacts?

Null Hypothesis: Suspended sediment, dissolved and particulate contaminant concentrations, and toxicological response are similar by station for each piece of equipment or technique used and are similar to reference conditions.

Approach: Samples will be taken at four stations (figure 10). Stations were selected based on the predicted extent of the plume. Sampling will occur during both operational and non-operational periods. Non-operational periods, both planned and those that occur as a result of delays, will be used as reference conditions. There is no adequate spatial reference that can be sampled simultaneously and using sampling either before or after the project as a reference would incorporate unknown seasonal influences that could only be factored out with years of data.

Sampling design: The operations to be tested are:

-Non-operational (immediately pre- and post-project and between each construction phase)
-CDF dike construction
-Dredge type 1
-Dredge type 2
-Dredge type 3
-Disposal into CAD cell

Section 3.3 describes the sequence of monitoring events in detail. Actual sampling will likely be somewhat different because of unknown factors such as equipment breakdowns, etc.

As discussed in the section on preliminary sampling, the Coggeshall Street bridge station is the focal point relative to the decision criteria described in Section 4. A sampling event will consist of ebb and flood composites of hourly samples at each station following the same procedure described under preliminary sampling. These composite samples will be analyzed for the following:

- -suspended solids
- -temperature
- -salinity
- -whole water PCB (total, aroclors, congeners)
- -metals on 50% of samples
- -TOC on 10% of samples
- -filterable PCB (total, aroclors, congeners) metals on 25%

Toxicological test on these samples will include:

- -sperm cell test on all samples
- - 2- and 7-day tests
  - once during CDF construction
  - three times during filling of CDF
  - once during disposal into the CAD cell
  - twice following project completion
- -mussel deployment at each station
  - once during CDF construction
  - once during CDF filling
  - 3 day sample for each dredge type and non-operational period?
  - once during disposal into the CAD cell
  - twice following project completion (spring-dry, spring-wet)

<u>Data Analysis</u>: Mean suspended solid concentrations, dissolved contaminant concentrations, and toxicological response between dredging operations will be analyzed using ANOVA.

3.2.5 Supporting Data Collections: Several data sets will also be collected to assist in interpretation of study results. These will include rainfall and wind velocity and direction, tide gage measurement, and freshwater discharge.

3.3 Sequence of Monitoring Events

The sampling stations refered to in the following paragraphs are shown on figure 10.

Preliminary Sampling: This work will consist of five events as described in section 3.2.1. Two events took place in July and the remaining three will be carried out in late September and early October.

CDF Construction: Construction of the section of the CDF located below the high water line will extend over approximately a six week period. The critical period is at the start of the operation when the geotechnical fabric and the initial lifts of fill will be put in place. The first sampling event will take place three days prior to the start of work. Sampling would continue for the first four days of the operation. Five sampling events will take place during the construction period when work is not going on. A sampling event will take place once a week for five weeks during the remainder of the operation.

Dredging with Disposal into the CDF: We anticipate that each dredge will operate for a three to five day period in the contaminated sediment with a five day shutdown period inserted between work periods. A sampling event would be carried out three days prior to the start of dredging. Sampling would take place during the first four days of operation for each dredge and three times during the shutdown period between dredges. Two sampling events will also take place while clean cap material is being placed in the CDF.

An evaluation of removal efficiency, rate of sediment resuspension at the dredgehead and plume generation will be ongoing during this same time period for all the dredges.

CDF Evaluation: While the dredges are operating in dredging area 1 the effluent being discharged form the CDF will also be sampled. The effluent going from the primary cell into the secondary cell will be analyzed for ten consequtive days while dredges 1,2,and 3 are working in the contaminanted sediment. This effluent will also be analyzed for ten consequtive days while cap material is being pumped into the site. The discharge from the primary cell into the estuary will also be analyzed for a twenty day period. The split stream of effluent entering the filtration and carbon absorbtion plant will be analyzed for a ten day period. Effluent will not be discharged back into the harbor while dredges are operating in contaminated sediment.

Dredging with Disposal in the CAD Cell: Samples would be taken during the first four days that the dredge is operating in the contaminated material. Samples would then be taken once a week for five weeks. This period would include the downtime prior to placing cap material on the CAD cell, while the cap material is being placed and several weeks after the operation has been completed.

An evaluation of the plume created by this disposal operation will also be ongoing. This sampling will begin when the disposal operation starts and will continue for at least three days.

Post Project: One sampling event per week for five weeks.

4. Decision Criteria

Section 3 described the monitoring program which will be ongoing during all phases of the pilot study. This section describes how the data aquired through the monitoring program will be used to determine if pilot study operations are causing an unacceptable risk to public health or the environment that will necessitate a modification in operating procedures or a termination of the project. This approach was developed by Mr. David Hansen of EPA's Environmental Research Laboratory in Narragansett, Rhode Island.

4.1 Background conditions: Decision criteria cannot be based on the enforcement of existing state or Federal water quality standards for PCB's because concentrations in harbor water currently exceed standards even in the absence of dredging. In addition, decision criteria cannot be based on the accumulation of biologically available PCB concentrations to the 2 ug/g FDA action level for seafood because PCB concentrations in indigenous organisms presently exceed this level. Decision criteria based on detection of toxicity in site waters or sediments are not practical, because sediments and water are toxic in the absence of dredging.

4.2 Approach to Developing Criteria: Given these existing conditions, our approach is to develop decision criteria which is based on the premise that this remedial action will provide a solution to what is a long-term environmental problem. This approach accepts the risk of a short-term moderate increase in the release of contaminants or associated toxicity, as long as the goal of long term clean up is achieved. We estimate that the release of PCBs and metals at the Coggeshall Street Bridge will be low and within the range of background conditions. The monitoring plan is specifically designed to validate these predictions. Information on background conditions is presented in Appendix 2.

As described in Section 3.2.1, pre operational monitoring data sets will provide baseline levels of the variablility of contaminant concentrations, toxicity, and bioaccumulation. This data will allow us to determine if sample intensity or design should be modified to improve precision of data prior to operational phases. Once the operational phases begin, collection of identical data sets will allow discrimination of statistically significant increases in contaminants, toxicity , or bioaccumulation. In addition, the magnitude of the increase must be greater than a factor of two above pre-operational phases. If both of these occur, the operation will be halted and the rate of return to pre-dredging conditions will be monitored. Providing that the return to pre-dredging conditions is acceptably rapid, the operation can recommence. This procedure will be used during each operational phase. If conditions produced by an operation are unacceptable in both magnitude and duration, additional engineering solutions will be required before operations can begin anew.

4.3 Monitoring Decision Matrix:

I. Characterize predredging conditions (See section 3.2.1)

A. Determine conditions existing at the site prior to operational activities. Particular emphasis will be placed on water exchange at the Coggeshall Street Bridge

B. Select appropriate sample intensity and location for operational phases.

C. Develop a document that lists numerical decision criteria developed from the preoperational monitoring. In addition, the document will summarize available data from preoperational monitoring and statistical methodologies for analyses of data from operational phase monitoring.

II. Characterize conditions during construction of the CDF dike, dredging with disposal in the CDF, dredging with disposal in the CAD cell, down time during dredging activities, and post operational phases.

A. During each of these phases and during the use of each type of dredge, monitoring activities will characterize site conditions using the methods described in Section 3.

B. Site conditions, during each of these operational phases, will be statistically compared with predredging conditions.

III. Decision Criteria

A. If no statistically significant increase is detected in data from any monitoring activities, the project will continue. To insure that preoperational conditions are representative for the site, conditions between operational activities will also be monitored and statistically compared with preoperational and operational phases to insure that no increase has occurred.

B. If a statistically significant impact is detected that is greater than a factor of two above the pre-operational phase for any operational phase in monitoring data from the Coggeshall Street Bridge, that phase will be stopped and the rate of return to preoperational conditions will be monitored.

1. If the conditions rapidly return to those of the preoperational phase, the operation can be continued. After the operation resumes, additional monitoring is required to confirm that any further impact is minimal and that the rate of return to "normal" is consistent with known flushing rates of the Acushnet River.

2. If conditions fail to return to those of the preoperational phase, an engineering solution to limit impacts must be instituted such as those discussed in Section 2.7.

3. If conditions fail to rapidly return to those during the preoperational phase following implementation of engineering solutions, it is possible that preoperational monitoring did not adequately characterize background conditions during the actual time of operation. For this reason, it may be desireable to resume the operation with planned shutdown times to demonstrate that interoperational monitoring does not result in continued increases in detectable impacts.

4. Finally, if data from environmental monitoring demonstrates that the above conditions cannot be met and that long-term, far-field impacts are likely to result from continued operations, then the project will be stopped.

Representatives from appropriate Federal and state agencies will form a group that will be responsible for reviewing the monitoring data as it becomes available. After reviewing this data the group would make decisions as to the daily operations during the pilot study.

4.4 Example Monitoring Scenario

Day 1

The sampling plan, sample analysis and toxicity testing described in Section 3.2.4 (B) (ii) Far Field Water Quality would be carried out.

Day 2

Decision Point: The group described in section 4.3 would convene to review the 24 hour data sets and consider the following options.

A. Decision criteria violated by 24 hour data sets

1. Discontinue operation?

2. Discontinue sample collection for seven day static renewal

bioassay?

3. Continue 24 hour sampling regimen until toxicity and chemical pulse drop to levels acceptable according to the criteria?

4. Consider amplitude (time vs. intensity) of chemical/toxicity pulse.

5. Consider containment strategies?

6. Re - initiate operation?

B. No violation of decision criteria

Continue operations and sampling, flood and ebb tide composite samples for seven day static renewal bioassays and 24 hour sample regimen.

Day 3

Collect first set of Mussels and analyze for chemistry and scope for growth.

Day 4

Decision Point

A. Decision criteria violated by tissue residues and or scope for growth.

Proceed through steps A1 - A6 as appropriate

Day 5 through 7

Follow A. if violation occurs in 24 hour turn around data sets.

Follow B. if no violation occurs.

Day 8

Decision Point

Decision criteria violated by bioassay/mussel results.

Repeat steps A1 through A6 as necessary.

Day 28

Collect remaining mussels for actual growth, scope for growth and tissue residue analysis.

Decision Point

APPENDIX 1: ESTIMATED CONTAMINANT RELEASE FROM PILOT STUDY OPERATIONS

Concerns for Contaminant Release

Sediment to be dredged during the pilot project is contaminated with PCBs and heavy metals. Therefore, the potential for release of contaminants to the environment during the pilot project must be considered. Various pilot project activities may release or increase potential for mobility of contaminants to the environment. These activities include the confined disposal facility (CDF) dike construction, the dredging operation, effluent from the CDF during filling, surface runoff from the filled and capped CDF, leachate from the CDF, and the confined aquatic disposal (CAD) filling/capping operation. The primary migration pathways for transport of contaminants from these operations to the environment are surface water (for dike construction, dredging, CAD filling and effluent from CDF) and groundwater (for leachate). Other pathways to be considered are air and biological uptake by organisms in the CAD and CDF site.

Purpose

This appendix presents estimates of the magnitude of contaminants, specifically PCBs and selected heavy metals, that may be released by the proposed pilot project based on the best available information. Complete information to determine the magnitude of all releases is not available because all laboratory studies and modeling activities needed for this task have not been completed. Also, not all of the techniques for estimating releases from an operation of this kind are well developed or field proven. An objective of the pilot study is to produce contaminant release data under field conditions for the site specific conditions at the New Bedford Harbor Superfund Site during dredging and disposal operations. The releases calculated, herein, are intended to be conservative or worst-case estimates, but the limitations of the predictions will be noted.

Pilot Study Operations

The proposed pilot project is a field operation that will physically remove appoximately 7,500 cu yds of contaminated sediment from the bottom of the estuary and transport the sediment to a CDF and a CAD cell. Disturbance of contaminated sediment at the dredge head, displacement of contaminated sediment during construction of the CDF, contaminant release during and after filling the CDF with dredged material, and contaminant release during and after placing and capping dredged material in the CAD cell present avenues for release of contaminants to the environment. These operations and the primary environmental pathways potentially affected by these operations are discussed below.

Dredging. In a hydraulic dredging operation, large quantities of water mix with the sediment to form a slurry as the dredge works its suction pipe, usually equipped with a cutter, auger, or other dredge head, into the sediment and pumps dredged material through a pipeline to the disposal facility. Operation of the dredge in the contaminated sediment will resuspend some sediment with attached contaminants and potentially release dissolved contaminants into the water column and affect surface water quality. Sediment

resuspension by various types of dredging equipment is discussed in Pankow (1987). The quantity of sediment resuspended will be minimized for the pilot project by selection of equipment that has been demonstrated to produce a reduced rate of sediment resuspension and operation of the selected equipment in a manner to minimize sediment resuspension. The heavier resuspended sediment particles from the dredging operation will settle on the bottom near the dredge. The finer sediment particles will disperse into the water column. Sediment concentration in the water column will decrease with distance down current from the dredge. Contaminants attached to the suspended sediment will be transported with the sediment, and soluble contaminants will be transported with water movement. However, some of the soluble contaminants are expected to become reattached (adsorbed) to suspended sediment and will then be transported in the same fashion as suspended sediment.

Dike construction. Construction of the eastern CDF dike will involve hauling clean fill material from off-site and carefully placing this material into the estuary as the dike is built from the shore. Earth moving equipment will shape and compact the material for the dikes. The sediment underneath the dikes, which is also contaminated with PCBs, will be disturbed and partially displaced by the dike construction operation. The filling operation will impact an area 500 ft in length along the shoreline and extending into the estuary approximately 170 ft from the shore. Disturbance of the contaminated sediment along the shore has the potential for contaminant release by the surface water pathway in the immediate vicinity of the dike construction activity.

CDF during dredging. Sediment initially dredged by the pilot project will be placed in the CDF. The CDF provides storage for the dredged material and will provide adequate volume to separate solids from liquid by gravity settling. After solids in the dredged material slurry settle in the disposal facility, excess water or supernatant is released from the disposal facility. This excess water that has been in contact with the sediment during the dredging process can be expected to contain dissolved and particulate-associated contaminants from the sediment. The pilot project will include provisions for addition of polymers at the overflow from the primary cell of the CDF. These polymers will promote flocculation of fine particulates that may be removed by settling in the secondary cell of the CDF. Final effluent discharged from the CDF during the filling operation will contain non-settleable particulates with associated contaminants, and dissolved contaminants. Most of these materials can be expected to be transported away from the project area.

A second potential pathway of concern during filling the CDF is volatilization of contaminants into the air. This release mechanism will be minimized by submerging the influent pipe below water level as slurry is pumped into the CDF and by keeping the contaminated sediment covered with water and saturated until the CDF is capped with clean material.

CDF after filling. The various pathways that may be affected by contaminated sediment in the pilot study CDF once the facility is filled are illustrated in Figure 1. These pathways include surface runoff, biological uptake, volatilization, seepage, and leachate. Capping the CDF with clean dredged material will minimize the magnitude of the contaminant releases via the first three pathways mentioned. The pathway of most concern for the completed CDF

is loss of leachate from the contaminated sediment through the bottom of the facility or seepage through the dike adjacent to the shore.

Loss of leachate from the CDF depends on hydraulic gradients and characteristics of the dike and foundation materials. The controlling hydraulic gradient for a free-draining foundation is directed downward in proportion to the static head produced by the height of saturated dredged material above the bottom of the CDF or above the water level on the outside of the dike, whichever is higher. Free drainage of pore water from the dredged material will slowly dissipate this head, but will force leachate through the bottom of the site.

The low permeability of the dredged material (10^{-6} to 10^{-7} cm/sec) limits the rate of infiltration of water downward from the surface of the CDF. Once the CDF is filled and capped, drainage will be provided to prevent ponding of water on the surface, and most rain water will run off. Evaporation, and later evapotranspiration if the site becomes vegetated, will reduce the volume of rain water and snow melt transmitted downward, resulting in a layer of unsaturated dredged material near the surface of the CDF. Therefore, the primary contributor to leachate or seepage volume is the pore water associated with the dredged material placed in the site.

Modifying the bottom of the CDF to impede leachate flow or breaking the hydraulic gradient by collecting leachate at the bottom of the CDF will reduce leachate percolation from the bottom of the site. However, lining the CDF(s) for a remedial action at New Bedford could increase the overall cleanup cost by an estimated $51 million (NUS Corporation 1984). Lining large in-water CDFs also presents construction requirements that have not been fully demonstrated in the industry, and long term reliability of a liner is questionable.

Information to predict contaminant losses from a CDF is currently being developed. Evaluating leachate quality from the pilot study CDF will contribute to the knowledge of leachate contaminant loads. A lined CDF by design imposes differing hydraulic and foundation characteristics compared to an unlined site. Evaluation of an unlined pilot site will provide data to indicate leachate quality through the dikes and foundation, and provide important information for the making the liner decision for a final remedial action. Therefore, the pilot study will evaluate leachate quality from an unlined CDF.

Clean material used to cover the CDF will minimize losses through volatilization, bioturbation, or surface runoff. Rainfall runoff from the clean cap is not expected to present a problem with PCB release.

<u>CAD filling</u>. The CAD facility is simply an area in the estuary that will be excavated to approximately a 4 ft depth by dredging sediment to fill the CDF. Contaminated dredged material will be placed in the bottom of the CAD cell by a submerged diffuser attached to the end of the pipeline from the dredge (Figure 2). The diffuser is designed to release the slurry parallel to the bottom of the site and at a velocity sufficiently low to minimize upper water column impacts. However, the water that separates from the dredged material slurry as the sediment settles to the bottom, will contain fine particulates with attached contaminants and contaminants dissolved in the water. These contaminants will be transported by currents created by the dredging operation and by currents in the estuary. The heavier suspended

sediment particles will settle in the CAD cell, and some of the dissolved contaminants will become attached to finer suspended sediment that may eventually settle on their own or aggregate and settle more rapidly. Transport in water is the primary pathway for loss of contaminants from the CAD filling operation. Volatilization losses will be minimized by maintaining the discharge pipe below the water.

CAD after filling. Placement of dredged material in the CAD facility returns the contaminated sediment to environmental conditions similar to those existing in the bottom of the harbor where the sediment originated. The advantage of the CAD site is that contaminants are separated from the water column by a layer of cleaner sediment, that prevents direct contact of the contaminated sediment with the water column, eliminates resuspension of contaminated sediment, attenuates contaminants that may move or diffuse through the cap, and reduces bioturbation with the contaminated sediment. As long as the integrity of the cap is maintained, contaminant losses from the CAD site will be minimal. Truitt (1986) reported on chemical studies of the Duwamish Waterway capping demonstration project, where vibracore sediment samples were collected at 4-cm intervals through a layer of capping material and a layer of contaminated sediment. Analyses of these samples for lead and PCB indicated that the cap effectively contained the contaminated dredged material.

Contaminant Release Estimates

Procedures for estimating contaminant releases from dredged material disposal operations for several transport mechanisms have been developed and verified. Specific testing protocols available for various pathways and transport mechanisms are discussed in Francingues et al.(1985). Testing protocols for surface water and ground water pathways are being applied to New Bedford sediment in the USACE Engineering Feasibility Study. Applicable testing protocols and the transport mechanism(s) they address are listed below:

Testing Protocol	Pathway	Transport Mechanism
Modified Elutriate	Surface water	Soluble and suspended contaminants from CDF during filling
Standard Elutriate	Surface water	Soluble contaminants from open water disposal
Leaching	Ground water	Soluble contaminants from confined disposal
Capping	Surface water	Soluble contaminants from CAD after filling
Surface runoff	Surface water	Soluble and suspended contaminants from CDF after filling

The estimates presented herein are based on preliminary results for elutriate and leachate testing of the composite sample collected for the USACE Engineering Feasibility Study, elutriate testing of a composite sediment sample from the area to be dredged by the pilot study, and evaluation of

sediment resuspension and settling rates predicted by field studies and a vertically-averaged, numerical sediment transport model.

Laboratory tests. The principal data needed to estimate contaminant release are the suspended sediment concentrations, particulate-associated PCB concentrations, and soluble PCB concentrations in the discharge or immediate vicinity of the dredge, the CDF effluent, and the CAD cell. The standard elutriate test and the modified elutriate test were selected as the best available laboratory methods for providing these data. The standard elutriate has been applied to soluble releases during open water disposal of dredged material (Brannon 1978) and the modified elutriate has been applied to soluble and particle-bound releases from diked disposal sites for dredged material (Palermo 1986). Laboratory procedures for the standard elutriate test are provided in Plumb (1981) and for the modified elutriate test in Palermo (1986). Differences in the tests include the following:

Laboratory Procedure	Standard	Modified
Mixing time, hr.	0.5	1.0
Settling time, hr.	1.0	Up to 24

In addition, the standard elutriate uses a volumetric ratio of 4 to 1 dilution water to sediment for preparing the slurry; whereas the modified elutriate test uses the sediment concentration anticipated for the particular project with a default value of 150 g/l. The standard elutriate analysis, with its shorter settling time, is more applicable to contaminants released at the dredge head and at the CAD site.

Assumptions and basic data. Table 1 lists the production data, sediment resuspension and release rates, and sediment escape rates used to estimate sediment flux at the Coggeshall St. Bridge during the pilot study operations. Flow rates shown in Table 1 for dredging volume per tidal cycle result from equalizing the 600 cy per day sediment removal rate over a 24 hour period. Duration of each tidal cycle is 12.4 hours.

Contaminant concentrations associated with suspended sediment and dissolved contaminant concentrations are based on standard and modified elutriate tests for a sediment sample collected from the cove. Elutriate results are presented in Table 2. The sediment sample was a composite of grab samples collected with a Van Veen sampler at sample locations 1, 2, 3, 4, 5, 7, and 8. The sampler collected the top 6 in. of sediment. Total PCB concentration of this sediment was 432 mg/kg. Water used for the elutriate tests was collected from the Upper Estuary.

Dredging. Estimates of contaminant release from the dredging plant begin with the basic flux rate assumption of 40 g/sec sediment resuspended. This number is based on field data collected during the box-coring operation for collection of the composite sample for the USACE Engineering Feasibility Study (EFS). Water column suspended sediment concentrations were measured during the box coring operation at a 5-yd and a 50-yd radius of the sampling barge. Although this was a mechanical dredging activity on a relatively small scale, the barge was operating in shallow water and resuspended material by direct contact with the bed and by prop wash, in addition to dropping and raising the

corer. Average sediment concentrations 50 yds from the barge were 80 mg/lit above background. The concentrations observed were fit with a two-dimension vertically averaged plume model to estimate the 40 g/sec sediment resuspension rate.

The sediment resuspension rate of 40 g/sec represents 0.4 percent of the sediment mass dredged and is equivalent to 2 kg sediment resuspended per cu m of sediment dredged. Nakai (1978) has reported sediment resuspension rates in fine grained material from 5 kg per cu m to as high as 45 kg per cu m for a large dredge pumping a sediment with 35 percent clay. The pilot project will dredge a material with less than 20 percent clay and will employ specialized equipment, dredging operational controls and silt curtains to minimize the rates of resuspension. Therefore, the assumed rate of resuspension (40 g per sec) is thought to be an acceptable estimate of the rate for pilot project conditions.

Only a portion of the sediment released at the dredge will be transported away from the site and through the bridge. The values given as fraction of sediment escaping at the bridge presented in Table 1 are based on results from numerical hydrodynamic and sediment transport modeling described in "Numerical Modeling of Sediment Migration From Pilot Dredging and Disposal, New Bedford Harbor, Massachusetts" (Teeter 1987a).

The mass of contaminant associated with the sediment particles resuspended by the dredge is based on the contaminant concentration measured for the sediment remaining in suspension following the settling phase of the modified elutriate test. The modified elutriate value was chosen because its suspended solids represent smaller particles and have greater contaminant concentrations than those for the standard elutriate test. This should be more representative of the particles most susceptible to transport. Calculations of contaminant mass released at the bridge for PCB and heavy metals are presented in Table 3.

Soluble release for the dredge is calculated from the contaminant pore water concentration. Application of preliminary data from the EFS batch leaching studies yields a pore water concentration of 0.3 mg/l PCB for in situ sediment with a PCB concentration of 126 mg/kg dry weight. For the purposes of these estimates, pore water concentrations for metals were selected as the maximum concentrations observed for batch leachate testing of the EFS sediment. These values are given as contaminant dissolved concentration for the dredging operation in Table 3. The mass of pore water released is estimated from the sediment resuspension rate and the water content of the in situ sediment, i.e., for each kg sediment resuspended, 1.6 kg of pore water is released (720 kg per tide). All the mass of dissolved contaminant released is assumed to escape beyond the bridge.

CDF effluent. Estimates of the suspended sediment released from the CDF are presented in Table 1. Laboratory settling column data for the EFS composite sample were used in the procedure outlined by Palermo (1985) to estimate the effluent suspended solids from the primary cell of the CDF. Results from bench scale jar tests performed for the EFS indicate that as much as 82 percent additional suspended solids reduction can be achieved in the secondary cell following polymer flocculation. These estimates indicate that an effluent suspended solids concentration of 70 mg per liter can be attained.

During the initial stages of filling the CDF with contaminated sediment, much longer settling times will be available in the CDF.

Contaminant release from the CDF discharge during dredging operations overflow is calculated directly from suspended sediment contaminant concentrations and dissolved contaminant concentrations observed in the modified elutriate test and the dredge flow rate. Mass flux of PCB and heavy metals are presented in Table 3.

CAD filling. A predictive tool for estimating the mass of suspended sediment released in the CAD cell during filling has not been developed and verified. The CAD cell could be considered as a semi-confined underwater settling area. The cell provides a volumetric retention time of 12 hours when half-filled. Application of settling test data in a manner similar to that for a CDF yields a suspended solids concentration on the order of 500 mg/liter or about 0.4 percent of the sediment dredging rate. Other studies of sediment loss during open water disposal of dredged material, generally reported where dredging depths were greater than 50 ft, have estimated sediment losses in the water column on the order of 1 to 5 percent of the original sediment mass (Montgomery 1986). Placing sediment in the CAD cell with the submerged diffuser will more efficiently place sediment in the bottom of the cell than conventional open water disposal. Use of the submerged diffuser for a Calumet Harbor, Illinois, project demonstrated that discharged dredged material was confined to the lower 20 percent of the water column with no increase in suspended solids above that point (McLellan and Truitt 1986). Directly comparable data for the release rate are not available. Calculations shown in Table 1 assume a sediment release of 1 percent of the dredging rate, which is greater than the settling test prediction but lower than some estimates in the literature.

Contaminant release rates for the CAD presented in Table 3 are based on suspended sediment contaminant concentrations from the modified elutriate test and soluble concentrations observed in the standard elutriate test. Use of the standard elutriate test for estimating soluble releases during open water disposal of dredged material is consistent with routine use of this test for evaluating open water disposal of dredged material.

Contaminant Concentration Increases at the Bridge

Mass flux increases for PCB and heavy metals are converted to water column concentration increases at the bridge in Table 3. An average tidal volume of 1,040,000,000 liters per tidal cycle was estimated from the average of 6 surveys reported by Teeter (1987b) and USEPA (1983). The average fraction of water escaping on the ebb tide based on PCB data from the same surveys was estimated as 0.47 of the tidal volume. The same ratio was used for heavy metals; however, no heavy metals flux data are available for direct comparison.

Existing Conditions

Water quality survey data for PCB for the Upper Estuary at the Coggeshall Street Bridge are presented in Table 4. Two sets of data are available: one from the USACE Engineering Feasibility Study (Teeter 1987b) and the second from the USEPA Environmental Response Team's Report (1982). Mass flux of PCB shown in Table 4 ranges from 0.07 kg per tidal cycle to 2.2 kg per tidal

cycle. Extremes of PCB concentration averaged for each phase of the tidal cycle are 0.67 and 5.8 ppb. Averages and standard deviations for all five tidal cycles reported are also shown in Table 4. Water quality concentration and mass flux data for heavy metals at the bridge are not available for direct a comparison. Water quality criteria will be used for comparison to pilot project effects with respect to heavy metals.

Mass Flux Comparisons

Comparison of the mass flux values directly from individual pilot study operations in Table 3 shows that the pilot study releases at the point of discharge are greater than the flux at the bridge measured on March 6, 1986, but are less than the flux values shown in Table 4 for the other four survey periods. The dredging and CAD filling operation will occur at the same time. The total mass PCB flux for these operations is estimated to be 0.85 kg per tidal cycle, which is approximately equal to the mass flux observed on January 11, 1983.

Comparison of PCB Concentrations

The maximum PCB concentration increase occurs on the ebb tide. During dredging and CAD filling the total concentration increase is estimated to be 1.8 ppb PCB at the bridge. This is less than the average concentration given in Table 4. For the case of dredging and CDF discharge the projected concentration increase is 0.5 ppb, which is less than all of the concentrations reported in Table 4.

Assessment of Heavy Metals Releases

The projected increases for heavy metals shown in Table 3 represent particulate and dissolved metals. The greatest increases will occur during the dredging and CAD filling phase of the pilot project. Increases for cadmium, chromium, lead, nickel, and zinc do not exceed the Gold Book water quality criteria for marine waters. Copper releases during dredging and CAD filling could increase the total copper concentration by 2.1 ppb, which approaches the 2.9 ppb criterion. However, the concentration increase for dissolved copper is only 0.06 ppb.

Summary

The projected net increases in contaminant mass flux and contaminant concentration for the estuary are within the range of variability measured for existing conditions. Considering the existing contaminant load, the relative magnitude of estimated releases from the pilot project, and the relatively short duration of the dredging project (2 to 4 months), the pilot project should be pursued as a means for reducing uncertainty in estimating contaminant releases from the full-scale project and for improving design and operational techniques prior to final design and implementation of the full-scale cleanup.

Estimates of Leachate Contaminant Releases from the CDF

In order to calculate the rate of contaminant loss from the CDF, the concentrations of contaminants and the rate of leachate seepage through the dikes and foundation of the site must be estimated. Estimates of leachate

quality and contaminant transport through the dredged material are being investigated in laboratory studies at the Waterways Experiment Station (WES). Batch leaching tests provide data for desorption isotherms, which measure the interphase transfer of contaminants from the dredged material solids to water at chemical equilibrium. Column or permeameter leaching tests address advective-dispersive transport and other mass transport effects that may occur in a CDF. Initial results from the batch leaching tests are available and provide a basis for a conservative estimate of leachate quality for the pilot study. Permeameter studies have not been completed requiring other assumptions for predicting the mass transport from the CDF.

The quantity of leachate crossing the CDF boundaries depends on local hydraulic gradients and the characteristics of the foundation materials. However, information on boundary characteristics and local groundwater flow is not available. Therefore, this analysis will assume that the foundation is free draining, i.e., there is no resistance to flow at the boundary of the CDF. This condition represents a worse case scenario because it is physically impossible to have a foundation with no resistance to flow. Also, water flowing through the dredged material will be assumed to depend on net water input from the surface of the CDF, hydraulic gradient in the CDF, and infiltration characteristics of the dredged material.

Ground water beneath the CDF is expected to flow toward the estuary. However, additional geohydrological data and modeling would be required to confirm site-specific flow patterns and rates for the pilot study area. Initial soil borings indicate that the foundation of the CDF is sandy material. The water table and high tide level will be higher than the CDF bottom for the eastern side of the CDF, and the water table will be 1 to 3 ft below the bottom of the shallower, western side of the CDF. Leachate exiting the boundaries of the CDF will likely enter the ground water or the estuary.

Leachate quality. Leachate quality will be estimated from batch leaching test data available from WES testing of a composite sediment sample from the Upper Acushnet Estuary. This sediment was subjected to 7 sequential leaching steps for heavy metals and 4 sequential leaching steps for PCB under anaerobic conditions. The maximum contaminant concentration observed for the batch leaching tests is used to estimate leachate concentrations for the pilot study sediment. Sediment to be dredged during the pilot study is generally less contaminated than the composite sample tested at WES. Therefore, the leachate quality for the pilot study sediment is adjusted by the ratio of the contaminant concentration in the pilot study sediment to the contaminant concentration in the composite sediment.

Estimated leachate concentrations are given in Table 5. These concentrations are worse case estimates because they are based on the maximum contaminant concentrations from the batch leaching test and because batch leaching tests generally overestimate pore water concentrations for a flow through system. Table 5 compares the estimated leachate concentrations with the maximum contaminant levels (MCL) established under the Safe Drinking Water Act. The estimated concentrations exceed the MCLs for chromium and lead.

Leachate volume estimate. Estimates of vertical percolation through the CDF bottom were made using the US Environmental Protection Agency's Hydraulic Evaluation of Landfill Performance (HELP) computer model (Schroeder et al. 1984). HELP models hydrologic movement of water across, into, through, and

out of landfills. It accepts climatologic, soil, and design data and uses a solution technique that accounts for the effects of surface storage, runoff, winter cover, infiltration, percolation, evapotranspiration, and soil moisture storage. The version (HELPDM) of the model used for this analysis has been adapted for dredged material to account for the saturated conditions initially present in a CDF. During a 5 year simulation period, HELPDM computed the maximum daily flow from the base of the CDF to be 438 cu ft. This maximum daily flow will be used in subsequent estimation of contaminant mass flux from the CDF.

Estimates of contaminant mass flux. Table 5 presents estimates of the rates of release of heavy metals and PCB from the pilot study CDF based on the leachate characteristics in Table 1 and the maximum daily flow rate estimated by HELPDM. These rates represent worse case scenarios based on the assumptions that leachate quality is proportional to the greatest batch leachate concentration, the bottom of the CDF is free draining, and leachate seeps from the site at the peak daily flow predicted by HELPDM. The impact of these mass loads on the estuary water quality is not likely detectable for any of the constituents listed in Table 5.

Table 1

Suspended Sediment Release Estimates for Pilot Project Operations

Parameter Description	Value
DREDGING OPERATION	
Dredge production rate, cu/yd/hr	100
Dredged material slurry flow rate, cu yd/hr	400
Dredge operation time, hr/day	6
Dredge pumping rate, cu/yd/day	2,400
Averaged dredge pumping rate, cu yd/tide, where tide=12.4 hr	1,240
Averaged dredge pumping rate, liter/tide	950,000
Dredged material solids concentration, g/liter	125
Dredged material solids concentration, percent by weight	11
Sediment removal rate as dry solids, kg/tide	120,000
Sediment resuspension rate at dredge, g/sec	40
Sediment resuspension rate at dredge, kg/tide	450
Fraction resuspended sediment escaping at bridge	0.16
Resuspended sediment escaping at bridge, kg/tide	72
CONFINED DISPOSAL FACILITY (CDF)	
Surface area for settling, primary cell, sq ft	123,000
Minimum ponded depth, ft	2
Settling volume, primary cell, cu yd	9,100
Minimum theoretical retention time in primary cell, day	3.8
Assumed hydraulic efficiency, percent	44
Adjusted retention time in primary cell, day	1.7
Estimated effluent SS from settling test, mg/liter	90
Adjusted (X 1.5) effluent SS for field conditions, mg/liter	140
SS removal efficiency by flocculation, secondary cell, percent	50
Effluent SS from secondary cell, mg/liter	70
Sediment release rate to estuary, kg/tide	67
Fraction CDF SS escaping at bridge	0.5
Sediment escaping at bridge, kg/tide	34
CONFINED AQUATIC DISPOSAL (CAD)	
Assumed fraction of dredged sediment released to water column	0.01
SS concentration in flow from discharge point, mg/liter	1,300
Sediment release rate to estuary, kg/tide	1,200
Fraction CAD SS escaping at bridge	0.31
Sediment escaping at bridge, kg/tide	370

Table 2

Elutriate Test Results for Pilot Project Sediment

Elutriate Procedure	Elutriate Phase	SS ppm	PCB 1242 ppb	PCB 1254 ppb	Total PCB ppb	Cd ppb	Cr ppb	Cu ppb	Pb ppb	Ni ppb	Zn ppb
Standard	Whole	490	280	300	580	48	963	1,100	387	134	1,140
	Centrifuged	77	110	25	135						
	Filtered		3	2	5	46	11	29	33	322*	1,570*
Modified	Whole	170	160	170	330	42	423	456	177	115	715
	Centrifuged	84	72	66	138						
	Filtered		7	6	13	61	18	72	30	287*	1,890*

Calculated Contaminant Concentrations on Suspended Sediment in the Whole Elutriates

Elutriate Procedure	PCB 1242 mg/kg	PCB 1254 mg/kg	Total PCB mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Pb mg/kg	Ni mg/kg	Zn mg/kg
Standard	565	608	1,173	3	1,943	2,186	722	273	2,327
Modified	900	965	1,865	245	2,382	2,259	865	676	4,206

* Filtered for these parameters were greater than whole water samples, suggesting contamination of the filtered sample. Calculations of suspended solids contaminant concentrations assume that all contaminant measured in the whole sample was associated with the solids. Filtered values are used for dissolved concentration estimates.

Table 3

Contaminant Release Estimates for Pilot Project Operations

Source	Cont.	Conc. on Suspended Sediment mg/kg	Conc.* Dissolved in Water ppb	Sediment Release at Bridge kg/tide	Mass Flux on Sediment at Bridge kg/tide	Mass Flux Dissolved in Water at Bridge kg/tide	Mass Flux Total at Bridge kg/tide	Total Conc. Increase Ebb Tide ppb	Total Conc. Increase Flood Tide ppb
Dredge	PCB	1,900	300	72	0.14	0.0002	0.14	0.3	0.2
CDF	PCB	1,900	13	34	0.06	0.01	0.08	0.2	0.08
CAD	PCB	1,900	5	370	0.70	0.005	0.71	1.5	0.8
Dredge	Cd	240	15	72	0.02	0.00001	0.02	0.04	0.02
CDF	Cd	240	61	34	0.01	0.06	0.07	0.1	0.07
CAD	Cd	240	46	370	0.09	0.04	0.13	0.3	0.1
Dredge	Cr	2,400	360	72	0.17	0.0003	0.17	0.4	0.2
CDF	Cr	2,400	18	34	0.08	0.02	0.10	0.2	0.1
CAD	Cr	2,400	11	370	0.89	0.01	0.90	1.9	1.0
D e	Cu	2,300	1,100	72	0.17	0.0008	0.17	0.3	0.2
(	Cu	2,300	72	34	0.08	0.07	0.15	0.3	0.2
	Cu	2,300	29	370	0.85	0.03	0.88	1.8	1.0
Dredge	Pb	860	400	72	0.06	0.0003	0.06	0.1	0.07
CDF	Pb	860	30	34	0.03	0.03	0.06	0.1	0.06
CAD	Pb	860	33	370	0.32	0.03	0.35	0.7	0.4
Dredge	Ni	680	66	72	0.05	0.00005	0.05	0.1	0.05
CDF	Ni	680	287	34	0.02	0.27	0.30	0.6	0.3
CAD	Ni	680	322	370	0.25	0.31	0.56	1.1	0.6
Dredge	Zn	4,200	1,800	72	0.30	0.001	0.30	0.6	0.3
CDF	Zn	4,200	1,890	34	0.14	1.8	1.9	4.0	2.1
CAD	Zn	4,200	1,570	370	1.6	1.5	3.1	6.3	3.3

* Dissolved contaminant concentrations for the CDF and CAD are derived from the modified elutriate test and standard elutriate test, respectively. Dissolved contaminant concentrations for the dredge are the estimated pore water concentrations for the in situ sediment, which were derived from preliminary batch leachate data.

Table 4

Water Quality Survey Data for Existing Conditions
At Coggeshall Street Bridge

Investigator	Date	Mass PCB Flux kg Per Tidal Cycle	PCB Concentration, ppb Ebb	Flood
USACE, WES	03/06/86	0.07	1.3	1.3
USACE, WES	06/05/86	2.2	5.8	3.0
USEPA, ERT	01/11/83	0.83*	1.6	1.1
USEPA, ERT	01/11/83	0.99*	1.8	0.94
USEPA, ERT	01/12/83	0.77*	1.3	0.67
	Average	0.97	2.4	1.4
	Std. Deviation	0.77	1.9	0.92

*USEPA values are adjusted to the same tidal prism calculated by USACE.

Table 5

Estimated Contaminant Flux by Leachate Seepage from Pilot Study CDF

Seepage Rate = 438 cu ft/d*

Contaminant	Maximum Contaminant Level** ug/l (ppb)	Estimated Leachate Concentration ug/l (ppb)	Peak Daily Flux at CDF Base kg/d
Arsenic	50	3	0.00004
Cadmium	10	7	0.00008
Chromium	50	200	0.002
Copper	—	600	0.007
Lead	50	100	0.001
Nickel	—	30	0.0004
Zinc	—	1000	0.01
PCB (1242 + 1254)	—	300	0.004

* Seepage rate is the peak daily rate estimated by HELPDM for pilot CDF. Predicted average daily seepage rate for the first year is 273 cu ft/d.

**Maximum contaminant levels specified for compliance with Safe Drinking Water Act.

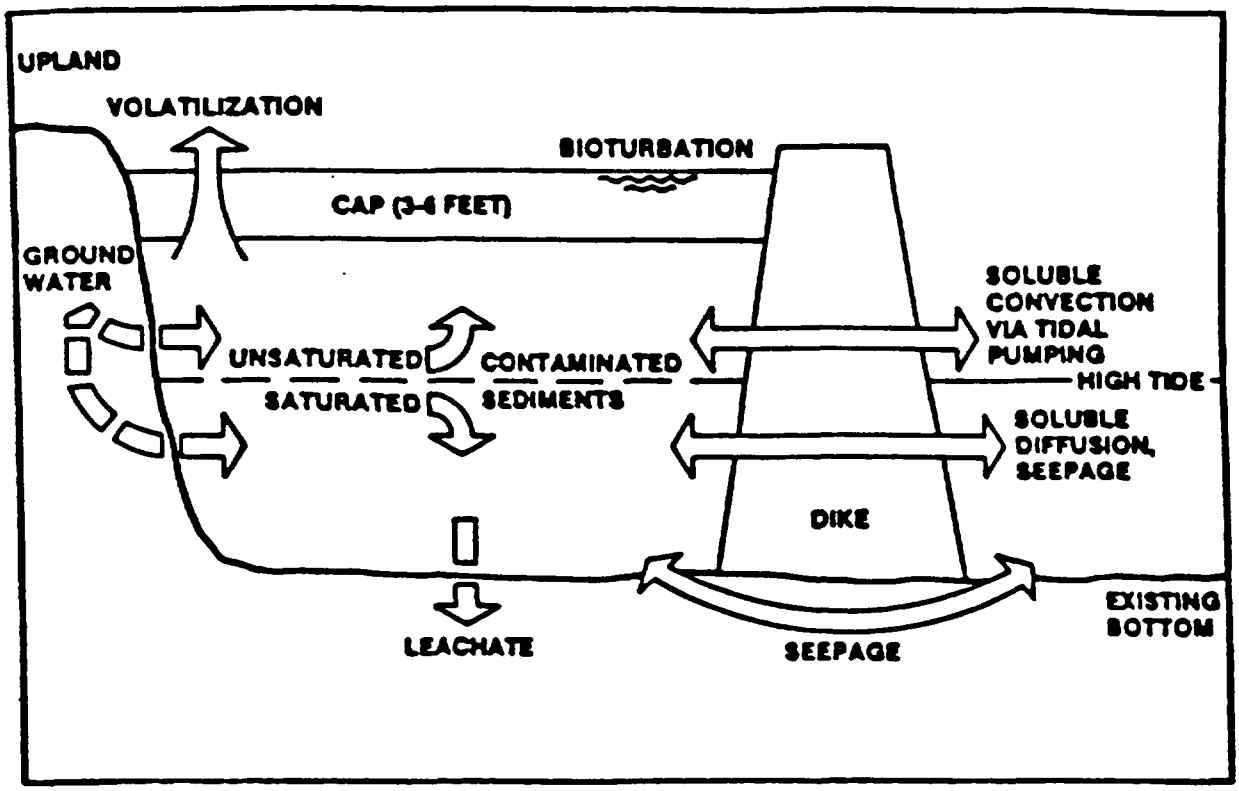


Figure 1. Contaminant Migration Pathways for a Nearshore CDF

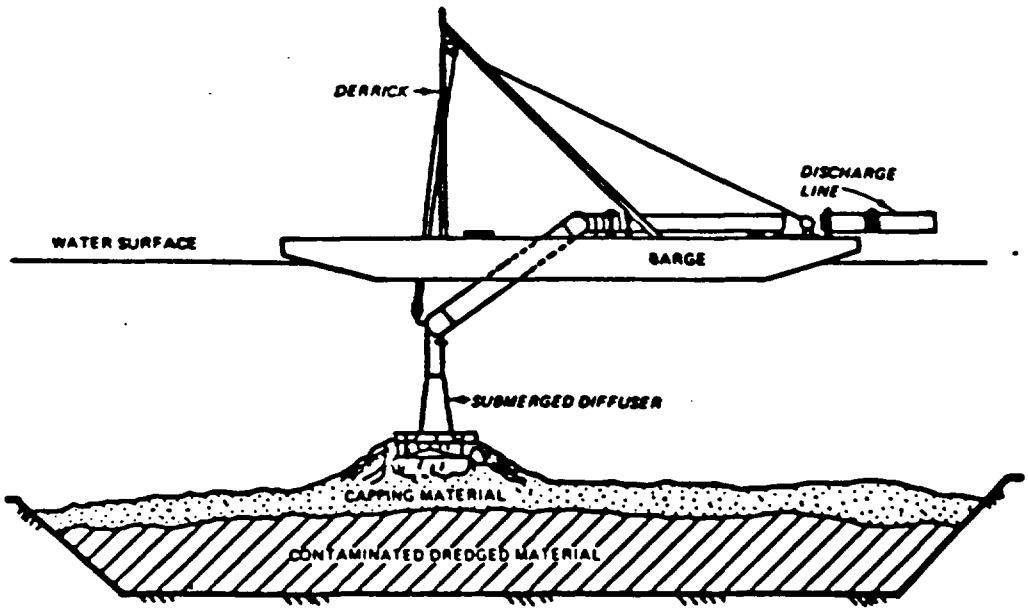


Figure 2. CAD Cell Filling with a Submerged Diffuser

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APPENDIX 2: Baseline Conditions for Contaminant and Sediment Migration, New Bedford Harbor, Massachusetts

Introduction

The Waterways Experiment Station Hydraulics Laboratory (WESHL) collected field data in New Bedford Harbor as part of the USACE's Engineering Feasibility Study of Dredging and Disposal Alternatives. One of the objectives of that task was to determine baseline conditions in the upper harbor with regard to movements and migration of contaminants out of the upper harbor. The purpose of the baseline is to provide a gage to judge the acceptability of cleanup dredging risk or damage associated with contaminant spreading and an understanding of the physical processes active in the transport of PCB from the upper harbor. This appendix briefly summarizes the results obtained.

Background

Field data were collected during three surveys. Survey dates, tides, freshwater flows, and winds are given in Table 1. Nine stations were sampled repeatedly over three tidal-cycles. Figure 1 shows station locations.

Three stations were located across the opening of the Coggeshall Bridge which forms the boundary between the upper and lower harbors. Current speed and direction, salinity, and suspended material were sampled. In addition, flow-proportioned composite samples and surface floatable samples were collected for PCB analysis.

Analyses of the field data were performed, and results summarized below. PCB results for the 24 April survey were very different from the other two surveys, and these results were treated separately.

Fluxes of PCB's at Coggeshall Bridge

Survey data were used to calculate tidal volumes for ebb and flood tidal phases. Current velocities were integrated spatially over the bridge cross section, correcting for tide height, and were integrated in time to determine total discharge for each tidal phase. The upper harbor's surface area is about 8.6 E6 sq ft. The cross-sectional area at the bridge is about 1524 sq ft to mean tide level. Table 2 shows results expressed in billions of liters.

Ebb and flood PCB Aroclor concentrations were mutliplied by the tidal volumes to obtain ebb and flood PCB fluxes. The difference between ebb and flood fluxes is the tidal net flux.

Results are shown in Table 2 for the first and last surveys. Observed net fluxes were always seaward (negative), -0.32 and -1.27 kg, with a mean net flux of -0.79 kg per tidal cycle.

There are biasses in the observered fluxes introduced by tidal asymmetry. If the ebb tide range and tidal volumes are greater than those of the flood tide then the fluxes are biased toward the ebb phase and vice versa. To remove tidal bias, tidal-corrected fluxes were calculated and shown in Table 2. Tide-corrected fluxes were computed as the sum of net-flow fluxes (freshwater volume times mean concentrations) plus tidal-pumping fluxes (the difference between ebb and flood concentrations times the mean tidal volume).

The tide-corrected net PCB fluxes were also seaward, -0.07 and -2.22 kg, with a mean net flux of -1.15 kg per tidal cycle. The dominant mechanism for PCB net flux out of the upper harbor is tidal-pumping, which will be described later. PCB concentrations were generally lower on the flood than on the ebb tide, and the "to-and-fro" tidal motions effectively disperse contaminants seaward, either attached to particles or dissolved.

An EPA Response Team (USEPA,1983) studied PCB fluxes at the Coggeshall Bridge in 1983 using a slightly different method. Their results were similar in magnitude to the present study, and net fluxes were always seaward. In reviewing and comparing our results to EPA's, a discrepancy was noted between tidal volumes and tidal prisms. EPA's computed cross-sectional area for the bridge was apparently too great, but the PCB fluxes can be easily corrected. The corrected average total-PCB net flux was -0.83 kg, with a range of -0.62 to -1.20 kg per tidal cycle.

Floatable material samples at the birdge were low in PCB's, mostly below analytical detection limits (0.01 micro-g/sq ft). Fluxes of PCB in the floatable transport mode could not be accurately estimated, but were at least several orders of magnitude less than that carried by the flow.

Fluxes of Suspended Material at Coggeshall Bridge

Bridge fluxes of total suspended material (TSM) were estimated by integrating discrete measurements of velocity and TSM over space and time. Results are shown in Table 2, and also include tide-corrected net fluxes. Flow-proportioned TSM concentration values for ebb and flood phases were calculated based on the tidal volumes, and are shown in Table 2.

The net flux of TSM was always found to be landward or upstream although fluxes in either direction were at least twice net values. About one-third of the sediment which enters the upper harbor on the flood tide settled there during that tide. Average net flux of TSM into the upper harbor was about 2,200 kg per tidal cycle. The freshwater inflow adds some additional sediment, on the order of a several hundred kg per tidal cycle.

Shoaling resulting from the deposition of 2,500 kg of sediment per tidal cycle amounts to 3 mm per year when spread over the entire surface area of the upper harbor at a bulk wet density of 1.5 g per cu cm (775 dry-g per l). Actual sedimentation rates would vary widely over the upper harbor, depending on current, wave, and depth regimes. Summerhayes, et al. (1977) estimated sedimentation rates in the lower harbor to be about 4 cm per year in previously dredged areas and 2-3 mm per year for Buzzards Bay.

April 24 Survey

The 24 April survey was unusal for several reasons. The tide range was the highest for any survey and, therefore, current speeds were highest. The freshwater inflow was the highest of any survey. Freshwater inflow hit a peak of 65 cfs on this day, up from only 13 cfs three days earlier. Wind conditions were the highest of any survey, 20-30- mph from the NE. Wind waves under the Coggeshall Bridge were estimated to be 3 ft during a portion of the survey. In short, the 24 April survey was, by far, the most extreme condition surveyed.

PCB Aroclor concentrations from the 24 April survey were about 1,000 times greater than those from the other two surveys. Ebb and flood total PCB Aroclors were 1.93 and 0.76 ppm, respectively. Reported PCB values were confirmed by WESEL chemists for the original samples, but no other direct data are available for comparison. The only comparable value from WESHL water sampling was 0.142 ppm total Aroclors measured near composite core-sampling on 31 March 1986. Until the PCB concentrations from the 24 April survey are verified, they must be considered preliminary.

PCB fluxes, computed in the same way as for the other surveys, are shown in Table 3. Net flux of PCB Aroclor was -1,648 kg for one tidal cycle.

The harbor was not vertically stratified during the survey; vertical salinity differences were small. The TSM concentrations at the bridge stations and at station 7 had higher peak and mean values near the surface than at the bottom. This caused the vertical distribution of suspended material to have a most unusual, inverted nature. Higher near-surface suspended concentrations, not associated with a freshwater lens or surface input, could be caused by slightly buoyant particles.

Overall suspended concentrations were only slightly higher than the other surveys. Peak TSM concentrations at stations 7, 8, and 9 were 57, 35, and 28 mg/l, respectively, indicating possible mild resuspension.

PCB concentrations determined on the ebb and flood composite samples were well above saturation values, and yet relatively little suspended material was in transport. Calculated values of PCB concentration by sediment dry weight are meaningless, higher than any reported sediment values. PCB Aroclor could have been transported as small oil-like droplets released from sediments, or associated with organic material torn loose from the bottom by waves. An unknown, external release or input of PCB's cannot be ruled out.

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Table 1. Summary of Survey Conditions

Survey Date	Freshwater Inflow cfs	Tidal Range ft at TG#3	Wind Direction, Speed	Water Temperature
3/6	41.3	3.4	S, 15-20 mph	4 °C
4/24	52.9	5.4	NE,8-12 then 20-30 mph	11 °C
6/5	8.9	3.4	SW, 10-15 mph	17 °C

Table 2. Fluxes of PCB's and TSM at the Coggeshall Bridge

Survey Date	Tidal Phase	Tidal Volume, E9l	PCB, Aroclor ppb	TSM[1], ppm	PCB/TSM Aroclor, ppm sed. dry-wt	PCB Flux, kg	TSM, Flux, kg	Tide-Corrected[2] PCB flux, kg	Tide-Corrected[2] TSM flux, kg
3/6/86	ebb	-1.13	1.3	3.9	340	-1.47	-4,400		
	flood	0.89	1.3	7.2	180	1.15	6,400		
	total	-0.25				-0.32	2,100	-0.07	3,100
4/24	ebb	-1.47	-	5.9	-	-	-8,700		
	flood	1.57	-	8.1	-	-	12,800		
	total	0.10					4,000	-	2,900
6/5	ebb	-0.67	5.8	6.6	800	-3.90	-4,400		
	flood	0.88	3.0	7.4	400	2.63	6,500		
	total	0.21				-1.27	2,100	-2.22	605

1. Total suspended material.

2. See text for explanation.

Table 3. PCB Fluxes for the 24 April Tidal Cycle Survey at the Coggeshall Bridge

Tidal Phase	PCB Aroclor, ppm	PCB Flux, kg	Tide-Corrected PCB Flux, kg
ebb	1.934	-2,850	
flood	0.764	1,200	
total		-1,650	-1,870

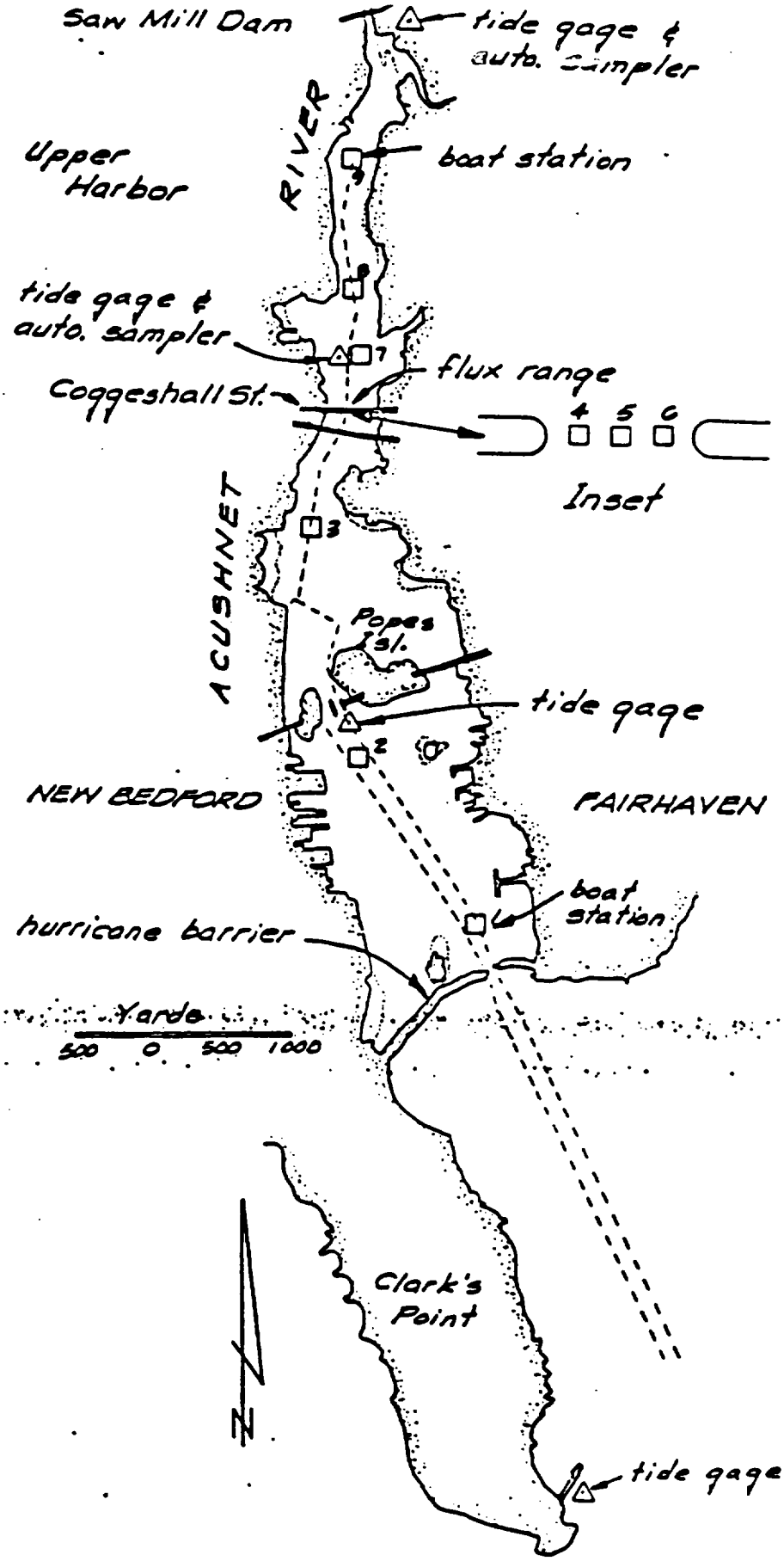

Figure 1. Sampling and gaging locations for New Bedford Harbor

Appendix 3

DREDGING EQUIPMENT

Three hydraulic pipeline dredges will be used during the Pilot Study; a cutterhead dredge, a horizontal auger dredge known as a Mudcat and a cutterhead dredge with the cutterhead replaced by a special attachment called a Matchbox. This equipment was selected after a thorough evaluation that considered a wide range of dredging equipment. Input was received from Corps of Engineer personnel at the New England Division, Waterways Experiment Station, Water Resources Support Center's Dredging Division as well as other Corps Districts and Divisions.

The following factors were considered critical in evaluating the dredging equipment.

a) General: Any equipment considered for the Pilot Study would have to be capable of accomplishing the overall cleanup of the upper estuary.

b) Availability: Will contractors with this equipment be willing and able to work in New Bedford?

c) Safety: Will the dredging process create additional environmental or health problems?

d) Resuspension of material: To what extent will material be resuspended in the water column during the dredging operation?

e) Maneuverability: Will the equipment be able to operate effectively at the site?

f) Clean Up: What is the ability of the equipment to effectively remove PCBs with a minimum mixing of clean and contaminated sediment?

g) Cost and Production: What are the production rates and cost per cubic yard of material removed as well as the ability of the equipment to minimize overdredging?

h) Flexibility: What is the ability of the equipment to adjust/modify its operation?

i) Compatibility with disposal sites: How does the dredging operation meet the requirements of the two disposal options?

j) Shallow Water: Will the equipment be able to operate in the very shallow water (6" at low water)?

k) Access: Will the equipment be able to reach the dredging site? Equipment must be able to pass through restricted bridge openings (10' vertical, 60' horizontal) or be capable of being transported by truck.

Each dredge evaluated was given a comparative rating between 1 and 3 for each of the factors described above, three being the best rating. Each factor was considered to be of equal importance. The dredges selected scored considerably higher than other types of equipment.

Equipment Selected for Pilot Study

General: Hydraulic dredges operate on the principal of the centrifugal water pump. A vacuum is created on the intake side of the pump and atmospheric pressure acts to force water and sediments through the suction pipe. The dredge materials are then hydraulically pumped via pipeline to the disposal site.

Cutterhead Dredge or cutter - suction dredge: This is the most common dredge in use in the United State today. In this dredge, the suction head is fitted with a rotating basket that can have blades or teeth depending on the type of material to be removed. The dredge size is determined by the discharge diameter of the dredge pump. The dredge used for the pilot study will have an 8 inch diameter pump discharge.

The dredge is moved into position by a push boat and is held stable by a stern spud which is driven into the sediment. Anchor cables at a distance from the dredge are used to control the swing of the cutterhead. The dredging operation consists of the side to side movement (swing) of the rotating cutterhead. The dredge is advanced by lowering a second stern spud at the end of a lateral swing. The first spud is then raised and the dredge advances and pivots on the lowered spud. This walking action allows the dredge to advance with a zig zag dredging action.

The dredge that will be used for the pilot study will make approximately a 60 foot wide cut and will pump the material to the disposal site in a slurry of approximately 20% solids.

Most of the turbidity associated with a cutterhead dredging operation is in the immediate vicinity of the rotating cutterhead. The amount of resuspended sediment decrease exponentially from the cutter to the water surface and depending on the sediment type, the operational conditions, and the current velocity, turbidity levels decrease rapidly with distance from the cutter.

Horizontal Auger Dredge (MUDCAT): This equipment has a horizontal cutterhead equipped with cutter knives and a spiral auger that cuts and moves the material laterally toward the suction. This small portable dredge can float in water as shallow as 21 inches. Its movement through the water is controlled by winching along a cable anchored on the shore. The cutterhead is surrounded by a mudshield that is effective in minimizing turbidity by entrapping suspended sediment. The manufacturer claims that discharges with as much as 60 percent solids have been obtained. This cutter can remove a layer up to 18 inches thick and 8 feet wide and leaves the bottom flat and free of windrows and ridges.

Matchbox: This is a special attachment which resembles a matchbox and replaces the cutterhead on the cutter suction dredge. It is designed to dredge fine grain sediments at near in-situ density and keep resuspension to a minimum. The matchbox housing is used to channel material into the suction pipe while the dredge swings. It has been used in Holland for dredging contaminated sediment. A comparison test of sediment resuspension of a matchbox suction head and a cutterhead was conducted by the Corps of Engineers in Calumet Harbor, Illinois on Lake Michigan. As the matchbox head is new to this country, the dredge operator was inexperienced in determining the location of the head, a factor that affected the quality of some data. In general, the report concluded that the matchbox is capable of removing sediment with very little resuspension.

Other Equipment Evaluated:

Mechanical Dredging: This would involve the use of a crane mounted on a barge or working from land. This equipment is considered to be less desirable than hydraulic dredges for work in New Bedford due to deficiencies in three major areas.

a) Resuspension of material during the dredging process: A clamshell bucket is lowered into the material, closed to contain the sediment, raised up through the water column and then swung to either a barge or scow where it is emptied. Past field data has indicated that this process results in a higher level of suspended sediment than a hydaulic cutterhead dredging operation. The dredged material must also be rehandled to place it in the disposal site which provides another opportunity for sediment to be resuspended. Auxiliary equipment (workboats, scows) are needed with this operation and moving them around in the shallow water conditions of the upper estuary will resuspend an additional amount of sedment. This auxiliary equipment is not needed with a hydraulic dredging operation

b) Removal of PCB'S: The procedure of removing one bucket of sediment at a time leaves an irregular, cratered bottom. The normal dredging procedure is to remove as much material as possible across the width of the cut and then to swing the bucket to knock down any high spots. This procedure would not be acceptable when we are attempting to remove the entire top layer of sediment.

c) Cost and Production: The dredged material would initially be placed in a scow or barge. It would then have to be removed from this vessel and placed in the disposal site. By handling the material twice you significantly increase the cost of the work. As discussed in paragraph b, control over this dredging operation is not as precise which would lead to overdredging and the need to handle a larger quantity of material.

Pneumatic Dredge systems: This equipment uses compressed air instead of centrifugal motion to pump slurry through a pipeline. The principal under which the pump operates is the pressure differential

between the pressure in the chamber and the hydrostatic pressure of water outside the pump. The use of this equipment in the upper estuary was ruled out because water depths of 10-12 feet are needed for it to operate effectively.

Reference: Pankow, V.R. 1987 MFR "Controls for Dredging, Engineering Feasibility Study for Dredging and Disposal of Highly Contaminated Sediment - Acushuet River Estuary above Coggeshall Street Bridge, New Bedford Superfund Site, Massachusetts"

Appendix 4: CAPPING EFFECTIVENESS LABORATORY TESTING

INTRODUCTION

One of the principal design decisions in a Confined Aquatic Disposal (CAD) operation is the nature and thickness of the capping material to be placed over the contaminated dredged material. The capping material provides the isolation necessary to prevent or reduce the diffusing substances in the underlying contaminated dredged material from reaching the overlying water column and prevents direct contact between the aquatic biota and the contaminated material.

A prime concern about capping as an acceptable disposal method is its efficiency in isolating contaminated dredged material from the water and from both pelagic and benthic biota. Much work has addressed this concern (Brannon et al. 1985, 1986; Gunnison et al. 1986, 1987; Palermo et al. 1986). In these studies the effectiveness of capping in chemically and biologically isolating a contaminated sediment from the overlying water column was studied using a two-step process that involved small-scale and large-scale experimental units. Results from these studies indicated that the small-scale laboratory test can be used to determine cap thicknesss needed to chemically isolate a contaminated sediment from the overlying water column and biota.

This appendix presents iterim results of small scale laboratory capping studies conducted at the Waterways Experiment Station as an element of the USACE Engineering Feasibility Study of Dredging and Disposal Alternatives for the Acushet River Estuary.

Objective

The objective of laboratory testing is to provide guidance on the thickness of capping material in a CAD that will chemically islate contaminated New Bedford Harbor sediment from the overlying water column and biota.

Small-Scale Laboratory Test

The effectiveness of capping in chemically isolating New Bedford Harbor sediment from the overlying water column was investigated at the Waterways Experiment Station using small-scale (22.6 L) experimental units (Figure 1). The rationale for this test is that a cap thickness that is effective in preventing the movement of ammonium-nitrogen and orthophosphate-phosphorus will also be effective in preventing the movement of PCBs that are strongly bound to sediment. In adddition, the behavior of soluble reduced inorganic species (e.g. arsenic) will also be similar to the tracers.

The thickness of cap material needed to isolate the contaminated sediment from the overlying water column was evaluated by following changes in dissolved oxygen (DO) depletion, ammonium-nitrogen, and orthosphosphate-phosphorus. The design and sediment-loading arrangement of an individual unit are shown in Figure 1. This experiment was conducted in triplicate in a controlled environment where the temperature was regulated at 20 + or - 0.5 degree C. A 10-cm thick layer of New Bedford Harbor contaminated sediment was placed into the bottom of the small-scale unit; to this was added the cap material and 10L of artificial seawater having a salinity of 35 parts per thousand. Cap thicknesses tested in this study were 5, 15, and 35 cm (Table 1). Uncapped New Bedford Harbor contaminated sediment and capping material alone were used as controls.

Verification Test

A verification test using the same small-scale units was performed to substantiate results obtained with tracers. by anlyzing water samples for polychlorinated biphenyl (PCBs). This test was conducted in triplicate in a controlled environment where the temperature was regulated at 20 + or - 0.5 degree C. The design and sediment-loading arrangement of an individual unit were the same as in the small-scale laboratory test. (Figure 1) Capped New Bedford Harbor sediment and capping material alone were used as controls.

RESULTS

Sediment Characterization

The New Bedford Harbor contaminated sediment was classsified as a dark gray sandy organic silt sediment, whereas the capping material was classified as a clay organic silt sediment. The contaminated sediment tested was the composite sample evaluated by the Corps of Engineers Engineering Feasibility Study. Capping material was collected from the estuary at 3 ft to 11 ft sediment depth.

The concentration of PCB aroclors and congeners (Table 2) was signigicantly higher in the contaminated New Bedford Harbor sediment than in the capping material ($p<0.05$). PCB aroclor concentrations in the capping material were below detection limits (<0.002 ug/g), with the exception of PCB 1242 and 1254. The PCB congener concentrations in the capping material were each less than 1.0 ug/g. The total PCB concentration in the capping material was 8.4 ug/g, considerably less than the total PCB concentration (2167 ug/g) in the New Bedford Harbor contaminated sediment.

PCB aroclors 1242 and 1254 and congeners dichlorobiphenyl, trichlorobiophenyl, and tetrachlorobiphenyl constitued the largest fraction of PCBs in the New Bedford Harbor sediment (Table 2). Since these constituents were much higher in the New Bedford Harbor sediment than the capping material, they were used as tracers in the verification test.

Dissolved Oxygen Deplation Rates

Dissolved oxygen depletion in the water column would normally not be a problem in an open-water disposal environment due to mixing and reaeration of the water column. Dissolved oxygen depletion, however, can be used as a tracer for determining the effectiveness of a cap in isolating an underlying contaminated dredged material having a demand exceeding that of the capping material.

The DO depletion rates of the capping material (504 + or - 44 mg/m2/day) were not significantly different ($p<0.05$) from those of the contaminated sediment (500 + or - 64 mg/m2/day). This condition precluded the use of DO depletion as a tracer in evaluating cap effectiveness.

Nutrient Release Rates

Ammonium-nitrogen release rates to the overlying water, derived by performing linear regression analysis of mass release per unit area (mg/m2) versus time, are presented as a function of cap thickness in Figure 2. Rates plotted are the means and standard deviations for three replicates. The 5 cm cap thickness reduced the ammonium-nitrogen release rates by 32 percent from those observed with uncapped New Bedford sediment. At 35 cm, ammonium-nitrogen release rates of the capped New Bedford sediment were not significantly different ($p<0.05$) from those of the capping material. This indicated that at a cap thickness of 35 cm, the contaminated New Bedford Harbor sediment was not exerting any influence on the overlying water column.

Orthophosphate-phosphorus release rates to the overlying water, derived in the same manner as for ammonium-nitrogen, are shown in Figure 3. Based on the data, a cap thickness of 35 cm resulted in a 99 percent reduction in orthophosphate-phosphorus release rate.

Verification Test

The results from the verification test substantiated results obtained in the small-scale capping test (Table 3). The results indicated that a 35 cm cap thickness, which was effective in preventing the release of ammonium-nitrogen and orthophosphate-phosphorus, was also effective in preventing the movement of organic contaminants (PCBs) into the overlying water column. PCB aroclor and congener concentrations (Table 3) in the water column above the capped sediment did not significantly differ ($p< 0.05$) from their respective concentrations in the water column overlying the capping material alone (control), indicating an effective seal.

Summary and Discussion

The results from the small-scale laboratory tests indicate that the capping material is effective in isolating contaminated New Bedford Harbor sediment from the overlying water column. Increasing the cap thickness from 5 to 35 cm prevented the release of ammonium-nitrogen and orthophosphate-phosphorus from the underlying contaminated New Bedford Harbor sediment into the water. The ability to significantly decrease the movement of these reduced inorganic chemical constituents is an indicator of cap effectiveness. A cap thickness that is effective in preventing the movement of these inorganic contaminants will also be effective in preventing the movement of organic contaminants that are strongly bound to sediment [e.g. polynuclear aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and polychlorinated biphenyls (PCBs)], as was demonstrated in this study. In addition, when soluble reduced inorganic species (e.g. arsenic) are of concern, the behavior of these materials will also be similar to the tracers (Brannon et al. 1985, 1986, Gunnison et al. 1986, and Palermo et al. 1986).

Data from the small-scale test show that a cap thickness of 35 cm was an effective seal that chemically isolated New Bedford Harbor sediment from the overlying water column.

The estimated thickness is for a chemical seal only and does not include allowances for bioturbation. The importance of bioturbation by burrowing aquatic organisms to the mobility of contaminants cannot be overstated. In addition to the disruption (breaching) of a thin cap that can result when organisms actively work the surface sediment, there is the problem of direct exposure of burrowing organisms to the underlying contaminated sediment.

The thickness needed to prevent breaching of cap integrity through bioturbation can be obtained indrectly from other sources. For example, the benthic biota of US coastal and freshwater areas have been fairly well examined, and the depth to which benthic organisms burrow is available from regional authorities on these animals. In discussions with Mr. Russ Bellmer, who is Section Chief of the Environmental Resources Branch, New England division (NED) and Dr. Cheryl A. Buttnan of woodshole Oceanographic Institution, Mya arenaria, Macoman voltica, Mercenaria mercenaris, and Squilla are the deepest burrowing organisms that are found in the New Bedford Harbor area.

The thickness required to obtain a complete chemical and biological seal (TR) is provided by the equation:

$$TR = TP + DB$$

where TP = predicted thickness (cm) to obtain a chemical seal (the thickness found in the small-scale test to effectively prevent contaminant migration from New Bedford Harbor sediment into the water column, and

DB = depth (CM) to which the deepest burrowing organism in the region can reach (depth obtained by consultation with authorities on bioturbation in the region).

The above equation and information obtained in the New Bedford Harbor capping study were used along with the deepest burrowing depth (410cm for Squilla) to calculate the maximum thickness of capping material needed that will biologically and chemically sequester contaminated New Bedford Harbor sediment from the overlying water column. That thickness is 445 cm - i.e., TR = TP (35 cm)+ DB (410 cm) or TR = 445 cm.

A cap thickness of 445 cm seriously reduces the feasibility of the CAD alternative. The population density and migratory habits for Squilla with respect to the estuary and inner harbor are being further discussed. The impact of Squilla on cap integrity may not necessarily present a substantial risk to the CAD alternative. Design thickness for other burrowers found in the inner Harbor is in the range of 95 to 135 cm.

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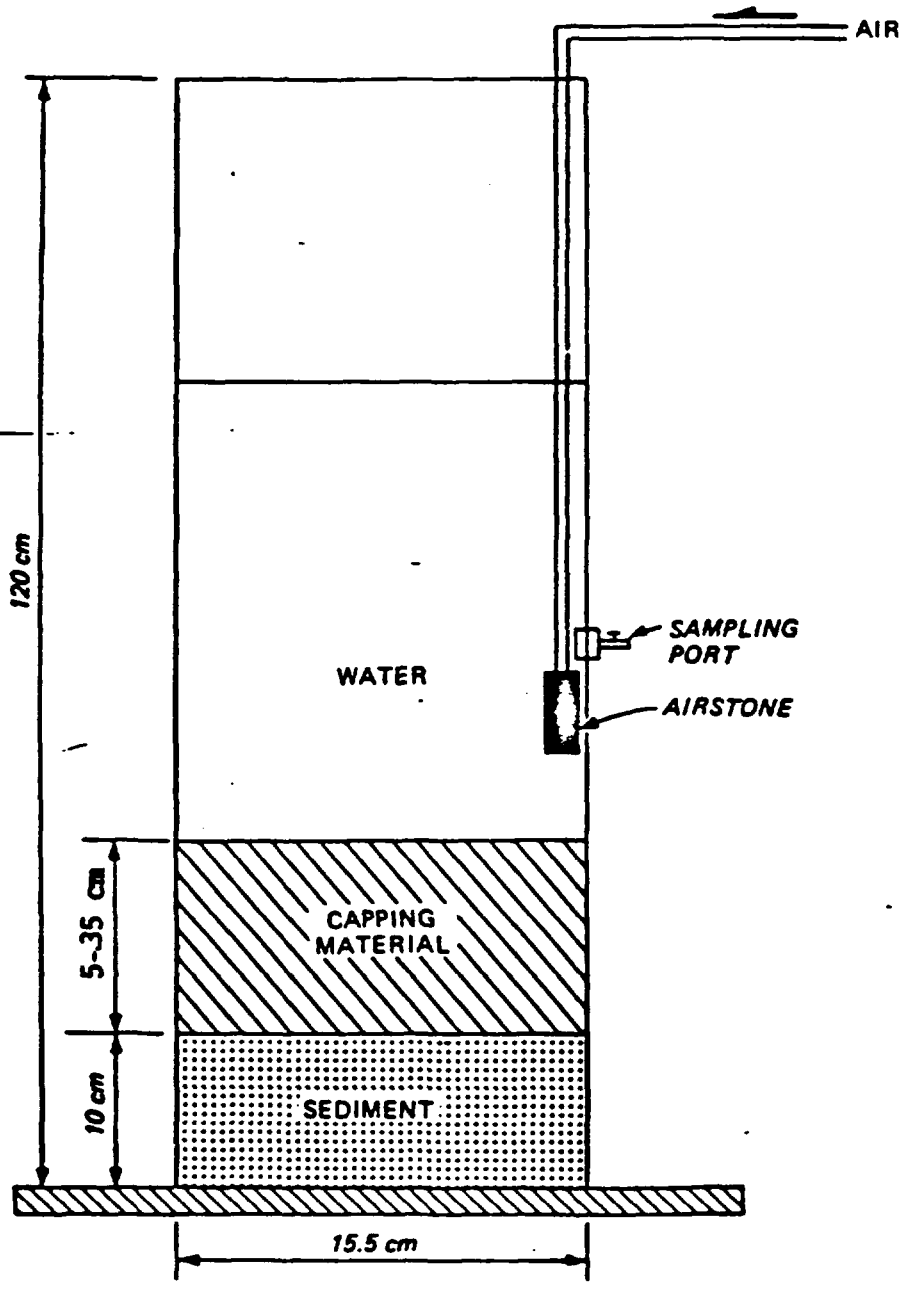


Figure 1. Small-scale experimental unit

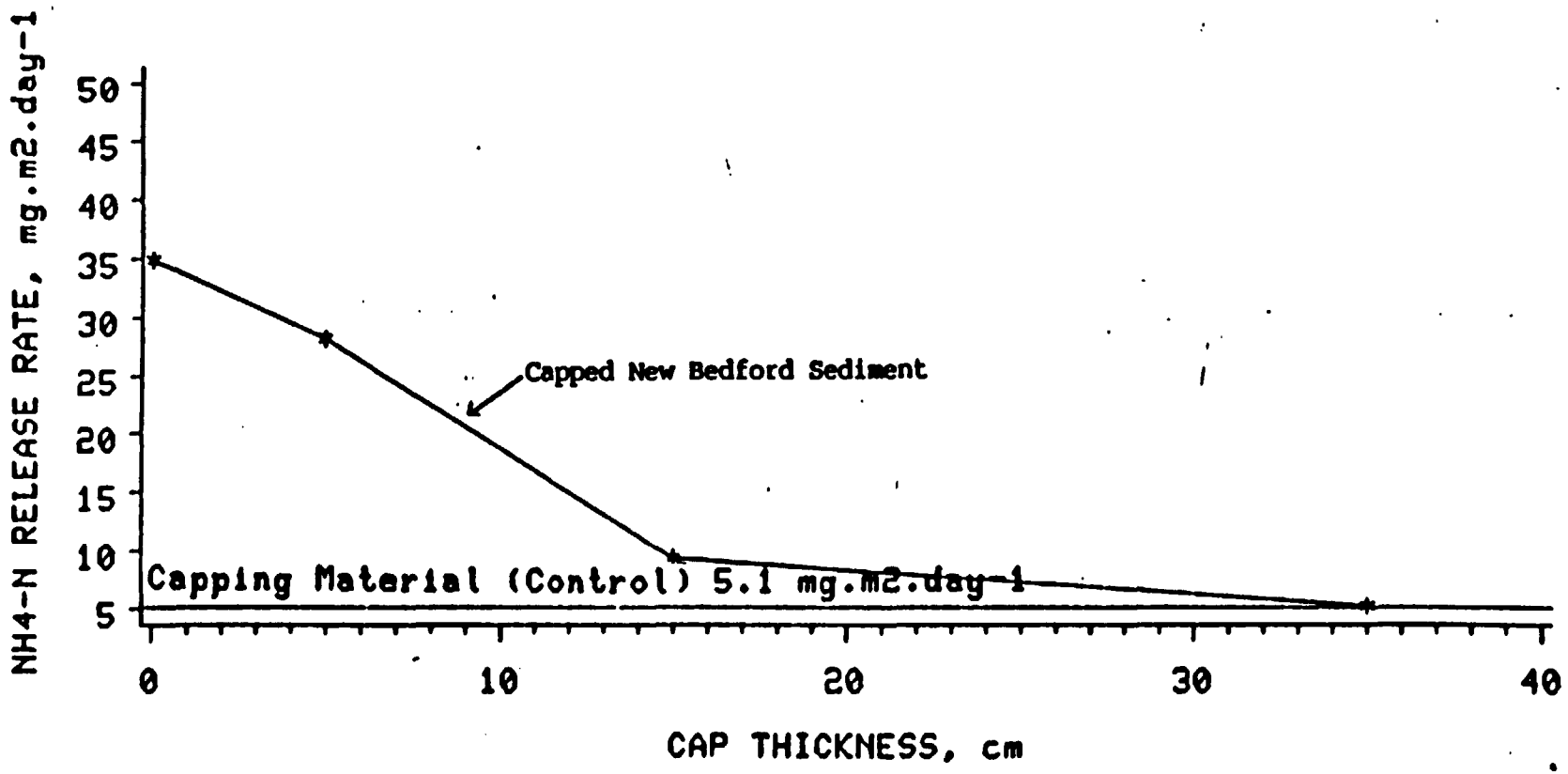


Figure 2. Effect of Cap Thickness on Ammonium-nitrogen Release Rate

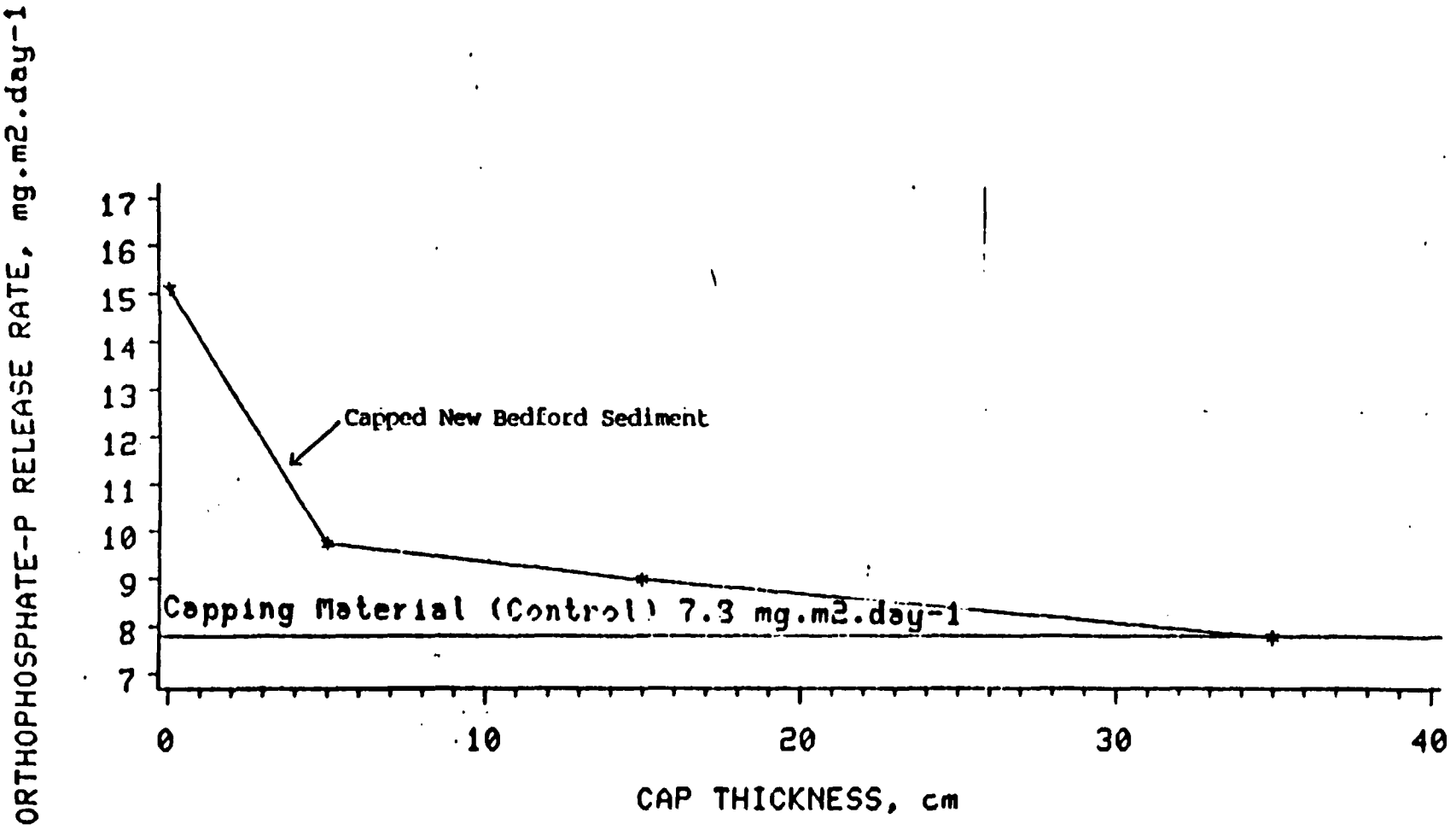


Figure 3. Effect of Cap Thickness on Orthophosphate-Phosphorus Release Rate

Table 1. Experimental Setup for New Bedford Harbor Capping Study

Sediments	Cap thickness tested, cm
Capping Material (control)	0
New Bedford Harbor sediment (control)	0
New Bedford Harbor sediment plus capping material	5, 15, 35

Table 2. Sediment PCB concentration (ug/g sediment +/- SEA)

Analysis	PCB Concentration: New Bedford (triplicate)	PCB Concentration: Capping material (single)
Aroclors		
PCB 1016	<50.0 +/- 0.00	<0.002
PCB 1221	<50.0 +/- 0.00	<0.002
PCB 1232	<50.0 +/- 0.00	<0.002
PCB 1242	807.0 +/- 106.00	5.300
PCB 1248	<50.0 +/- 0.00	<0.002
PCB 1254	662.0 +/- 107.00	3.500
PCB 1260	<50.0 +/- 0.00	<0.002
Congeners		
2,4-Dichlorobiphenyl	<1.0 +/- 0.00	0.004
2,4'-Dichlorobiphenyl	165.0 +/- 3.00	0.620
2,4,4'-Trichlorobiphenyl	153.0 +/- 5.00	0.810
2,2',3,5-Tetrachlorobiphenyl	84.0 +/- 3.00	0.280
2,2',4,5'-Tetrachlorobiphenyl	28.0 +/- 0.85	0.070
2,2',4,6-Tetrachlorobiphenyl	153.0 +/- 5.00	0.910
2,2',5,5'-Tetrachlorobiphenyl	173.0 +/- 4.50	0.510
2,3',4',5-Tetrachlorobiphenyl	59.2 +/- 3.20	0.430
3,3',4,4'-Tetrachlorobiphenyl	<1.0 +/- 0.00	0.720
2,2',3,3',4-Pentachlorobiphenyl	<1.0 +/- 0.00	0.180
2,2',3,4,5'-Pentachlorobiphenyl	<1.0 +/- 0.00	0.180
2,2',3',4,5-Pentachlorobiphenyl	27.9 +/- 1.10	0.720
2,2',4',5,5'-Pentachlorobiphenyl	71.0 +/- 4.00	0.420
2,3,3',4,4-Pentachlorobiphenyl	<1.0 +/- 0.00	0.470
2,3',4,4',5-Pentachlorobiphenyl	29.6 +/- 1.00	0.300
2,2',3,3',6,6-Hexachlorobiphenyl	17.1 +/- 0.50	0.055
2,2',3,4,4',5'-Hexachlorobiphenyl	25.0 +/- 0.40	0.250
2,2',3,4,5,6-Hexachlorobiphenyl	<1.0 +/- 0.00	0.690
2,2',4,4',5,5'-Hexachlorobiphenyl	57.0 +/- 3.00	0.730
2,2',4,4',6,6'-Hexachlorobiphenyl	<1.0 +/- 0.00	0.070
2,3',4,4',5,5'-Hexachlorobiphenyl	<1.0 +/- 0.00	0.032
2,2',3,4,4',5,5'-Heptachlorobiphenyl	7.9 +/- 1.60	0.076
2,2',3,4,5,5',6-Heptachlorobiphenyl	<1.0 +/- 0.00	0.013
Total PCBs	2167.0 +/- 57.70	8.400

ASE = Standard Error

Table 3. Results of Verification Test Showing Water Column PCB Concentration (ug/l +/- SE*) Following 30 Days of Incubation

Analysis	Capping material	NB**	NB+35***
Aroclors			
PCB 1016	<0.00020 +/- 0.0000	<0.0002 +/- 0.0000	<0.0002 +/- 0.0000
PCB 1221	<0.00020 +/- 0.0000	<0.0002 +/- 0.0000	<0.0002 +/- 0.0000
PCB 1232	<0.00020 +/- 0.0000	<0.0002 +/- 0.0000	<0.0002 +/- 0.0000
PCB 1242	<0.00020 +/- 0.0000	0.0040 +/- 0.0015	0.0003 +/- 0.0002
PCB 1248	<0.00020 +/- 0.0000	<0.0002 +/- 0.0000	<0.0002 +/- 0.0000
PCB 1254	0.00017 +/- 0.0003	0.0016 +/- 0.0004	0.0002 +/- 0.0001
PCB 1260	<0.00020 +/- 0.0000	<0.0002 +/- 0.0000	<0.0002 +/- 0.0000
Congeners			
2,4-Dichlorobiphenyl	<0.00001 +/- 0.00	<0.000010 +/- 0.00000	<0.000010 +/- 0.00000
2,4'-Dichlorobiphenyl	<0.00001 +/- 0.00	0.000200 +/- 0.00003	0.000100 +/- 0.00006
2,4,4'-Trichlorobiphenyl	<0.00001 +/- 0.00	0.001000 +/- 0.00003	<0.00001 +/- 0.00000
2,2',3,5-Tetrachlorobiphenyl	<0.00001 +/- 0.00	0.000200 +/- 0.00006	<0.00001 +/- 0.00000
2,2',4,5'-Tetrachlorobiphenyl	<0.00001 +/- 0.00	0.000090 +/- 0.00003	<0.00001 +/- 0.00000
2,2',4,6-Tetrachlorobiphenyl	<0.00001 +/- 0.00	0.001000 +/- 0.00030	<0.00001 +/- 0.00000
2,2',5,5'-Tetrachlorobiphenyl	<0.00001 +/- 0.00	0.000500 +/- 0.00010	<0.00001 +/- 0.00000
2,3',4',5-Tetrachlorobiphenyl	<0.00001 +/- 0.00	0.000100 +/- 0.00002	<0.00001 +/- 0.00000
3,3',4,4'-Tetrachlorobiphenyl	<0.00001 +/- 0.00	0.000200 +/- 0.00005	<0.00001 +/- 0.00000
2,2',3,3',4-Pentachlorobiphenyl	<0.00001 +/- 0.00	0.000020 +/- 0.00001	<0.00001 +/- 0.00000
2,2',3,4,5'-Pentachlorobiphenyl	<0.00001 +/- 0.00	0.000040 +/- 0.00000	<0.00001 +/- 0.00000
2,2',3',4,5-Pentachlorobiphenyl	<0.00001 +/- 0.00	0.000050 +/- 0.00002	<0.00001 +/- 0.00000
2,2',4',5,5'-Pentachlorobiphenyl	<0.00001 +/- 0.00	0.000100 +/- 0.00002	<0.00001 +/- 0.00000
2,3,3',4,4-Pentachlorobiphenyl	<0.00001 +/- 0.00	0.000070 +/- 0.00004	<0.00001 +/- 0.00000
2,3',4,4',5-Pentachlorobiphenyl	<0.00001 +/- 0.00	0.000070 +/- 0.00001	<0.00001 +/- 0.00000
2,2',3,3',6,6-Hexachlorobiphenyl	<0.00001 +/- 0.00	0.000040 +/- 0.00002	<0.00001 +/- 0.00000
2,2',3,4,4',5'-Hexachlorobiphenyl	<0.00001 +/- 0.00	0.000040 +/- 0.00001	<0.00001 +/- 0.00000
2,2',3,4,5,6-Hexachlorobiphenyl	<0.00001 +/- 0.00	0.000040 +/- 0.00002	<0.00001 +/- 0.00000
2,2',4,4',5,5'-Hexachlorobiphenyl	<0.00001 +/- 0.00	0.000090 +/- 0.00005	<0.00001 +/- 0.00000
2,2',4,4',6,6'-Hexachlorobiphenyl	<0.00001 +/- 0.00	0.000010 +/- 0.00003	<0.00001 +/- 0.00000
2,3',4,4',5,5' Hexachlorobiphenyl	<0.00001 +/- 0.00	<0.00001 +/- 0.00000	<0.00001 +/- 0.00000
2,2',3,4,4',5,5' Heptachlorobiphenyl	<0.00001 +/- 0.00	<0.00001 +/- 0.00000	<0.00001 +/- 0.00000
2,2',3,4,5,5',6-Heptachlorobiphenyl	<0.00001 +/- 0.00	<0.00001 +/- 0.00000	<0.00001 +/- 0.00000
Total PCBs	<0.00001 +/- 0.00	0.005000 +/- 0.00008	<0.00001 +/- 0.00000

*SE = Standard Error
**NB = New Bedford Harbor Sediment only
*** NB+35 = New Bedford Harbor Sediment + 35 cm capping material

APPENDIX 5 SEDIMENT TESTING RESULTS

Chemical Testing

Sediments from 20 push cores representing 19 locations within the pilot study area were analyzed for PCBs. The results are shown on Table 1.

Sediments from 2 push cores (locations 5 and 7) were analyzed for metals. The results are shown on Table 3.

This testing was performed at the New England Division's Water Quality Laboratory.

Elutriate Testing

Grab samples (top six inches of material) were taken from 7 locations (locations 1, 2, 3, 4, 6, 8 and 11). These samples were composited and a standard and modified elutriate test was run on the composited sample. The results are shown on Table 2. This testing was carried out at the Waterways Experiment Station.

Physical Testing

Each core sample was analyzed to determine the grain size distribution. Material in the 0 - 24 inch falls between the following ranges:

0 - 14% Gravel
8.9 - 79% Sand
6.6 - 78.2% Silt
0.4 - 12.9% Clay

This data is summarized on figure 2.

Material in the 24 - 48 inch sediment depth falls between the following ranges:

0 - 5.5% Gravel
12.8 - 83.9% Sand
9.7 - 68.8% Silt
0.9 - 18.5% Clay

This data is summarized on figure 3.

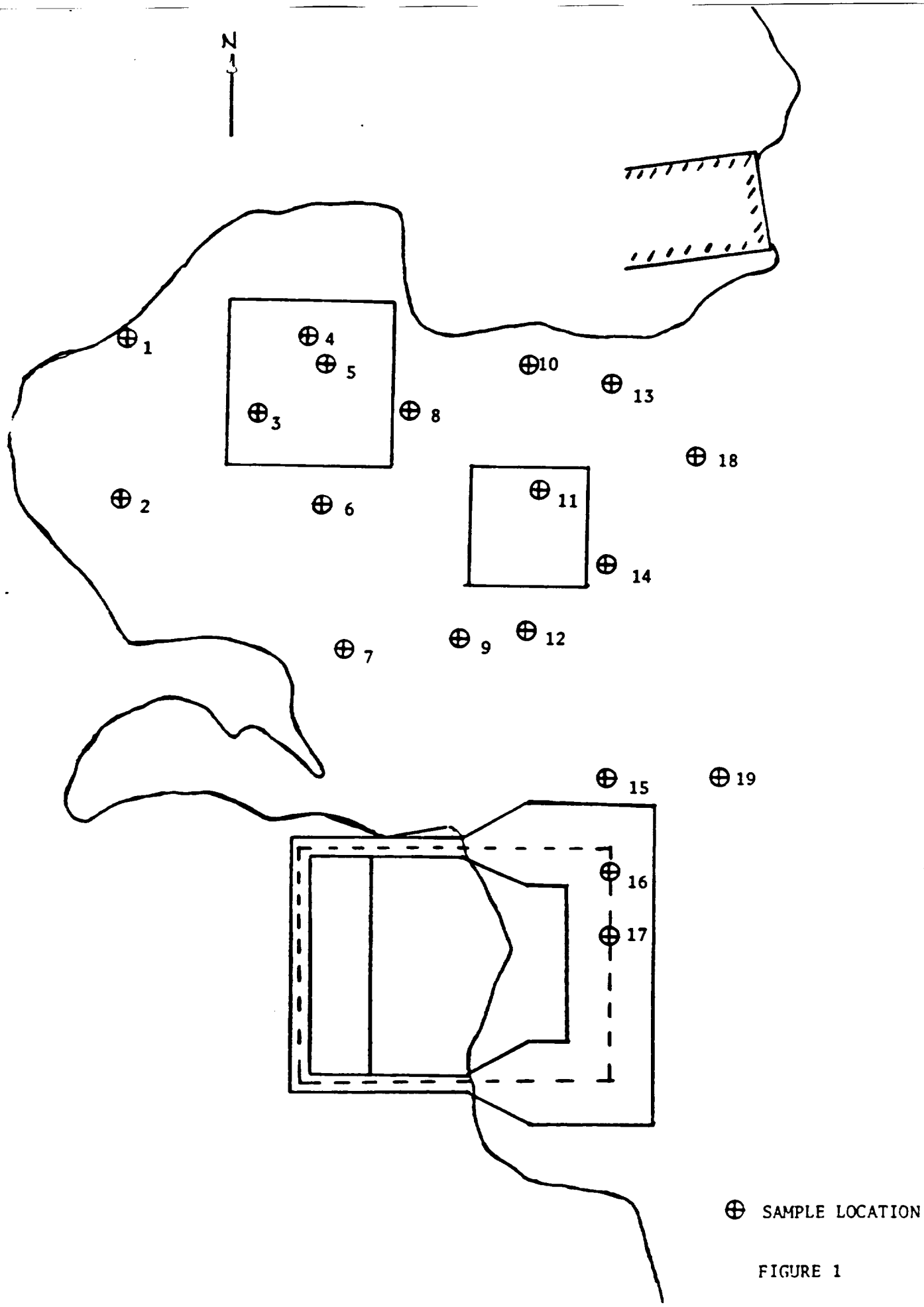


FIGURE 1

TABLE 1

PCB LEVELS PILOT STUDY COVE

Sample Location	Horizon	Total PCBs (PPM)
1	0-12"	1.70
	12-24"	-1.00
2	0-12"	28.00
	12-24"	105.00
3	0-12"	67.00
	12-24"	3.20
4	0-12"	220.00
	12-24"	2.70
5	0-12"	90.70
	12-24"	2.08
	24-30"	0.21
6	0-12"	24.00
	12-24"	2.20
7	0-24"	26.70
	24-33"	1.10
8	0-12"	15.00
	12-24"	-1.00
9	0-12"	82.80
	12-24"	-2.00
10	0-12"	9.90
	12-24"	1.10
11	0-12"	89.00
	12-24"	-1.00
12	0-12"	57.50
	12-24"	-2.00
13	0-12"	67.00
	12-24"	1.20
14	0-12"	3.10
	12-24"	2.80
15	0-12"	110.00
	12-24"	-2.00
16	0-12"	53.10
	12-24"	-2.00
17	0-12" A	2.10
	12-24" A	-2.00
	0-12" B	53.50
	12-24" B	-2.00
18	0-12"	75.00
	12-24"	29.00
19	0-12"	125.00
	12-24"	4.70

NOTE: Negative values are detection limits and indicate that substance was not detected.

Table 2

Elutriate Test Results for Pilot Project Sediment

Elutriate Procedure	Elutriate Phase	SS ppm	PCB 1242 ppb	PCB 1254 ppb	Total PCB ppb	Cd ppb	Cr ppb	Cu ppb	Pb ppb	Ni ppb	Zn ppb
Standard	Whole	490	280	300	580	48	963	1,100	387	134	1,140
	Centrifuged	77	110	25	135						
	Filtered		3	2	5	46	11	29	33	322*	1,570*
Modified	Whole	170	160	170	330	42	423	456	177	115	715
	Centrifuged	84	72	66	138						
	Filtered		7	6	13	61	18	72	30	287*	1,890*

Calculated Contaminant Concentrations on Suspended Sediment in the Whole Elutriates

Elutriate Procedure	PCB 1242 mg/kg	PCB 1254 mg/kg	Total PCB mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Pb mg/kg	Ni mg/kg	Zn mg/kg
Standard	565	608	1,173	3	1,943	2,186	722	273	2,327
Modified	900	965	1,865	245	2,382	2,259	865	676	4,206

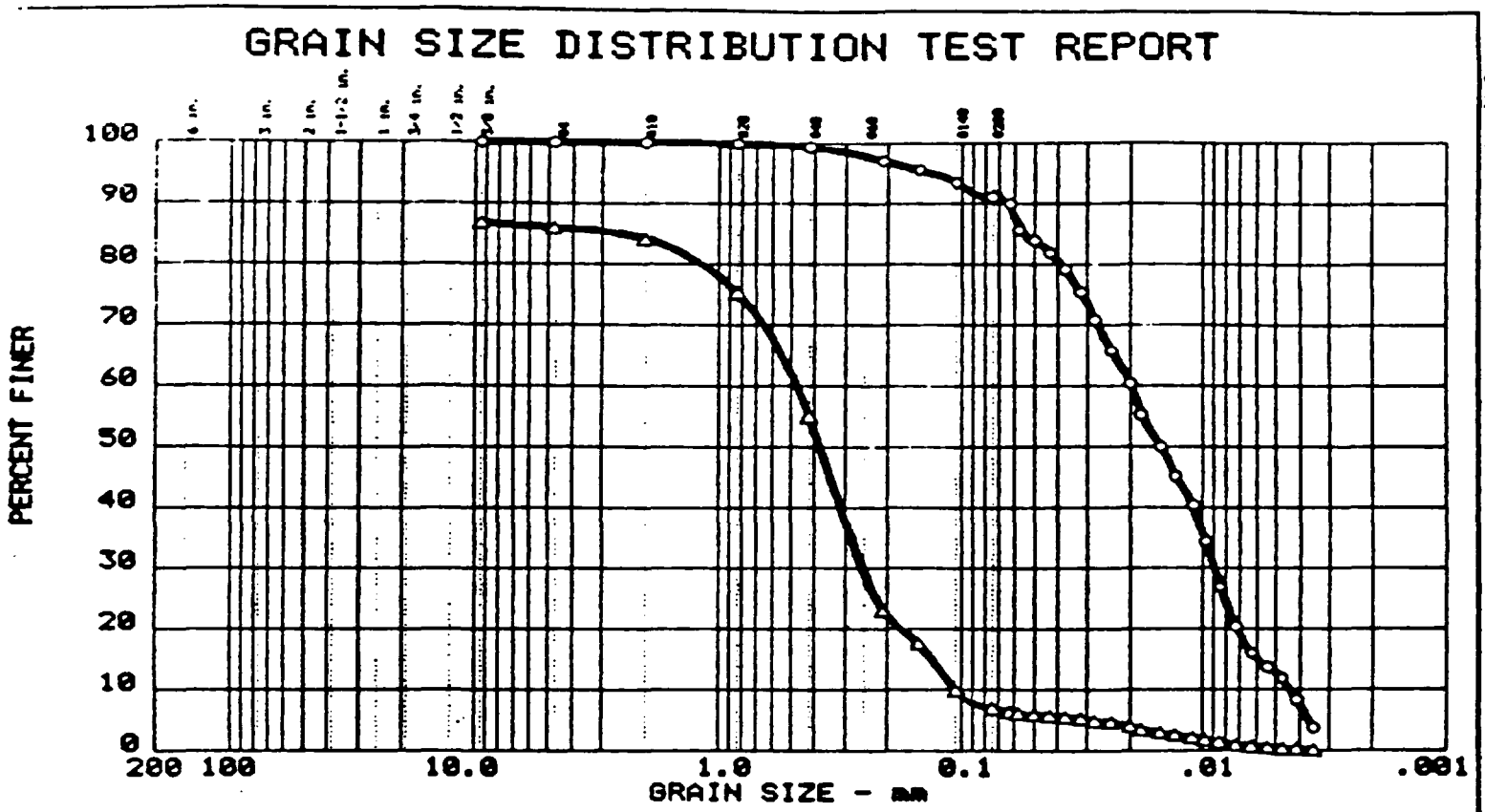
* Filtered for these parameters were greater than whole water samples, suggesting contamination of the filtered sample. Calculations of suspended solids contaminant concentrations assume that all contaminant measured in the whole sample was associated with the solids. Filtered values are used for dissolved concentration estimates.

TABLE 3

Levels of Oil & Grease and Metals Sample Locations 5 & 7

Sample	Depth	Oil & Grease (ppm)	Arsenic (ppm)	Cadmium (ppm)	Chromium (ppm)	Copper (ppm)	Lead (ppm)	Mercury (ppm)	Nickel (ppm)	Zinc (ppm)
5	0-12"	10,100	2.4	16	325	897	434	1.1	57	1120
	12-24"	329	1.8	7	115	748	539	<0.1	44	1760
	24-30"	50	1.4	<2	<7	<6	<20	<0.1	<24	12
7	0-24"	3,910	3.8	12	209	392	183	0.7	30	455
	24-33"	590	1.8	<2	16	36	27	0.4	<24	50

0 - 24 inch sediment depth

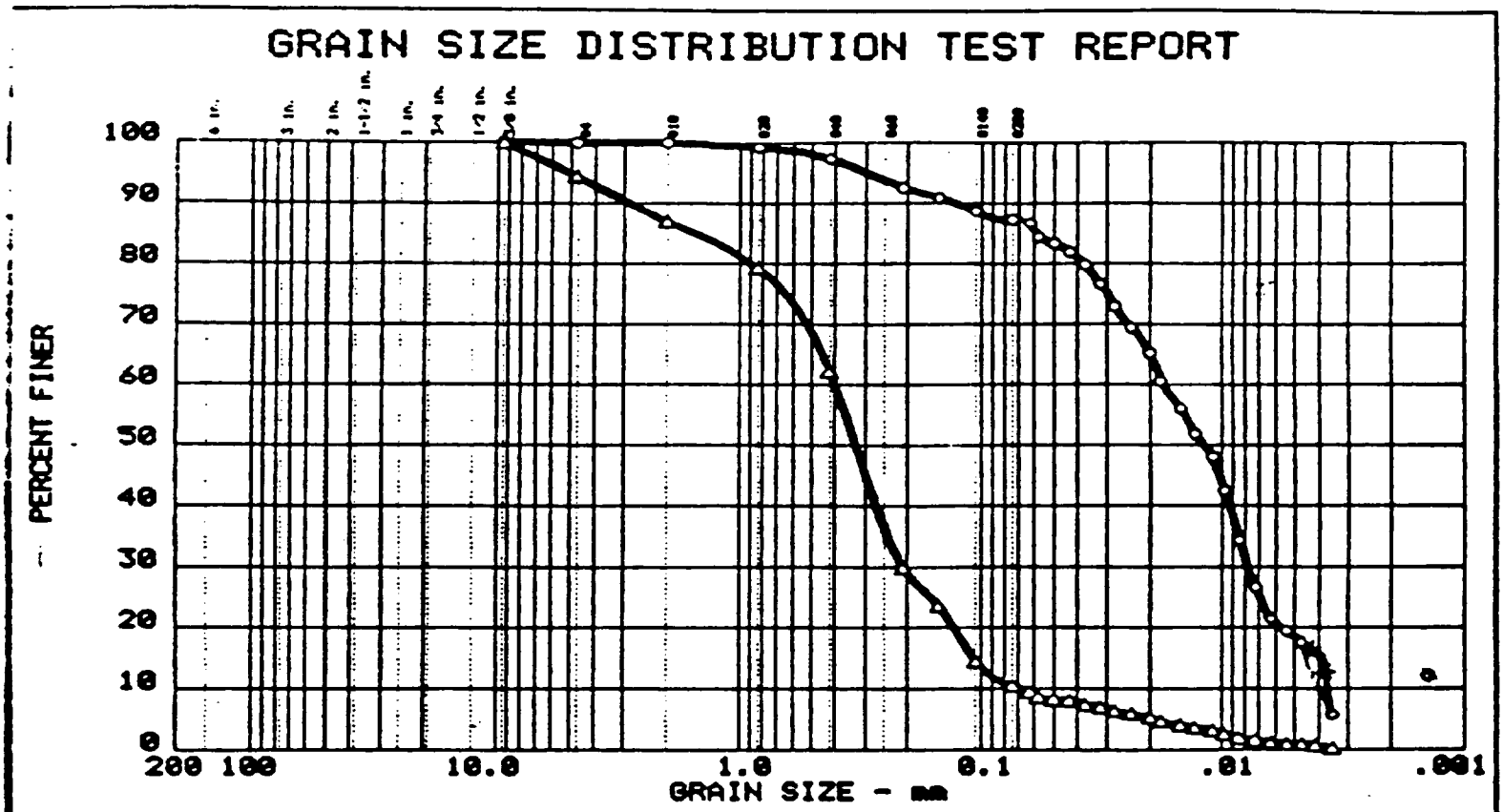


	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
O	9	0.0	-0.0	8.9	78.2	12.9
Δ	10	0.0	14.0	79.0	6.6	0.4

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
O			0.03	0.02	0.01	0.009	0.0081	0.0043	0.95	4.6
Δ			0.82	0.47	0.38	0.255	0.2241	0.1048	1.31	4.5

FIGURE 2

24 - 48 inch sediment depth



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	11	0.0	-0.1	12.8	68.8	18.5
△	12	0.0	5.5	83.9	9.7	0.9

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.03	0.02	0.01	0.008	0.0070			
△			0.64	0.40	0.33	0.209	0.1589	0.0647	1.69	6.2

FIGURE 3

Appendix 6

CONTROL DEVICES

Diffuser

A control technology to reduce the impacts associated with the disposal of dredged material in open water during hydraulic pipeline dredging involves the use of a submerged diffuser. The purpose of this device is to reduce the velocity of the dredged slurry as it reaches the deposition location (CAD cell) and to segregate it from the water during the process of diffusion. The lower discharge velocity reduces turbulence at the deposition area and minimizes the mixing of the dredged slurry and the water column.

The dredged material slurry is turned downward through a 90 degree elbow and approaches the diffuser from above. The cross sectional flow increases gradually through the vertical section of the diffuser. The 15 degree expansion angle is the largest angle the flow can negotiate before separation sets in and causes the flow to jet. The flow is then turned from vertical to horizontal within the diffuser and discharges parallel with the bottom of the deposition area (CAD cell). The dredged slurry does not come in contact with the water column until it is discharged at the bottom of the deposition area.

A schematic view of the diffuser processor design is shown on Figure 1. A scaled drawing of the diffuser that would be used at New Bedford is shown in Figure 2.

A support barge is used in conjunction with the diffuser. A small crane is mounted on this barge which positions and adjusts the depth of the diffuser.

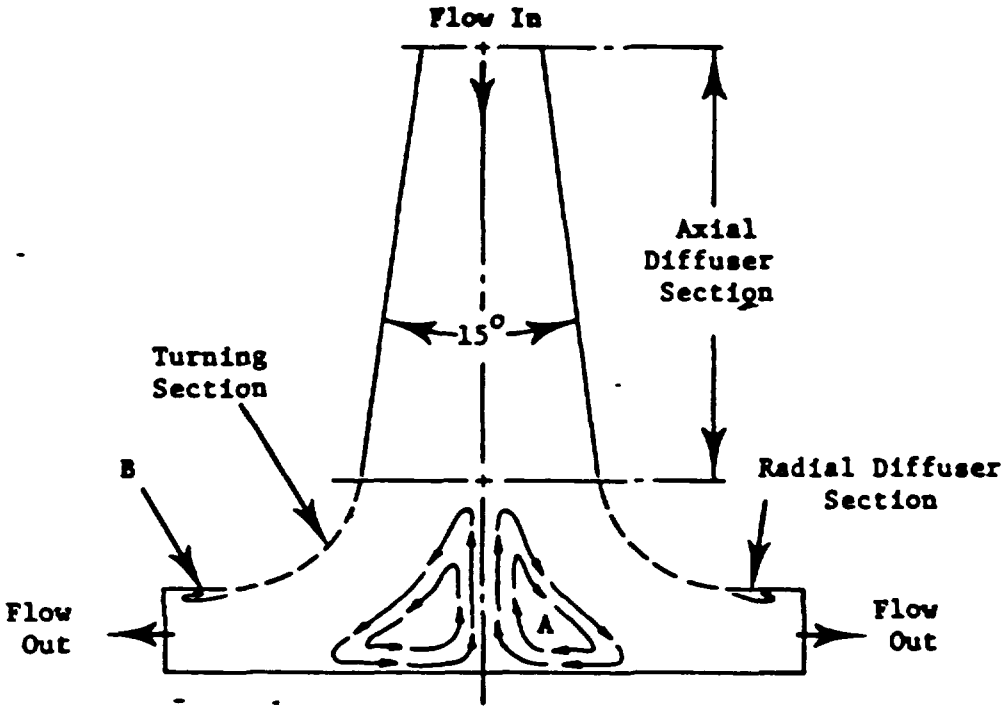
Silt Curtains

A silt curtain or turbidity barrier is a flexible, impervious barrier that hangs down vertically from the water surface. The silt curtain consists of four major elements: a skirt that forms the barrier, flotation material at the top, ballast weight at the bottom, and a tension cable. (see figure 3) The floatation and ballast keep the curtain in a verticle position while the tension cable absorbs stress imposed by currents and other hydrodynamic forces. The fabric material is commonly nylon-reinforced polyvinyl chloride (pvc). The curtains are manufactured in 100-foot long sections that are joined together for the overall curtain length. The curtain may be attached to shore or held stationary with large anchors attached to mooring floats on the ends and smaller anchors at regular intervals along the length of the curtain.

The primary purpose of the silt curtain is to reduce turbidity in the water column outside the curtain, not to retain the fluid mud or bulk of the suspended solids. The presence of a silt curtain results in a change of flow patterns in the vicinity of the curtain so that exiting flows are redirected. Under quiescent conditions (currents less than 0.5 knots (0.85ft/sec) with no strong tidal action), turbidity levels outside a properly deployed and maintained silt curtain can be reduced by 80 to 90

percent of the levels inside. The curtain used for the pilot study would have the skirt anchored to the bottom. Floatation material at the top would allow for adjustments necessitated by the rise and fall of the tide. Windows (cut out sections) in the skirt would be provided near the surface to allow for the flow of water

An oil boom would be used in conjunction with the silt curtain to contain the thin layer of floating oil or contaminant that is found on the water surface.

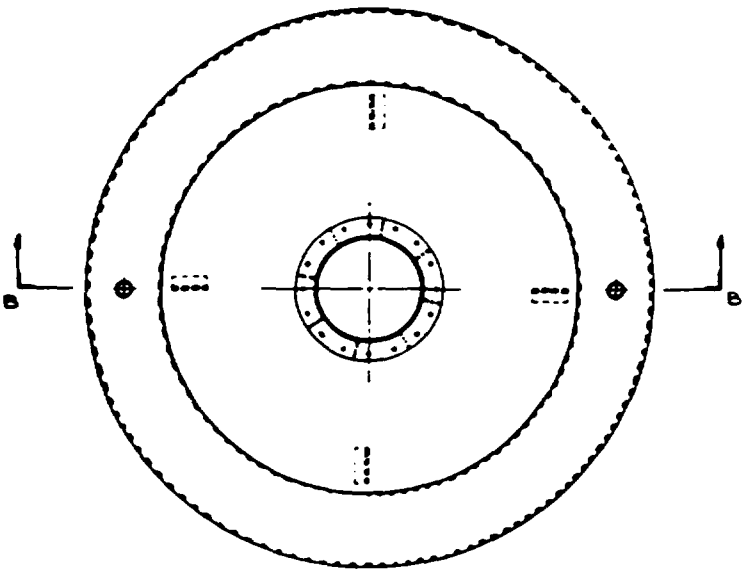


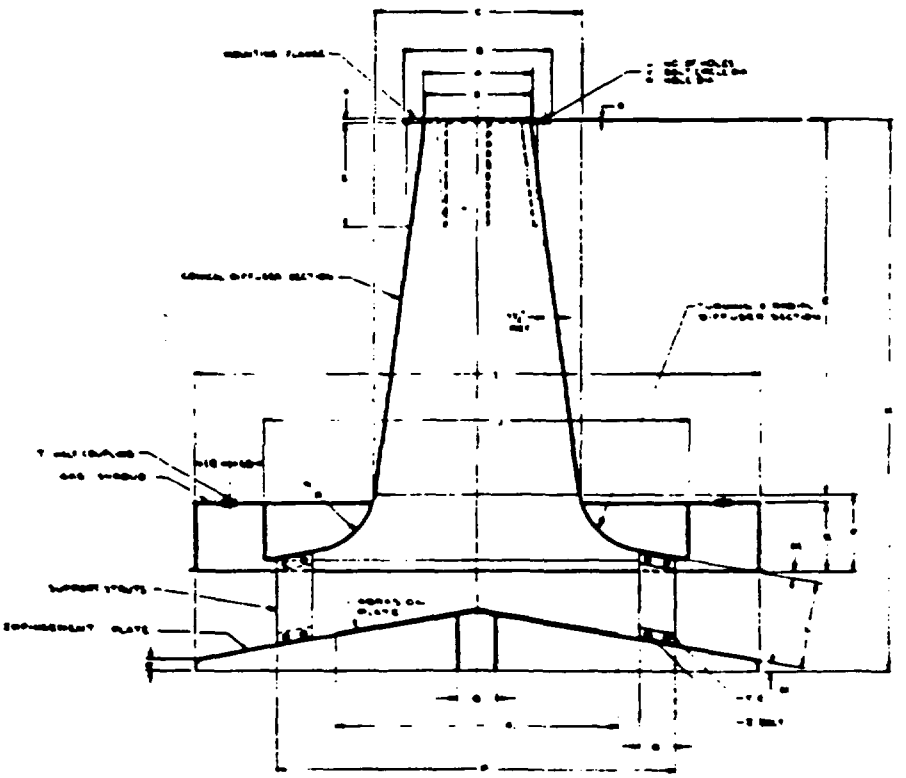
DIFFUSER
SCHEMATIC VIEW

FIGURE 1

DIMENSION

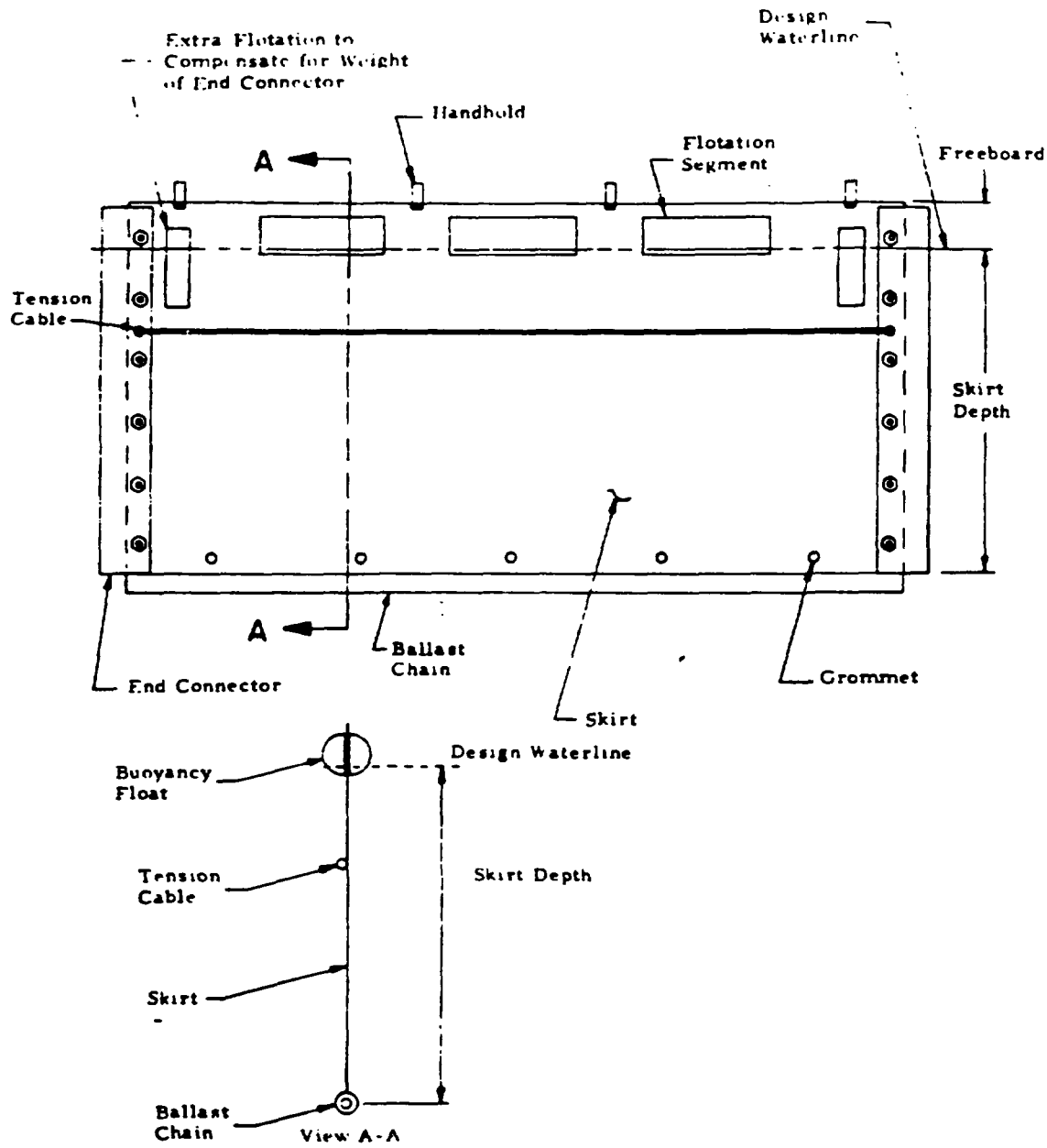
A	8 5/16"
B	15"
C	73/4"
D	8 3/16"
E	20 15/16"
F	6 1/5"
G	7/32"
H	42 31/32"
I	42 3/4"
J	32 1/32"
K	5 5/16"
L	4" - 8"
M	10
N	15/16"
O	2 11/16"
P	30 1/4"
Q	3"
R	5 5/16"
S	8"
	1 NPT
	9
	12 3/4"
	3/4"
X	5/8"
Y	1 1/2 x 1 1/2 x 1/4
Z	16 @ 3/8"
A1	21 3/8"





DIFFUSER

FIGURE 2



TYPICAL SILT CURTAIN SECTION

FIGURE 3

APPENDIX 7

TECHNICAL ISSUES (Engineering Feasibility Study (EFS) vs. Pilot Study)

Listed below are specific questions that must be answered in evaluating proposed dredging and disposal alternatives. For each question the information to be provided by the EFS and the additional or improved information that can be provided by the Pilot Study are discussed.

a. What is the rate of sediment resuspension caused by the dredging operation?

EFS: Rate of sediment resuspension will be extracted from available literature. Most of this data is for maintenance dredging projects where water depths are usually considerably deeper than those that exist in the upper estuary. The studies that are available are generally measured concentrations of suspended sediment rather than rates of generation. Because the data depends on the type of material, the type of dredge, how the dredge is operated, water depth, and hydraulic conditions, there is high variance in the available data. Without site specific data a very conservative value, i.e., a high rate of sediment resuspension will be used.

Pilot Study: Field data will be collected to measure the rate of sediment resuspension caused by the dredging operation for the material characteristics specific to this site, for the site conditions, and for the types of equipment likely to be used for a full scale dredging operation. Resuspension rates can then be related to dredge production rates and other operating parameters for the dredge. The pilot study also affords the opportunity to compare results for the different types of dredging equipment and to evaluate resuspension caused by other components of the dredging and disposal operation, such as movement of equipment and construction of in - water dikes.

b. What is the rate of contaminant release, in particular PCB release, associated with the dredging operation?

EFS: A series of laboratory tests are being performed to determine the concentrations of contaminants potentially released due to sediment resuspension during dredging. Standard elutriate testing has been performed on a composite sediment sample from the upper estuary in order to estimate PCB concentrations associated with the particulate and dissolved fractions. Fractionation of the composite sample into 3 ranges of particle sizes and analysis of each fraction for PCB's is also being done in order to distribute contaminants among the particles being tracked using sediment migration techniques and modeling. These laboratory procedures are straightforward. Limited field data was collected to support correlation between the laboratory and the field release associated with sediment resuspended by a sampling operation and for contaminant transport during existing conditions. However, because of the limited data available, conclusions made using these field data should be considered unverified.

Pilot Study: The pilot study will allow direct measurement of contaminant release for soluble and particle-associated fractions during dredging and allow comparison of field data to predictions based on laboratory data. Data relating contaminant concentration to particle sizes resuspended by the dredge will be particularly helpful in assessing the rate of contaminant release during dredging and the transport of these particles away from the dredge and out of the Upper Estuary.

c. What dredging controls are needed to minimize the rate of sediment resuspension at the dredge and what measures should be employed to contain the suspended sediment plume near its point of generation?

EFS: Information from the literature will address the effectiveness of various operational controls and suspended sediment containment techniques. Dredging conditions at this site are unique and may be outside the range of conditions covered in the literature.

Pilot Study: The pilot study will allow testing of operational controls and techniques available for the type of equipment suited to this site and on the type of material and site conditions unique to this site. The need for and effectiveness of containment techniques can also be evaluated during the pilot study. If the pilot shows that dredging can be conducted without major physical controls, the prototype operation need not incur this expense. The pilot study will further define the costs and constraints, such as minimum water depth, operational controls and major physical barriers.

d. What is the contaminant flux in and out of the Upper Estuary during dredging for various tidal conditions?

EFS: A 2-Dimensional sediment-associated contaminant transport model has been developed. The hydrodynamic model was developed for the Upper Estuary based on field hydraulic data collected during three different tidal conditions. An analytical plume model is applied and results for various currents and settling velocities are superimposed. Dispersal of resuspended sediment is predicted by a multiple component numerical transport model. Results from the hydrodynamic model, data from laboratory flume studies to evaluate sediment resuspension and deposition, and estimates of contaminants in the various fractions (soluable and particle-associated by particle size ranges) furnish input to the sediment transport model for several dredging scenarios. The transport model assumes that no adsorption or desorption occurs and tracks contaminants as it tracks suspended sediment movement.

Pilot Study: Monitoring of sediment and contaminant fluxes near the dredge, and at the Coggeshall Street Bridge will reverify the models and develop additional confidence in the results of the contaminant transport model for the case of increased suspended sediment concentrations during dredging. Migration of contaminants released from the confined disposal facility (CDF) and from placing material in the confined aquatic disposal (CAD) cell can also be addressed by collecting data on the rate of contaminants released during these operations and feeding those data into the contaminant transport model.

e. What is the efficiency of contaminant removal by dredging?

EFS: Operational characteristics for various dredges will be reviewed. The cutting precision and amount of residual sediment after one or more passes and between adjacent cutting paths will be addressed, primarily based on manufacturer's literature.

Pilot Study: The level of control for the dredge cut can be evaluated for the site specific conditions and the types of equipment evaluated. Sediment sampling at various phases of the dredging project will measure the quantity of contaminants remaining. Minimizing the depth of cut and/or the number of dredging passes offers considerable cost savings not only by reducing dredging time, but also by reducing the volume of dredged material that must be disposed.

f. What is the effluent quality of the overflow from the CDF?

EFS: Effluent from the CDF is characterized by the modified elutriate test, which is one of the testing protocols included in the Management Strategy. This test defines the dissolved and particle-associated concentration of contaminants in the effluent and accounts for the settling behavior of the dredged material, retention time in the CDF, and chemical environment in ponded water during active disposal. This test has been field verified for at least three dredging projects, but these were not superfund projects, and contaminant concentrations were not as high as this site.

Pilot Study: Verification of the modified elutriate test in the field study is not a primary objective of the pilot study. Its predictions are likely in the same order of magnitude as what will be encountered in the field, and adjustments in treatment measures for the prototype operation could be designed for without too much redundancy. However, for the proposed pilot study concept, a CDF will be necessary to store at least the initial excavation of contaminated sediment. Field data on CDF effluent quality will be required to address substantive requirements of Section 401 water quality certification and to insure environmental protection. Data to verify predictions of the modified elutriate test for this site will be obtained during the effluent monitoring.

g. What will be the surface runoff quality from a CDF filled with contaminated sediment from this site?

EFS: A laboratory surface runoff test is being conducted using a rainfall simulator-lysimeter system. Sediment from the lower end of the Upper Estuary (near the Coggeshall Steet Bridge) with a PCB concentration on the order of 40 ppm is being tested by applying rainfall to the wet sediment and later to a dewatered sediment. Contaminant concentrations in the rainfall runoff are then analyzed.

Pilot Study: The CDF site will be capped by a cleaner sediment than that used in the laboratory surface runoff test. The need for evaluation of the rainfall runoff from the CDF can be better addressed when results from the laboratory test are available. Surface runoff from the CDF will have the same control requirements (water quality and environmental protection) as CDF effluent produced by the dredging operation and will require monitoring and possible containment or treatment prior to release.

h. What is the leachate quality from the CDF?

EFS: Batch leaching tests and divided flow permeameter tests are being conducted on anaerobic and aerobic sediment from New Bedford. Data from these tests will be synthesized to provide an assessment of contaminant mobility in dredged material. A one-dimensional, convective-dispersive mass transfer equation with a source term for contaminant leaching will be used to model leachate quality in the disposal site and to estimate contaminant flux at the dredged material/site bottom interface.

Pilot Study: An array of monitoring wells will be installed to detect contaminant movement through the dikes and bottom of the CDF. However, the time period required to detect this movement will exceed the target for getting results of the Pilot Study. Leachate monitoring is included as an environmental protection measure for long term observation of the CDF. Undisturbed cores of dredged material will be collected after the CDF undergoes initial drying (1 to 6 months). These cores will be collected for the entire depth of dredged material in the CDF. They will be divided into strata if the sediment is dry enough and cohesive enough for this purpose. The dredged material samples will be centrifuged to separate pore water from the solids, and the water fraction and the solid fraction will be analyzed for contaminants. These analyses will directly indicate leachate quality in the CDF and may be compared to batch and permeameter leaching test data to support application of the laboratory tests to field conditions. Coupled with monitoring well data, this approach may also indicate attenuation of contaminants by the dike and foundation of the CDF.

i. What is the feasibility of the Confined Aquatic Disposal (CAD) alternative?

EFS: Laboratory studies are being conducted to determine the appropriate cap thickness required to isolate the contaminated dredged material. An engineering evaluation of the design requirements for a series of CAD cells for the entire project will be conducted. This evaluation is based on experience with capping contaminated sediment in the U.S. and on limited Dutch experience in actually excavating underwater cells for disposal of contaminated sediment.

Pilot Study: Chemical migration through the cap can be evaluated under field conditions after the CAD cells are completed. However, the real benefit of the pilot study for CAD evaluation is derived from the field experience gained in implementing the construction sequence for removing contaminated material, deepening the cell by removing additional clean material, filling the bottom of the cell with contaminated material, and capping the contaminated dredged material with clean material. Questions regarding contaminant release during placement of contaminated material, consolidation/bulking of material in the CAD cell, feasibility of using a submerged diffuser to fill the cell, and stability of the cell after closure can only be answered by a field study.

j. What are the design parameters for the CDF?

EFS: Laboratory settling column tests provide design information for