

# **THE BOSTON HARBOR NAVIGATION IMPROVEMENT PROJECT: DREDGING TODAY FOR A DEEPER TOMORROW**

Susan Nilson<sup>1</sup>, Deborah Hadden<sup>2</sup>, and Paul Giard, Jr.<sup>3</sup>

## **ABSTRACT**

The Boston Harbor Navigation Improvement Project (BHNIP), a joint project between the U.S. Army Corps of Engineers and the Massachusetts Port Authority, will deepen key portions of Boston's Inner Harbor, its tributary channels, and berth areas. A total of approximately 3 million cubic yards of material will be dredged. With the completion of this project, Boston's channels will be deeper than neighboring ports, greatly enhancing its competitive position and providing a significant economic benefit to the New England region.

Dredging projects in many other ports have been derailed due to environmental concerns over the disposal of harbor sediments. In Boston, however, there has been close cooperation between environmental advocates, dredging proponents, and regulatory agencies. After many years of effort, an innovative and environmentally sound solution for disposal of contaminated dredge material has been achieved through the use of in-harbor containment cells.

Phase 1 of the BHNIP was completed in July of 1997. Phase 1 dredging represented less than 5% of the total dredging volume, but it included the construction of one in-harbor disposal cell, dredging of contaminated sediments, disposal of these sediments into the cell, dredging and offshore disposal of clean sediments, and cell capping. Environmental monitoring was conducted by CLE Engineering, Inc. in compliance with the Water Quality Certification issued by the Department of Environmental Protection. The monitoring requirements were detailed and extensive but feasible. In-situ measurements of turbidity were performed and water samples were collected for physical and chemical analyses.

Data collected during dredging and disposal operations demonstrated environmental compliance. In fact, the turbidity plume during disposal was locally confined and dissipated quickly. The overall impact on the water column was far less than predicted through modeling efforts. Based on Phase 1 results, recommendations have been implemented for Phase 2, which is anticipated to begin in the spring of 1998.

**Keywords:** Cell disposal, water quality monitoring, turbidity, silt, contaminated sediments

---

<sup>1</sup>S. Nilson, Project Manager, CLE Engineering, Inc., 15 Creek Road, Marion, MA 02738, (508) 748-0937, (508) 748-1363 Fax, CLEGRP@aol.com

<sup>2</sup> D. Hadden, Manager of Maritime Environmental Affairs, Massachusetts Port Authority, Fish Pier East II, Northern Avenue, Boston, MA 02210, (617) 946-4426, (617) 946-4422, dhadden@massport.com

<sup>3</sup> P. Giard, Jr., Project Manager, CLE Engineering, Inc., 15 Creek Road, Marion, MA 02738, (508) 748-0937, (508) 748-1363 Fax, CLEGRP@aol.com

## INTRODUCTION

### **Overview of the Port of Boston**

Established as a fishing and shipbuilding center in the early 1600's, Boston Harbor has been one of America's more active seaports for nearly 400 years. Innovations in cargo transportation systems and ship design; market changes; extensive landfilling; two world wars; the development of refrigeration; the introduction of railroads; highways and an airport, as well as a host of other factors have continually redefined the Port of Boston and the nature of its maritime activities during the past few centuries.

Today, the Port of Boston remains New England's major seaport as well as a center of national and international shipping and commerce. The Port of Boston is a full-service industrial transportation hub serving New England, upstate New York, the mid-western United States, and eastern Canada. The port and its industries handle more than \$8 billion in goods and employ more than 9,000 people. Cargo that crosses Boston's docks includes petroleum and petroleum by-products, liquefied natural gas, containerized cargo, autos, lumber, scrap metal, gypsum, electrical machinery, salt, and a wide array of consumer goods. Boston is also a fishing port and a major seafood processing and distribution center.

As the 21st century approaches, markets, industries and modes of transportation are all changing, creating a demand for the port to reinvent itself to remain competitive. Perhaps the biggest challenge and opportunity for the port is the changing global economy. As new markets open along the southern Pacific rim, a new trade route is developing across the Indian Ocean and Suez Canal, leading directly to ports on the U.S. east coast. Boston must take bold steps to attract carriers using the new trade route. Huge container vessels -- three football fields long and carrying over 4,000 containers -- are becoming the standard. To compete for their trade, Boston must provide specialized services, modern terminal facilities, efficient container transfer between ship and rail and, perhaps most importantly, deeper water.

### **Overview of the Boston Harbor Navigation Improvement Project**

While the Port of Boston's principal entrance and main ship channels are 40 feet deep, the three major tributaries along which most of the port's terminals are located are only 35 feet deep. The lack of sufficiently deep water in both channels and berths creates costly time delays, restricts vessel size and loading, and creates inefficiencies in cargo shipments. While existing channels have experienced siltation and need dredging simply to maintain the currently authorized depth ("maintenance dredging"), deepening to new, lower depths ("improvement dredging") is also critical in order to more safely and efficiently accommodate the vessels that currently call on the port as well as the next generation of "post-Panamax" container ships that are expected to visit the port.

The Boston Harbor Navigation Improvement Project -- a joint project between the U.S. Army Corps of Engineers and the Massachusetts Port Authority (Massport) will deepen key portions of Boston's Inner Harbor, its tributary channels, and berth areas. A total of approximately 3 million cubic yards of material will be dredged from key portions of the channels and berths (see

attached figure). With the completion of this project, Boston's channels will be deeper than most of the east coast ports, greatly enhancing the Port of Boston's competitive position and providing an estimated \$5.5 million annual economic benefit to the New England region. The three key areas of benefit that have been identified for the project are:

- ◆ ***Increased navigational efficiency by reducing the need to “wait out the tides” or decrease loads prior to entering the harbor.*** The increased navigational efficiency that will result from the project translates into significant cost savings for shippers and greatly enhances the port's ability to retain existing shippers and attract new shippers.
- ◆ ***Ability to ship more tons of containerized cargo with fewer ships.*** Changes in the world wide shipping fleet have occurred in response to the need to minimize vessel operating costs -- the primary change is a trend toward larger vessels. While large vessels are more costly to operate, they can move much more cargo on a given trip thereby lowering the unit cost for the cargo. Ports need to be deeper to efficiently accommodate these larger vessels.
- ◆ ***Improved navigational safety for vital petroleum product vessels.*** Vessels carrying petroleum products are also increasing in size to minimize operating costs per gallon and in response to the mandate for double-hulled tankers pursuant to the Oil Pollution Act of 1990. The BHNIP will allow these larger vessels to operate in the port, minimizing the frequency of operation of petroleum carrying vessels in the port, and to enhance the safety of the deeper draft vessels that currently operate in the port.

BHNIP will result in the following depths below mean low water:

Reserved Channel, Inner Confluence, Mystic River Channel	40 feet
Chelsea Creek	38 feet
Massport and Other Private Berths	35 to 45 feet

After more than 20 years of planning, studies, and permitting, BHNIP received its final approvals in early 1997. Dredging projects in many other ports have been derailed due to environmental concerns over the disposal of harbor sediments. In Boston, however, there has been close cooperation between environmental advocates, dredging proponents, and regulatory agencies. An innovative and environmentally-sound solution to the disposal of contaminated dredge material has been achieved through the anticipated use of in-harbor containment cells. Rather than being dumped at sea or filling local landfills, contaminated sediments will be placed in deep cells below the existing navigation channels and capped with clean granular material. Clean sediments may be disposed of at sea or beneficially used onshore. The first phase of the project, involving dredging at Conley Terminal Berths 11 and 12 in South Boston, was completed in July 1997; dredging for the full project will begin in the spring of 1998 and is expected to continue for approximately 2 years. The total project cost is estimated at \$68 million.

Figure 1: Plan View of Site

## **Key Environmental and Permitting Issues**

With any type of dredging project, the key environmental issue to be resolved is generally where and how to dispose of the sediments. The level of difficulty in identifying and permitting a disposal site relates to the volume and quality of the sediment to be dredged. The Boston Harbor project involves primarily two types of sediment:

1. Approximately 1 million cubic yards of silt material that had accumulated in previously dredged areas (“maintenance material”) - this material contains elevated levels of various contaminants such as certain heavy metals, PCBs and PAHs; and
2. Approximately 2 million cubic yards of parent material from areas that had not historically been dredged, consisting primarily of Boston blue clay in addition to some rock and gravel.

Because the Boston blue clay and other improvement project material was determined to be “suitable for unconfined open water disposal,” it will be cost-effectively disposed of at the Massachusetts Bay Disposal Site (MBDS), an EPA-designated sediment disposal site located approximately 30 miles east of Boston in Massachusetts Bay. Alternatively, the contractor will have the option of using the material for a beneficial reuse if any viable reuse options are identified.

Although the New England District of the Corps determined that approximately 360,000 cy of the silty material was suitable for ocean disposal based on bulk chemistry, bioassay and bioaccumulation data, the U.S. Environmental Protection Agency (EPA) disputed this finding. To keep the project on track, the Corps and Massport agreed to characterize all silt from the BHNIP project as “unsuitable for unconfined ocean disposal.” Since the EPA had recently closed the MBDS to such material until the efficacy of capping could be proven to their satisfaction, another disposal site had to be found. The Corps and Massport initially considered over 300 disposal options for the silt, eventually selecting in-channel disposal cells as the “least environmentally damaging practicable alternative (LEDPA).” The selected disposal plan consists of excavating approximately 54 disposal cells beneath the federal navigation channels in the Inner Confluence, Mystic River, and Chelsea River. The cells are expected to be approximately 20 feet deep (constructed as deep into the Boston blue clay as possible until bedrock is reached), 200 feet wide and 500 feet long. All silt removed from the navigation channels and berths will be placed in the cells and capped with a 3-foot layer of clean granular material. The top elevation of the sand will be -42 feet MLW, which is as deep as the Inner Harbor navigation channels are ever expected to be dredged due to major infrastructure constraints near the mouth of the harbor. Construction of the in-channel disposal cells will generate an additional 2 million cy of clay, which will be disposed of at MBDS.

Because the selected disposal alternative would not involve impacting any additional area beyond the dredging footprint, and because the material would be capped with a 3-foot layer of clean granular material, this disposal alternative is not associated with any significant long-term impacts and therefore was widely accepted by the environmental community and regulators.

The only environmental impacts that needed to be addressed by the project mitigation plan were short-term in nature, mostly related to turbidity increases during dredging and disposal activities.

Massport and the Corps committed to a number of specific measures designed minimize the environmental impact of the project and to ensure compliance with the project permits. Key impact minimization commitments include:

- ◆ Use of a sealed environmental bucket for dredging of fine silty sediments to minimize turbidity increases during dredging operations;
- ◆ Disposal of silt material only at high slack tide when tidal currents are minimal and the volume of water available for dilution is highest;
- ◆ Installation of a 3-foot cap of clean granular material on the disposal cells to minimize transport of disposed silty sediments and related contaminants;
- ◆ Incorporation of various fish protection measures in the project specifications including avoiding blasting, dredging, and disposal operations during key fish migration and spawning periods and use of a state-approved fish observer, fish startle system, and sonar during other periods;
- ◆ Conducting of an extensive monitoring program to ensure that state water quality standards and permit conditions are met during dredging and disposal operations and that the sand cap is properly installed and maintained; and
- ◆ Funding of an independent observer to oversee all aspects of the construction and monitoring program and report findings to the state regulatory authorities and a Technical Advisory Committee.

## **Overview of Phase I**

When it appeared that federal funding for the full BHNIP may not come through as planned, Massport agreed to proceed with dredging at Conley Terminal, the Port of Boston's primary container terminal, at its own expense ahead of the rest of the project. This project, which became known as Phase I, provided a unique opportunity to "pilot test" the proposed project specifications, permit requirements, and monitoring program prior to conducting the full scale project.

Highlights of Phase I, which was conducted according to the full project specifications and permits, are as follows:

- ◆ The project was conducted by Weeks Marine, Inc. at a cost of approximately \$2 million.
- ◆ 66,500 cubic yards of sediment (fine silt and clay) was removed from the two berths at Conley Terminal, and an additional 102,500 cy of sediment (fine silt and clay) was removed from the disposal cell.
- ◆ The 26,500 cy of silt removed from the berths and cell was disposed of in the 200-foot by 500-foot disposal cell constructed in the Inner Confluence of Boston Harbor beneath the navigation channel.
- ◆ 142,500 cy of clay was disposed of at the Massachusetts Bay Disposal Site.

- ◆ 20,000 tons of sand was placed on top of the silt at the disposal cell as a cap.
- ◆ Extensive water quality monitoring was conducted by CLE Engineering, Inc., demonstrating that the work was conducted in full compliance with the project permits and state water quality standards.

Overall, the Phase I project was highly successful. Not surprisingly, however, much was learned from the first phase and numerous amendments were made to the project specifications, permits, and monitoring program for Phase II.

### **Construction of the First In-Harbor Disposal Cell**

The first cell was constructed below the existing channel by first removing the overlaying surface silts (approximately 3,500 cubic yards). This material was stored in a disposal scow for later placement into the cell. The remainder of the cell was then excavated to a capacity designed to accommodate the surface silts from Conley Terminal Berths 11 and 12 and a three foot sand cap. The underlying clay (“parent”) material removed from the cell (approximately 99,000 cubic yards) was deposited at the Massachusetts Bay Disposal Site. The dimensions of the cell were approximately 500 by 200 feet to an average depth of 57.5 feet below mean low water. The actual construction differed from the original design due to the ability of the parent material to support a nearly vertical cut for the side slopes.

After cell construction was complete, the overlaying surface silts from the cell were disposed of into the cell. The surface silts from Conley Terminal Berths 11 and 12 (approximately 23,000 cubic yards) were then dredged and disposed of in the first cell. Upon completion of dredging of the surface silts, the underlying clay material (approximately 43,500 cubic yards) from Conley Terminal Berths 11 and 12 was disposed at the Massachusetts Bay Disposal Site. After acceptance of the surface silts, the cell was capped with clean, granular material. The cell was not capped until all possible material was disposed and time was allowed for additional consolidation of the materials in the cell. Figure 1 shows the project areas.

## **WATER QUALITY MONITORING**

The waters of Boston Harbor are designated as Class SB Waters in the Massachusetts Surface Water Quality Standards, and as stated in the Water Quality Certificate (WQC) issued by the Massachusetts DEP for the BHNIP, such waters are intended “*as habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation.*” Anti-degradation provisions of the Standards require that “*existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.*” Although numerous permits were required for the BHNIP, the Water Quality Certificate was the key permit as it set the performance standards for dredging and disposal operations, specified detailed environmental monitoring requirements. As part of a separate commitment, Massport agreed to fund an Independent Observer to monitor the project. ENSR (Acton, MA) was selected by the Massachusetts Coastal Zone Management (MCZM) to serve as the Independent Observer. The Independent Observer and MCZM chaired the weekly meetings of the Technical Advisory Committee that was formed for the project.

The Final Environmental Impact Report / Statement (USACE, Massport, 1995) addresses in detail the potential for dredging and disposal activities to impact water quality. Modeling efforts were made to predict the potential transport and fate of contaminated particles during dredging and disposal. Predictions based on these modeling efforts, as well as DEP's experience with similar projects in Boston Harbor, were used to define the mixing zone and to develop the environmental monitoring program. According to the WQC, the mixing zone is defined as 300 feet downcurrent from the activity. At this location, as well as within the mixing zone, the acute standards, defined as the one hour average concentration, must be met at all times. The chronic standards, defined as the 4 day average concentration (for PCBs = 24 hour limit of exposure), must also be met at the edge of the mixing zone and beyond.

**Table 1: Water Quality Criterion**  
(DEP, 1996)

<u>Parameter</u>	<u>Acute Standard (ug/L)</u>	<u>Chronic Standard (ug/L)</u>
Total PCBs (aroclors)	10	0.030
Arsenic	69	36
Cadmium	42	9.2
Chromium (VI)	1100	50
Copper	2.4	2.4
Lead	210	8.1
Nickel	74	8.2
Zinc	90	81
Total Recoverable Mercury	1.8	0.025

The WQC divided the environmental monitoring into three distinct phases. These phases are defined by the dredging and disposal operations and are as follows: (1) dredging of the surface silts of the first cell, (2) dredging of the parent material at the first cell, and (3) disposal of dredged material into the cell. Reporting of all results was required 36 hours following the receipt of the samples by the laboratory. The monitoring requirements were complicated and extensive but feasible. Through comprehensive planning efforts and coordination with the contractor and laboratories, CLE developed a practicable work plan.

Throughout the project, an accurate determination of the exact location of samples and the sediment plume was critical. Inability to locate the exact limits of the disposal cell and the subsequent mixing zone could have caused time delays and had an adverse effect on the overall project. CLE's monitoring efforts were made aboard a research vessel equipped with sub-meter Differential Global Positioning System (DGPS) interfaced with a computer providing real time graphic display of the dredge cell, the mixing zone, and the sample vessel position. A fathometer was employed to determine the depth of the water column and to ensure that samples were collected from mid-water column and from within three feet of the bottom. Water samples were collected using a pump equipped with a teflon impeller and teflon tubing. In-situ measurements of turbidity, temperature, dissolved oxygen, pH, conductivity, and salinity were made and recorded with a YSI 6000 series multi parameter water column monitor. During disposal operations, a Miniflow current flow meter verified bottom current speed and direction.

## **Surface Silts**

The dredging of the surface silts was performed using a level cut / environmental clamshell bucket. During removal of the overlying surface silts at the first cell, samples were collected and tested at two locations: 500 feet downcurrent from the dredging and at a reference station 1,000 feet upcurrent of the dredging. Samples were collected after a period when dredging had been ongoing for two hours during each of the four extreme tidal conditions: maximum flood, slack before ebb, maximum ebb, and slack before flood. All samples were collected at mid-water column depth and from within three feet of the bottom and composited at the laboratory for Total Suspended Solids (TSS) analysis. Turbidity measurements were recorded in the field along a transect 500 feet downcurrent of the cell. The temporal and spatial location of any dredge plume was documented using the in-situ turbidity meter and sub-meter positioning.

The predictive modeling indicated that for dredging 3,000 cubic yards/day, the TSS plume was predicted to increase suspended sediment by 32 to 42 mg/L (ENSR, 1997) immediately around the dredge. The WQC set a performance standard for the concentration of suspended solids at 200 mg/L at 500 feet downcurrent of the operating dredge. In situ turbidity measurements ranged from 3 to 5 nephelometric turbidity units (NTU) at the reference station and were only slightly elevated, 5 to 9 NTU 500 feet downcurrent of the dredge. TSS ranged from 4 to 5 mg/L at the reference location and 5 mg/L at slack tidal conditions to 9 mg/L at maximum flood at the downcurrent station.

Data indicated a small plume localized to the dredge bucket, which dissipated rapidly. In very close proximity to the bucket, the turbidity levels were elevated-readings showed a maximum of 40 NTU twenty-five feet from the bucket. This measurement indicates that the concentration of suspended solids was still far below the performance standard. Dredging of the surface silts was completed within 24 hours and the material was left in the scow for future disposal into the cell.

## **Parent Material**

Removal of the underlying parent material was accomplished using a standard open-toothed bucket. The Water Quality Certificate required sample collection at two locations: 300 feet downcurrent from the dredging and at the reference site 1,000 feet upcurrent. Samples were collected at mid-water column depth and from within three feet of the bottom and composited for analysis. Prior to the collection of samples, at the 300 feet downcurrent location, a transect was run with the YSI 6000 turbidity probe deployed. After tracking the turbidity levels across the 300-foot boundary, samples were collected within any discernible plume. These samples were analyzed for TSS, arsenic and copper. Dissolved oxygen measurements were made in situ using the YSI 6000 meter.

In comparison to the dredging of the surface silts, a discernible plume was visible for a greater distance around the operating dredge. In situ measurements of turbidity at the reference site ranged from 3 to 7 NTU; 300 feet downcurrent turbidity measurements ranged from 8 to 56 NTU. TSS values ranged from 8 to 60 mg/l at the reference site and ranged from 19 to 48 mg/l 300 feet downcurrent, which is still far below the performance goal set by the Water Quality

Certificate. As for the surface silts, predictive modeling indicated that for dredging 3,000 cubic yards/day, the TSS plume was predicted to increase suspended sediment levels by 32 to 42 mg/L (ENSR). Weeks Marine, Inc. actually removed approximately three times the modeling estimate per day, and the suspended sediment concentrations were still well below the performance standard. The elevated levels at the reference site indicated that other factors in the harbor directly influence the amount of suspended sediment by the same amount if not more than the dredging operations. One of the major contributing factors was vessel traffic.

Arsenic concentrations were below the detection limit, and copper concentrations ranged from 0.8 to 1.2 µg/L, which was detected at both the reference location and at 300 feet downcurrent. This level is less than half of the acute criterion (2.4 µg/L).

### Disposal Operations

The extensive monitoring requirements within a relatively short time span made timing of sample collection and location of the sediment plume critical during disposal operations. The same methods for determining plume location and sampling were used as described previously. Table 2 outlines the locations and timing of sample collection for the first five days of disposal activities occurring during daylight hours.

All samples were analyzed for TSS and DO. The samples from 300 feet downcurrent and 1,000 feet upcurrent (reference) were also analyzed for PCB aroclors, dissolved copper, cadmium, lead, chromium, arsenic, nickel, zinc, and total mercury. The bottom current speed and direction were recorded at the reference location to verify that this location was upcurrent of the cell.

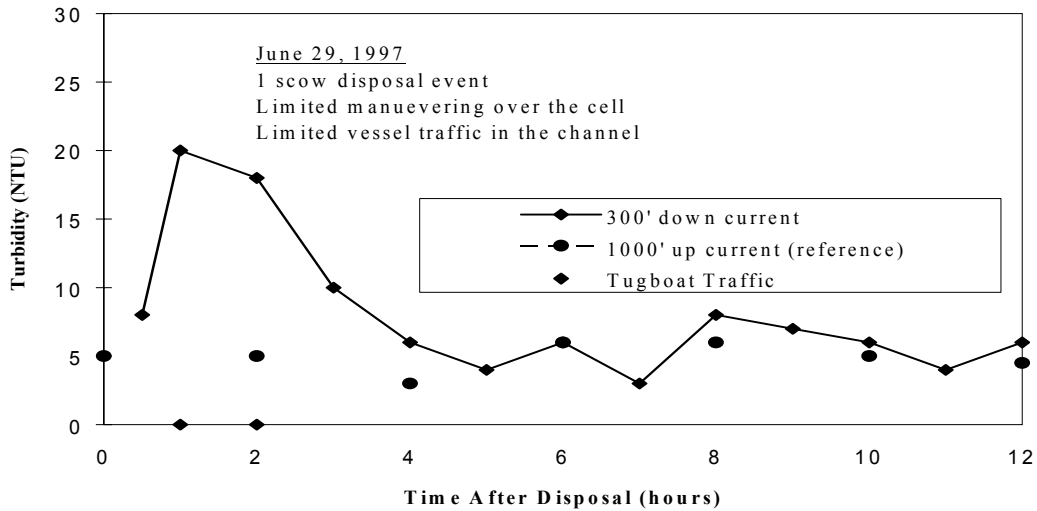
**Table 2: Sampling During Disposal Operations**

<u>Location (relative to cell)</u>	<u>Time After Disposal (hours)</u>
1,000 feet downcurrent	2.5
200 feet lateral	1.5
300 feet downcurrent	0.5, 1.0 (note: for comparison to acute criterion)
300 feet downcurrent	Hourly for 12 hours (composite) (note: for comparison to chronic criterion)
1,000 feet upcurrent (reference)	Prior to disposal, and every other hour for 12 hours (composite)

The Water Quality Certificate specified that all disposal events occur only at high slack tide. During each disposal event, the dredge and dump scow were positioned over the cell and the dredge lowered three spuds. Assisting tugs were used to maneuver over the cell. On the first three days of monitoring, one scow of material was deposited in the cell. On the fourth day two scows were released and on the fifth day there were three disposal events during the daylight high tide. An estimated volume of 26,500 cubic yards of material, representing fourteen scows, was disposed into the cell without any violations of the Water Quality Certificate. Figure 2 shows a schematic of the cell.

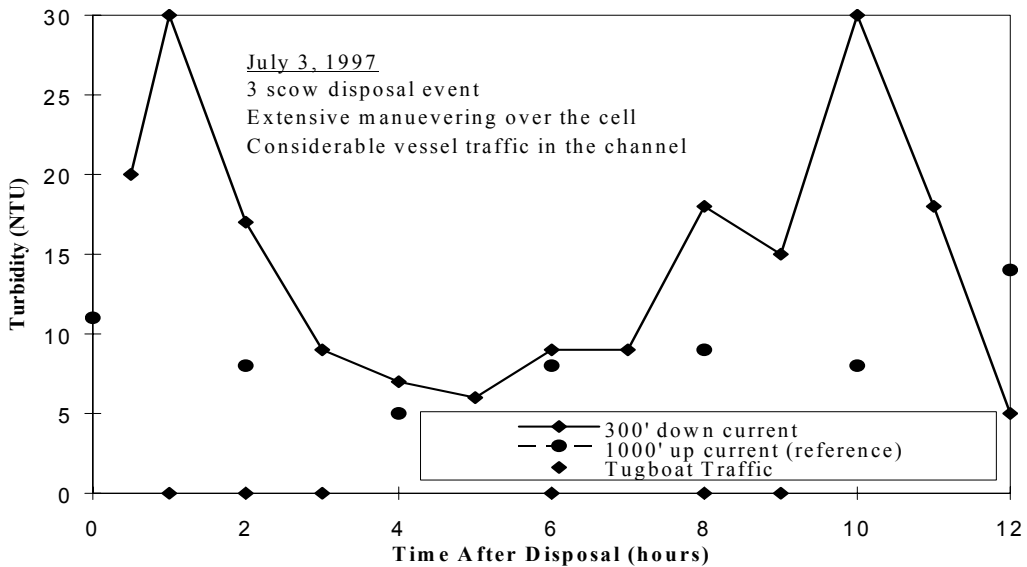
**Turbidity, TSS, and DO:** Prior to each sample collection at the mixing zone limit, transects were conducted to ensure collection within any sediment plume. Although a plume was visible immediately following disposal, it dissipated quickly. Turbidity measurements ranged from 1 to 30 NTU at this location and from 2 to 14 NTU at the reference location. TSS concentrations ranged from 5 to 64 mg/L at the 300 feet downcurrent of the cell and from 3 to 29 mg/L at the reference site. The highest levels were recorded on the fifth day of disposal. Some of the elevated levels were attributable to unrelated vessel traffic, but all results indicated that the concentrations of suspended solids were far below the performance goal, and only slightly increased over background levels. Dissolved oxygen concentrations revealed no apparent difference between the reference and the downcurrent locations.

Figure 3 illustrates the turbidity measurements recorded in the field along the mixing zone limit (300 feet downcurrent) and at the reference location on June 29, 1997. On this date, the first disposal event of the project occurred at eleven minutes after high tide according to the NOAA tide tables. There was limited maneuvering of the assisting tugs and limited vessel traffic in the channel. Turbidity values were elevated above background at the mixing zone limit, but TSS concentrations ranged only from 5 to 14 mg/L one hour after disposal. During this time, there was tug traffic in the channel. Between four and twelve hours after disposal, turbidity values showed no significant difference between the downcurrent location and the reference station.



**Figure 3: Turbidity Within Bottom Three Feet of Water Column vs. Time After Disposal**

As illustrated in Figure 4, turbidity measurements recorded on July 3, 1997 were slightly higher. For this disposal event, three scows were emptied into the partially filled cell, assisting tugs were maneuvering over the cell, and vessels were passing the site within the channel. Even with this external activity and more than twice the disposal volume used in the predictive modeling, the maximum concentration of suspended solids was 64 mg/L at the downcurrent station one hour after disposal. At ten hours after the disposal event, the peak turbidity was most likely due to a passing tug. The value for the turbidity at this time was the same as the maximum value at the mixing zone limit one hour after disposal.



**Figure 4: Turbidity Within Bottom Three Feet of Water Column vs. Time After Disposal**

**PCB and Metals** All detection limits were below the chronic standards noted in Table 1. During the five day monitoring period, no PCBs, arsenic, cadmium, chromium VI, or nickel were detected in any of the samples. Copper was detected in the majority of the samples, but the maximum concentrations detected at the reference and downcurrent station were 0.79 and 0.82 ug/L, respectively. These concentrations were well below the chronic water quality criterion of 2.4 ug/L. Zinc was detected in all samples, but again there was little difference between the reference and downcurrent concentrations and all results were far below the chronic criterion. Lead was not detected until the fifth day of monitoring, when it was detected in both the reference and downcurrent samples. The maximum concentration, 0.06 ug/L was far below the acute criterion. Mercury was detected during the third and fourth days of monitoring at the downcurrent location at 0.5 and 1.0 hours after disposal with a maximum concentration of 0.011 ug/L. On the fifth day, the 0.5 and 1.0 hour samples at the mixing zone limits had concentrations of 0.04 and 0.034 ug/L respectively. All of these detects are considerably below the acute criterion of 1.8 ug/L. The composite value was 0.01 ug/L, which is well below the chronic criterion of 0.025 ug/L. Mercury was not detected in the reference sample.

**Biological Testing** Water samples were collected on the second day of disposal activities for bioassay tests. These samples were collected 300 feet downcurrent and 1,000 feet upcurrent from the cell at 0.5 and 1.0 hours after disposal. Two bio assays: the Sea Urchin Fertilization (*Arbacia punctulata*), and the seven day *Mysidopsis Bahía* test were conducted. After 7 days exposure, the test did not reveal acute or chronic toxicity to the mysid. A chronic sublethal impact on egg fertilization was revealed, but this impact was the same for both the reference and the downcurrent location and was therefore considered a background condition of the harbor.

**Predictions versus Actual Data** Predictive modeling assumed a 5% release rate of material during a disposal event. For a 3,000 cubic yard release at an Inner Confluence cell, TSS concentrations were predicted to exceed 200 mg/L at 347 meters downcurrent one hour following disposal (ENSR, FEIR). Actual concentrations were much lower than predicted even though the volume of the releases was up to approximately two or three times the predicted volume. The plume dissipated faster than predicted and other factors such as vessel traffic had the same impact on the turbidity as the disposal event itself. The bulk chemistry results also demonstrated compliance with the Water Quality Certificate.

Variable factors that may affect the turbidity plume following a disposal event include the following: depth of the cell relative to surrounding bottom, slope of cell side walls, the amount of material in the cell, the volume disposed, weather conditions, and the chemical concentrations in the silt material (ENSR, 1997). The first cell constructed may be considered optimal as far as plume minimization. The side walls were nearly vertical, and initially the cell-bottom was 15 to 20 feet below the surrounding bottom. Monitoring during Phase 2 of the project may reveal higher concentrations of suspended solids as the multiple cells are filled to capacity throughout the federal navigation channels.

## **RECOMMENDATIONS FOR PHASE 2**

The predictive modeling overestimated the impacts of the dredging and disposal operations. Although these modeling efforts were intended to be conservative estimates, they triggered an

extensive, complicated, and costly monitoring program. Based on the data collected during Phase 1, monitoring requirements during disposal events were modified for Phase 2 to reduce the number of samples and the duration of monitoring without sacrificing data critical for determining plume extents and demonstrating permit compliance. These modifications include the following:

- ◆ Current meter requirement was eliminated.
- ◆ Samples at 200-foot lateral and at the 1,000-foot downcurrent locations were eliminated.
- ◆ Sample collection for evaluation of chronic criterion was changed from hourly following disposal to two samples collected one hour apart between four and six hours following disposal at both the mixing zone limit and at the reference location.
- ◆ Plume location equipment capable of providing real-time display and data capture of light transmittance or turbidity as a depth profile was added as a requirement to produce a plan view depicting contours of turbidity values over the area and a figure in cross section depicting contours of turbidity along the mixing zone limit. (DEP, 1996).

These modifications reduce the amount of time spent collecting samples in areas apparently unaffected by the disposal event while providing a more detailed tracking of the plume. This information will be very useful for future disposal operations. Predictive modeling efforts for other projects may be able to incorporate this data to refine estimates of contaminant transport.

The intensive equipment requirements for Phase 2 make strategic planning for dredging and disposal operations critical. Extensive coordination with the monitoring team will also be essential for project success. A work stoppage order due to a contractor's inability to satisfy the monitoring requirements would prove to be much more costly than funds spent on an experienced monitoring team.

## **CONCLUSIONS**

Overall, the Phase I project was highly successful. Through key planning and coordination between the monitoring team, dredging contractor, Massport, the Corps, and the various regulatory agencies, monitoring demonstrated that the work was conducted in full compliance with the permits and state water quality standards. Any logistical problem could have thrown off an entire day of sampling, risking the issuance of a Stop Work Order from the Department of Environmental Protection. Due to the critical nature of the timing and location of sample collection, the monitoring team's experience on large dredging projects and ability to respond quickly to changing conditions in the field was essential for success. Analysis of data collected during Phase 1 enabled regulators to revise requirements for Phase 2 to more effectively obtain data at a reduced cost to the Contractor.

The Independent Observer also contributed to the success of Phase 1. Initially this role appeared to be redundant of the USACE inspectors; however, the Independent Observer effectively served as a liaison between the contractor and the regulatory agencies often resolving conflicts and

providing clarification to complicated issues. In addition, the weekly meetings of the Technical Advisory Committee seemed to increase everyone's comfort level with the work.

The deepening of Boston harbor's channels and berths to provide a competitive port is going forward due to the successful completion of Phase 1. This deepening will provide economic benefits to the New England region. The innovative disposal option proved feasible and although complicated, monitoring efforts demonstrated compliance with the permits. Results from Phase 1 confirm that this Port can be deepened with minimal environmental impacts.

## REFERENCES

CLE Engineering, Inc. 1997. "Water Column Monitoring Report for Dredging of Silt and Parent Material at the First Disposal Cell and Disposal of Silt Material from Conley Terminal Berths 11 and 12, Volume 1-6. Boston Harbor Navigation Improvement Project Water Quality Certification DEP Transmittal Number: 114030." July 18, 1997

Commonwealth of Massachusetts Executive Office of Environmental Affairs Department of Environmental Protection. 1996. "Water Quality Certification BRP WW 07 Major Project Certification Boston Harbor Navigation Improvement and Berth Dredging Project dredging and in water disposal", September 30, 1996.

ENSR. 1997. "Summary Report of Independent Observations Phase 1 - Boston Harbor Navigation Improvement Project." October 1997.

U.S. Army Corps of Engineers and Massachusetts Port Authority. 1995. Boston Harbor, Massachusetts Navigation Improvement Project and Berth Dredging Project Final Environmental Impact Report/Statements. 3 volumes. June 1995

