USACE CONTRACT NO. DACW33-94-D-0002
TASK ORDER NO. 017
TOTAL ENVIRONMENTAL RESTORATION CONTRACT

FINAL
PRE-DESIGN FIELD TEST
DREDGE TECHNOLOGY
EVALUATION REPORT
NEW BEDFORD HARBOR SUPERFUND SITE
New Bedford, Massachusetts

August 2001

Prepared for

U.S. Army Corps of Engineers
New England District
Concord, Massachusetts

2001-017-0250
8/15/01

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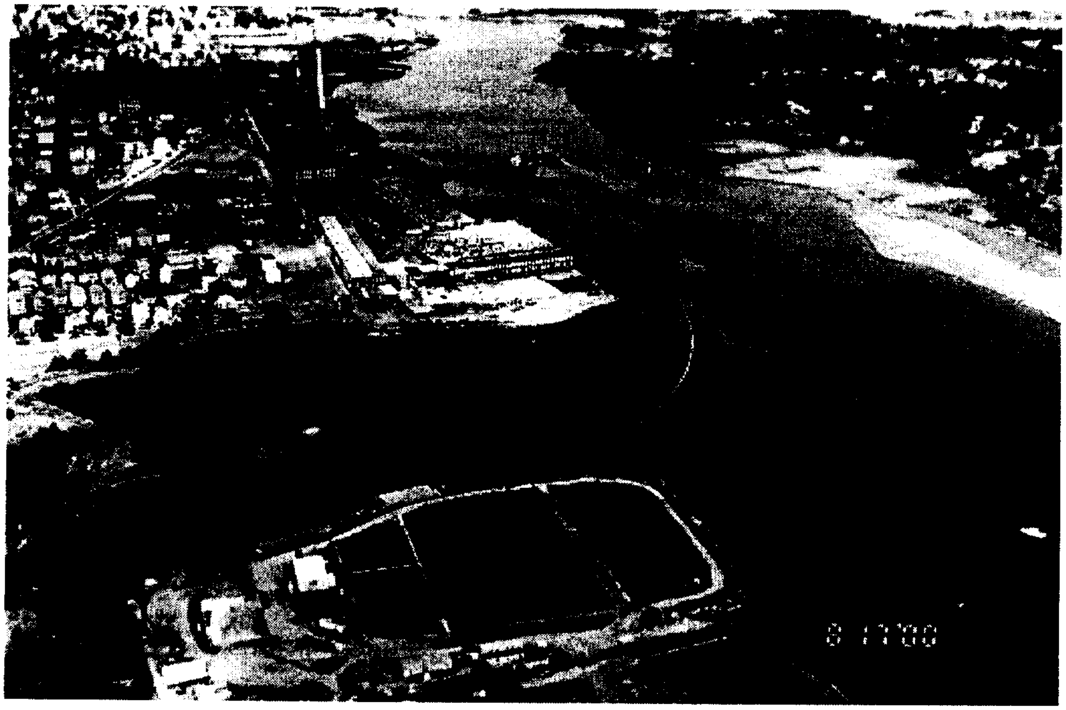

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Prepared by

Foster Wheeler Environmental Corporation
133 Federal Street
Boston, MA 02110

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ABBREVIATIONS AND ACRONYMS

alum	aluminum sulfate
BARR.PR	Barometric Pressure, inches of Hg
BATTERY	Meteorological Station Battery Voltage
Bean TEC	Bean Technical Excavation Corporation
BELLC	Bean Environmental LLC
CDF	confined disposal facility
cf	cubic feet
CGI	Combustible/Toxic Gas Indicator
CMS	Crane Monitoring System
CO_2	Carbon Dioxide
CRZ	Contaminant Reduction Zone
cy	cubic yards
cy/hr	cubic yards per hour
DDA	debris disposal area
DELTA-T	Temperature Differences
DEP	Massachusetts Department of Environmental Protection
DGPS	Differential Global Positioning System
DTM	Digital Terrain Model
ECD	electron capture detector
EE/O	electrical energy per order
EHS	Environmental, Health & Safety
ENSR	ENSR International
EPA	U.S. Environmental Protection Agency
EZ	Exclusion Zone
ft.	feet
ft^2	square feet
FWENC	Foster Wheeler Environmental Corporation
g/L	grams per liter
GAC	granulated activated carbon
GC	gas chromatography
gpm	gallons per minute
H_2S	Hydrogen Sulfide
HDPE	high density polyethylene
HPG	Horizontal Profiling Grab bucket
in.	inches
Kg/m^3	kilograms per $meter^3$
kW	kilowatt
lbs	pounds
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MHW	Mean High Water
MLLW	Mean Lower Low Water
mm	millimeter
MRL	method reporting limit
MS	mass spectrometry
NBH	New Bedford Harbor
ng/m^2-min	nanogram per $meter^2$ minute
NOAA	National Oceanographic and Atmospheric Administration
NTU	Nephelometric Turbidity Units

OBS	optical backscatter sensor
PCB	polychlorinated biphenyl
pcf	pounds per cubic foot
PDFT	Pre-Design Field Test
PID	Photo-Ionization Detector
PPE	personal protective equipment
ppm	parts per million
PRECIP	Precipitation, inches
psig	pounds per square inch gauge
RH	Relative Humidity, %
RL	Reporting Limit
ROD	Record of Decision
RPD	Relative Percent Difference
RTK	Real Time Kinematic
SAP	Sampling and Analysis Plan
SG	specific gravity
SGU	specific gravity unit
SIGMA	Standard Deviation, degrees
SIM	selected ion monitoring
SPU	Slurry Processing Unit
SR	Solar Radiation, watts · m^2
SSHP	Site Safety and Health Program
TEMP10M	Temperature (°F) at 10 meters aboveground surface
TEMP2M	Temperature (°F) at 2 meters aboveground surface
TSS	total suspended solids
µg/L	micrograms per liter
USACE	U.S. Army Corps of Engineers, New England District
WD	Wind Direction, degrees
WES	Waterways Experiment Station
WHO	World Health Organization
WS	Wind Speed, miles per hour
WTP	Wastewater Treatment Plant

ABSTRACT

The New Bedford Harbor Superfund Site is contaminated with polychlorinated biphenyls (PCBs), heavy metals and other chemicals. Remediation of the site will include dredging contaminated sediments from the harbor to final placement in shoreline confined disposal facilities (CDFs).

This report focuses on the dredging component of the remedial design and presents results of the August 2000, Pre-Design Field Test (PDFT). The main objective of this PDFT was to determine site specific dredge performance values for use in developing a full-scale remediation plan. The PDFT demonstrated and recorded performance data including dredge production, accuracy, slurry solids concentration, and air and water quality impacts.

Foster Wheeler Environmental Corporation subcontracted with Bean Environmental LLC for the delivery and demonstration of a hybrid environmental mechanical/hydraulic excavator dredge. The hybrid dredge was designed to enable accurate dredging of the contaminated sediment, minimize the amount of water added during the slurry pumping process by recycling water decanted from the slurry effluent, and minimize the potential for adverse environmental impacts. The dredging system delivered to the site for the PDFT included a portable, shallow draft barge platform, a Horizontal Profiling Grab bucket (HPG), a Crane Monitoring System (CMS), the Bean patented Slurry Processing Unit (SPU), and a water recirculation system.

Dredge Production

Dredging was performed to obtain representative production rates over a range of conditions, including varying depths, bank height, and chemical and physical conditions. Production monitoring data were collected using a number of electronic data collectors and were summarized daily.

Over the course of the PDFT, the representative average production rate for the dredge was 80 cubic yards per hour (cy/hr). It is believed that excavator production could be increased by 20% on a full-scale project in the Upper Harbor to approximately 95 cy/hr with system optimization.

Dredging Accuracy

The test dredge equipment demonstrated that a mechanical bucket, operated from an excavator with rigid connections and a state-of-the-art monitoring and positioning system could achieve a +/- 4-inch vertical dredging accuracy based on comparison of the PDFT post-dredge survey with the target depths. An accuracy evaluation showed that 95% of the test area was dredged to within 6 inches (in.) of the target depth, and 90% of the test area was dredged to within 4 in.

Another component of the dredging accuracy evaluation was development and testing of a "visual" method to determine dredging depth. The visual method provides a fine-tuning of the dredge plan based on the continuous observations of the "clean" underlying clay layer. The goal of the visual method is to minimize removal of the underlying clay layer to eliminate unnecessary dredging, and further costly processing and storage.

Solids Concentration of Dredge Slurry

Average solids concentration values recorded by the SPU system over sustained dredging periods ranged from 13.3% to 16.3% solids by weight. These concentrations were achieved in dredge areas having *in situ* sediments with average solids concentrations of 32% to 43% solids by weight.

The use of the SPU system on the cleanup of the Upper and Lower Harbors, could reduce the volume of water transported and treated by an estimated 50% to 70% below that required for a hydraulic cutterhead system.

Recirculation System

A water recirculation system was integrated with the test dredge to evaluate the feasibility of recycling water generated by the hydraulic transport process. The recirculation system was highly effective in essentially creating a closed loop system, whereby the only water added to the dredge process was that entrained in the dredge bucket. Without the recirculation system, the volume of water added would be approximately 320% of the *in situ* volume. The recirculation system operated without any significant problems, and confirmed the feasibility of using such a system on the full-scale remediation.

PCB Removal Efficiency

A secondary objective of the PDFT was to evaluate this new dredging technology with regard to site specific cleanup levels. The dredge performed quite well in this regard. The average sediment PCB concentration (upper one foot) was reduced from 857 ppm to 29 ppm over the dredged area. This met the clean up criteria of 50 ppm for the Lower Harbor and approached the criteria of 10 ppm for the Upper Harbor. Based on experiences during the PDFT, it was determined that remedial dredging to 10 ppm is possible through the use of modified operational procedures and project design.

Water Quality Monitoring

Water quality monitoring revealed only a very limited impact on the water column from the actual dredging in terms of both PCBs and suspended solids. The detected elevations of these parameters were within the range of fluctuations normally found in the Harbor with changing environmental conditions. This limited impact was attributed to the bucket design and the method of operation. Larger increases in water column suspended solids and PCB concentrations were attributed to dredging support activities.

Air Quality Monitoring

Flux chamber samples and ambient air samples were collected to achieve various objectives during the PDFT. Overall, this air sampling indicated that CDFs will be a more significant PCB emissions source than the dredging platform.

Wastewater Treatment

Results of the wastewater treatment pilot study showed that granular activated carbon when used with clarification and filtration can remove PCB concentrations to below the site-specific discharge limit of 0.065 milligrams per liter (mg/L) per Aroclor. The study also showed that sludge generated from wastewater treatment plant operations could be dewatered using a plate and frame filter press.

Comparison with Baseline Dredge Technology

A comparison was made between the key performance areas evaluated during the 1989 Pilot Dredging, 1995 Hot Spot Dredging and 2000 PDFT events. The Ellicott 370 HP 10-inch hydraulic cutterhead dredge was the established baseline dredge in terms of dredging performance in the former two events. The PDFT demonstrated that current state-of-the-art dredge technology, in particular a hybrid mechanical/hydraulic dredge with sophisticated environmental controls systems, can attain dredge performance values exceeding that of the baseline dredge, particularly in the areas of dredging accuracy, dredging production, and solids concentration of the dredge slurry.

EXECUTIVE SUMMARY

INTRODUCTION

The New Bedford Harbor Superfund Site is contaminated with polychlorinated biphenyls (PCBs), heavy metals and other chemicals. Remediation of the site will be conducted in accordance with the Record of Decision (ROD) dated September 25, 1998 which includes dredging contaminated sediments from the harbor to final placement in shoreline confined disposal facilities (CDFs).

This report focuses on the dredging component of the remedial design and presents results of the August 2000, Pre-Design Field Test (PDFT) conducted to determine site specific dredge performance values for use in developing a full-scale remediation plan. Dredge performance values were previously estimated based on results of conventional and alternative hydraulic dredging systems used at the site in 1989 for a Pilot Dredging Study, and in 1995 for Hot Spot dredging. However, changes in dredge technology over the past several years makes it likely that newer technology could improve dredge production and other performance values over previous estimates. The PDFT demonstrated and recorded performance data including dredge production, accuracy, slurry solids concentration, and air and water quality impacts. To reflect full-scale remediation activities to the greatest extent possible, the PDFT was conducted over a 100-feet (ft.) by 550-ft. area in the New Bedford Upper Harbor. The PDFT team included: the U.S. Environmental Protection Agency - Region I, the U.S. Environmental Protection Agency (EPA), Narragansett, RI, Atlantic Ecology Division of the National Health and Environmental Effects Laboratory, the U.S. Army Corps of Engineers, New England District (USACE), the Massachusetts Department of Environmental Protection (DEP), Foster Wheeler Environmental Corporation (Foster Wheeler), Bean Environmental LLC (BELLC), ENSR International (ENSR), URS, Kevric, and CR Environmental.

OBJECTIVES

To evaluate the performance improvements of a state-of-the-art environmental dredge technology over conventional dredge technology previously used at the site several performance areas were evaluated:

- Horizontal and vertical dredging;
- Potential impacts to water quality;
- Potential impacts to air quality;
- Dredge production rates in shallow water and sediment with debris;
- Percent (%) solids concentrations in the dredge slurry and slurry pumping capabilities; and
- Removal of the contaminated sediment to a given depth.

A secondary objective of the PDFT was to evaluate this new technology with regard to site specific cleanup levels. Additional objectives of the PDFT were to evaluate the effectiveness of applying contaminant dispersants and flocculents within the CDF to reduce PCB losses to air, to evaluate mechanical dewatering methods and to evaluate the use of granulated activated carbon (GAC) to treat wastewater.

DREDGING TEST PLAN

The dredging test plan consisted of dredge technology selection, dredge performance tests, water quality monitoring, air quality monitoring, and wastewater treatment. A testing schedule was established to ensure that dredge performance testing and monitoring would be captured over five to ten days of dredging. In total, four days (from August 10, 2000 through August 13, 2000) were spent performing trial dredging during which the dredge system underwent modifications to prepare for test dredging. Test dredging was performed over the course of five days (from August 14, 2000 through August 18, 2000).

DREDGE TECHNOLOGY SELECTION

Over sixty dredge technologies available in the United States and internationally were screened prior to selecting three technologies demonstrating the highest probability for success in meeting the New Bedford Harbor project constraints. The technologies selected were:

- The Bean Technical Excavation Corporation (Bean TEC) Bonacavor
- The Normrock Industries *Amphibex*
- The Ellicott International Series 370 hydraulic cutterhead dredge

Because the Normrock Industries *Amphibex* was at the time built on a foreign hull and prohibited from operating in navigable waters of the U.S. under the Jones Act, and because adequate performance data was already available for the Ellicott 370 hydraulic cutterhead dredge, the PDFT only evaluated the Bean type environmental hydraulic excavator.

Foster Wheeler subcontracted with BELLC for the delivery and demonstration of a hybrid environmental mechanical/hydraulic excavator to work along with the Slurry Processing Unit (SPU) previously patented by C.F. Bean Corporation, now C.F. Bean LLC, an affiliate of BELLC. The hybrid dredge was designed to enable accurate dredging of the contaminated sediment, minimize the amount of water added during the slurry pumping process, and recycle the dredge slurry effluent. The dredging system delivered to the site for the PDFT included a portable, shallow draft barge platform, a Horizontal Profiling Grab bucket (HPG), a Crane Monitoring System (CMS), the Bean patented SPU, and a water recirculation system. The main components of the system are described in more detail below.

Horizontal Profiling Grab Bucket (HPG)

A HPG was used by BELLC to achieve the PDFT goal of applying mechanical dredging equipment to the site. The HPG is a mechanical clamshell bucket developed in the Netherlands, designed to excavate thin layers of material with a high degree of accuracy causing minimal spill and turbidity. A hydraulic excavator (backhoe) operates the HPG bucket, with rigid connections rather than wire cable, which are used with a conventional crane derrick. Since the HPG bucket is actively closed by hydraulic cylinders, instead of closing wires, its vulnerability to debris is also significantly reduced. The HPG was designed to provide a level cut as opposed to a conventional clamshell bucket's semi-circular or arched cut which decreases the need for overlap between adjacent grabs to achieve grade. The HPG is also designed to minimize resuspension of sediments by containing the dredged material during excavation and placement.

Crane Monitoring System (CMS)

The CMS is an on-board electronic sensor system that provides the dredge operator precise control of the bucket while dredging, both in the horizontal and vertical planes, and interprets signals from various components of the dredging system onto a computer display. The design dredge prism is based on the interpretation of the core logs by the design team. In using the CMS, the operator dredges in pre-programmed dredge sets based on a planned horizontal and vertical grid.

Slurry Processing Unit (SPU)

To minimize the amount of water delivered to the CDFs, the Bean patented SPU, which has been used successfully on other remediation projects to achieve high solids concentrations in the dredge slurry, was tested during the PDFT. The SPU system is a proprietary hydraulic slurry transport system that delivers high percent solids concentrations by introducing controlled amounts of water to mechanically dredged material.

Recirculation System

The SPU system is intended to minimize the amount of water added to the dredged material such that the dredge slurry density is optimized. Due to the full-scale project parameters and anticipated water requirements, additional efforts were made to develop a system that would serve to further minimize the volume of water generated during the full-scale project; therefore, a water recirculation system was also tested in the PDFT. The recirculation system involved the pumping of decant water from the CDF back to the dredge for use as make-up water, thereby creating a closed loop system.

DREDGE PERFORMANCE TESTS

The dredge performance tests evaluated three areas:

1) Dredge performance at removing PCBs:
    - Dredge production over a range of conditions
    - Dredging accuracy
    - Solids concentration of the dredge slurry
    - Recirculation system effectiveness
    - PCB removal efficiency (before and after sediment sampling).

2) Water Quality impacts within the Upper Harbor caused by dredging operations.

3) Air Quality impacts at the point of dredging and at the Sawyer Street CDF.

Dredge Production

Dredge production monitoring was performed during dredging operations in the PDFT test area. Dredging was performed to obtain representative production rates over a range of conditions, including varying depths, bank height, and chemical and physical conditions. Production monitoring data were collected using a number of electronic data collectors and were summarized daily. Excavator production and SPU production affected the overall dredge production. Excavator production was found to be dependent upon basic dredge production parameters including bucket capacity, cycle time, depth of cut, bank height, and dredge shifting (advances). Over the course of the PDFT, the representative average production rate for the excavator was 80 cubic yards per hour (cy/hr) in areas with bank height ranging between 1.7 ft. and 2.0 ft. It is believed that excavator production could be increased by 20% on a full-scale project in the Upper Harbor to approximately 95 cy/hr if the system is optimized. This production range would only be attainable in deeper areas of the harbor where access to the dredge areas would be unencumbered by a dredge of similar scale, and draft characteristics to that tested during the PDFT. In shallower areas, where working of the tides would increase the number of barge movements and reduce the overall dredging efficiency, the dredge production would be anticipated to be significantly less. Alternatively, a smaller dredge with less production capacity than that of a dredge of the scale tested during the PDFT could be used. In either case, with either a larger dredge working the tides, or with use of a smaller dredge, the production range would be on the order of 35 to 50 cy/hr. This is an estimate only, based on knowledge of the anticipated reduction in production efficiency (50%-60%) due to depth restriction on a larger dredge, and an understanding of production capacity of shallow hydraulic dredges. Both the breakpoint at which a larger production environmental dredge would be replaced by a smaller dredge, and the production range of that smaller dredge will be better assessed in the 90% Basis of Design/Design Analysis for the Dredging Design, to be completed in 2001.

SPU production was found to be the dredge production limit in testing during the PDFT, due primarily to problems with debris clogging. Attempts were made during the PDFT to remedy clogging problems by adding water jets in the suction line, welding baffle walls in the hopper, and other operational measures. It is believed that by optimizing the debris management system, SPU production will match, or exceed that of the excavator production for full-scale remediation.

Dredging Accuracy

Dredging accuracy will be key to minimizing the amount of overdredging while still attaining the target cleanup goals of the project. The test dredge equipment demonstrated that a mechanical bucket, operated from an excavator with rigid connections and a state-of-the-art monitoring and positioning system could achieve a +/- 4 inch vertical dredging accuracy based on comparison of the PDFT post-dredge survey with the target depths. An accuracy evaluation showed that 95% of the test area was dredged to within 6 inches (in.) of the target depth, and 90% of the test area was dredged to within 4 in. Most of the points that deviate more than 6 in. are in the slope area, to the north and south of the test area.

Another component of the dredging accuracy evaluation was development and testing of a "visual" method to determine dredging depth. The visual method provided a fine-tuning of the dredge plan based on the continuous observations of the "clean" underlying clay layer. Laboratory analysis has shown the clay layer to contain little to no PCB contamination, and is therefore assumed clean. The goal of the visual method is to minimize removal of the underlying clay layer to eliminate unnecessary dredging, and further costly processing and storage. In locations where this method was used, the depth of cut was reduced from a planned 2-ft. cut, to a 1.7-ft. and 1.8-ft. cut. The visual method was demonstrated as having potential for application across the New Bedford Harbor dredge areas where a distinct interface between the black organic silt surface layer and underlying, native clean gray clay layer is present.

Solids Concentration of Dredge Slurry

Average sustained solids concentration values recorded by the SPU system over sustained dredging periods ranged from 13.3% to 16.3% solids by weight. These concentrations were achieved in dredge areas having *in situ* sediments with average solids concentrations of 32% to 43% solids by weight. This corresponds to volume concentrations on the order of 40% to 50%. The solids concentration values attained by the BELLC dredge were affected by debris clogging. Higher solids concentrations would be attainable with inclusion of a more sophisticated debris separation system on the full-scale project.

The use of the SPU system on the cleanup of the Upper and Lower Harbors could reduce the volume of water transported and treated by an estimated 50% to 70% below that required for a hydraulic cutterhead system. A specific range of slurry density could be prescribed and provided by the SPU that would best accommodate the decanting time, recirculation water pressure, and movement of dredge material disposal operations within the CDF's.

Recirculation System

A water recirculation system was integrated with the test dredge to evaluate the feasibility of recycling water generated by the hydraulic transport process. The recirculation system was highly effective in essentially creating a closed loop system, whereby the only water added to the dredge process was that entrained in the dredge bucket. This water addition amounts to approximately 40% of the *in situ* volume. The water was recycled back to the dredge for use as make up water for the SPU system and as jet water for debris dislodgment in the suction line. As controlled by the SPU, excess recirculation water was directed back to the hopper, from the discharge line, to decrease water content and increase the solids concentration of the dredge slurry. The recirculation system operated without any significant problems, and confirmed the feasibility of using such a system on the full-scale remediation.

PCB Removal Efficiency

The evaluation of the dredge efficiency at PCB removal included two components. The first (primary) goal was to evaluate the dredge's ability to remove contaminated sediment <u>to a given depth horizon</u> relative to the dredging plan. The dredge performance was highly accurate in this regard. Comparison of the target dredge volume with the actual volume dredged yielded an overdredging value of only 16%, with vertical accuracy of +/- 4 in. relative to achieving the intended horizon. Comparison on pre- and post-dredging sediment PCB concentrations revealed that 97% of the PCB mass was removed over the dredged area.

A secondary objective of the PDFT was to evaluate this new dredging technology with regard to site specific cleanup levels. The design included: 1) delineating the 10 ppm PCB concentration horizon within the test area; 2) establishing a dredging plan based on that depth; and 3) assessing the dredge's ability to remove sediment to that depth. It should be understood that the project goal was **<u>not</u>** to leave a final sediment concentration of 10 ppm (as an average concentration over the upper one foot); this was a field test, **<u>not</u>** a remedial operation. The dredge performed quite well in this regard. The average sediment PCB concentration (upper one foot) was reduced from 857 ppm to 29 ppm over the dredged area. This met the clean up criteria of 50 ppm for the Lower Harbor and approached the criteria of 10 ppm for the Upper Harbor. A similar reduction in sediment concentration was observed for the area dredged to planned depth and the area dredged to depth based on the visual method.

The PCB mass remaining after dredging appeared to reside entirely in a thin surface veneer and was attributed to recontamination of the dredged area rather than incomplete removal. Potential recontamination mechanisms include material sloughing down slope along the sides of a dredged cut, material mobilized during bucket impact and retrieval, material mobilized during anchor wire/spud repositioning, material mobilized during support vessel operations, and general transport related to tides and meteorological events. Adjustments to dredging and operational controls will reduce the influence of many of these mechanisms, and, therefore, a corresponding reduction in surficial sediment recontamination is expected during full-scale dredging.

Based on experiences during the PDFT, it was determined that remedial dredging to 10 ppm is possible through the use of modified operational procedures and project design. During full scale operations, development of a dredge plan and sequencing that proceeds from upslope to downslope and with an understanding of the site current (tidal) regime would be made to address some of the recontamination effects due to sloughing. Additionally, dredging operational approaches could be employed during the full scale project including return sweeps, tighter overlap of bucket grabs, and slower retrieval of final bucket grab that would provide for a cleaner bottom surface and reduce sloughing of adjacent areas. As confirmation sampling results became available they would be shared with the dredge contractor and the operator in particular to modify dredging techniques to obtain a bottom that met the cleanup criteria.

Water Quality Monitoring

The test dredge's ability to minimize environmental impact to water quality by measuring the extent of contaminated sediment resuspension and transport was evaluated by ENSR, and represented a joint effort by EPA, USACE, and ENSR.

To evaluate water quality impacts associated with the PDFT, the following investigations were made:

- Predictive modeling to aid in designing the water quality monitoring field program and to assess the utility of modeling for the full-scale remediation effort. In addition, the expected suspended sediment concentration resulting from dredging activities under a variety of transport assumptions was predicted; and

- Field monitoring to assess sediment resuspension during the dredging operation, to collect water samples for laboratory analysis and to ground-truth the predictive modeling. The objectives of field monitoring included real-time location and mapping of any turbidity plume associated with the dredging as well as collection of water samples at designated stations downstream of the dredge for laboratory analysis. The monitoring program was structured to document water column conditions in the Upper Harbor over the course of ebb and flood tidal events during dredging operations. Water samples were analyzed for total suspended solids (TSS) and dissolved and particulate PCBs. An assessment of the correlation of the field turbidity and laboratory TSS data as well as the laboratory TSS and PCB data was also performed.

Correlation assessment between the field and laboratory data was made. Water quality monitoring provided data over a range of operational and environmental conditions. Upon examination of the data, it can be concluded that:

- The actual dredging process (removal of sediments with the hydraulic excavator) appeared to have a limited impact on the water column;

- Activities performed in support of dredging (operation of support vessels) appeared to have a much greater impact on water quality than the dredging; and

- Normal fluctuations in water quality occur in the Upper Harbor related to changing environmental conditions that appear similar or greater in scale than the overall impacts related to the dredging operation.

Air Sampling and Analysis

Flux chamber samples and ambient air samples were collected to achieve various objectives during the PDFT. Flux chamber sampling provided a measure of emissions as an indication of the relative contributions from the various operations to the ambient air concentrations. These will also be used to support the emissions and dispersion modeling calculations performed as part of developing ambient air action levels for upcoming construction work. In addition to flux chamber samples collected in the field, sediment from the bench scale dewatering studies was tested at the USACE Waterways Experiment Station (WES) for emissions measurements.

PDFT flux chamber sampling provided useful data for evaluating relative emissions from various sources. Some key findings are summarized as follows:

- Emission flux measurements do not correlate well with source material concentrations. However, they do generally appear to be the highest in association with well-mixed sediment and water slurries in the CDF.
- *In situ* sediments in the mudflat area do not provide the same magnitude of emission flux per square area as well mixed sediment in the CDF. However, given the large surface area of the exposed mudflats at low tide, these areas and exposed surface water will continue to be a significant source of ambient air concentrations of PCBs, as measured during the Baseline study.
- Total emissions, calculated as (flux) x (surface area) x (time), are directly proportional to the amount of exposed surface area. Accordingly, exposed CDF surface area is a significantly greater source of emissions than dredging operations. The contaminated sediments in the mudflat areas and the river/harbor surface water remain the largest surface area sources of emissions.
- Dredging activities, including the grizzly, hopper, and disturbed sediments in the moon pool are relatively small sources of PCB emissions in comparison with the CDF because of their lower flux measurements and limited surface area.
- The use of surfactants Dawn and Biosolve to control the sheen at the CDF does not appear to be effective at controlling PCB emissions. These limited data suggest that Simple Green may be more effective than other surfactants although additional testing is recommended before drawing definitive conclusions.
- The silt curtain at the moon pool appears to be somewhat effective at containing disturbed sediment thereby reducing the surface area of higher concentration water and the associated emissions in the dredge area.

Ambient air samples were collected to document conditions during dredging and CDF filling operations. The results from this study will be used in conjunction with the flux chamber results to support development of ambient air action levels, being conducted by Foster Wheeler under a separate task.

Wastewater Treatment

Dredging operations conducted as part of the PDFT resulted in generating wastewater requiring treatment before final discharge to the harbor. The volume of wastewater generated during the PDFT was minimized by the use of the water recirculation system. In an effort to test the performance of the equipment and processes proposed for a full-scale wastewater treatment system, a pilot-scale wastewater treatment system was used to treat the wastewater generated during the PDFT. Construction of the pilot-scale system was conducted from August 3, 2000 through September 3, 2000. The system was operated from September 4, 2000 through October 13, 2000 to treat over 1-million gallons of wastewater. The objectives of the pilot-scale study treatment were to evaluate the treatment efficiency, flexibility and reliability of the individual unit operations/processes and confirm the findings of the wastewater treatability studies. The individual unit operations that were evaluated in the pilot-scale treatment included:

- Chemical addition and settling;
- Ultrafine (0.45 μm nominal) sand filtration;
- Granular activated carbon adsorption;

- UV/Oxidation; and
- Sludge dewatering with a plate and frame filter press.

Water samples were collected before and after each of the unit processes. These grab samples were analyzed for TSS, PCBs, and total and dissolved metals (cadmium, chromium, copper and lead). TSS data did not indicate substantial removal of suspended solids from any of the treatment processes. Further investigation indicated some difficulty with laboratory analysis for TSS due to elevated levels of salts present in the samples. For this reason, field turbidity measurements (as NTUs) were taken to be a more accurate indicator of suspended solids removal throughout pilot-scale treatment.

Analysis results also indicate that the contaminants present within the wastewater are strongly associated with the suspended particles and by removing these suspended solids the majority of the contaminants can be removed from the wastewater stream. However, due to the source of the wastewater (seawater) there are colloidal particles present which flocculation, clarification and filtration alone cannot remove. The concentration of PCBs and copper associated with these colloidal particles is sufficient enough that the wastewater could exceed the discharge limits unless tertiary treatment in the form of activated carbon is performed.

The dewatering component of the wastewater treatment pilot-scale study showed that dewatering can reduce the water content and volume of sludge generated during the wastewater treatment process. Sludge is generated during the clarification stage and the amount of sludge generated will depend upon chemical condition, wastewater flowrates, and system operating hours.

Comparison with Baseline Dredge Technology

The Ellicott 370 HP Dragon Series 10-inch (discharge) hydraulic cutterhead dredge, used on both the Pilot Dredging Study in 1989 and the Hot Spot Dredging event in 1995 had been established as the baseline for the Upper Harbor site in terms of dredge efficiency and performance. Prior studies had excluded mechanical dredging techniques for use on these two events due primarily to the inefficiency of barge transport to the disposal facility because of shallow operating depths, the perception that a hydraulic system left a more uniform bottom surface and concern over resuspension of contaminated sediments. Comparison was made of the key performance areas evaluated during the Pilot Dredging, Hot Spot Dredging and PDFT events. The three dredging performance evaluations were conducted across different test areas with different chemical and physical conditions and with different performance testing/cleanup objectives. The PDFT, however, has demonstrated that current state-of-the-art dredge technology, in particular a hybrid mechanical/hydraulic dredge with sophisticated environmental controls systems, can attain dredge performance values exceeding that of the baseline dredge, particularly in the areas of dredging accuracy, dredging production, and solids concentration of the dredge slurry. In terms of impacts to the environment, for both the baseline dredge technology (hydraulic cutterhead) and the PDFT state-of-the art test dredge, water quality was found to be impacted by support vessels and anchor movements more so than the dredging operation itself, and air quality was found to be impacted more at the CDF than at the point of dredging.

CONCLUSIONS

A state-of-the-art hybrid mechanical/hydraulic dredging system demonstrated dredge performance values exceeding that which have previously been achieved at the New Bedford Harbor site in the areas of dredge production, accuracy, and slurry solids concentrations. Both the sediment removal data and PCB data acquired indicate that the dredging technology used for the PDFT is very efficient and has a high probability of achieving sediment PCB clean-up goals established for Upper New Bedford Harbor. Furthermore, given the data set collected during this study, the question of residual contamination due to sloughing or migration should be able to be addressed logistically by modifying certain dredging procedures during a full-scale remediation. For full-scale remediation activities, the following dredge performance design values are recommended:

Dredge Performance Parameter	Recommended Design Value
Dredging Production, Water Depths greater than 4 ft. [1]	95 cy/hr
Dredging Production, Water Depths between 2 ft. and 4 ft. [1]	35 cy/hr
Dredging Accuracy, Vertical Plane, to Design Depth	+/- .4 ft
Dredging Accuracy, Vertical Plane, using Visual Approach	+/- .5 ft
Dredging Accuracy, Horizontal	+/- 1.5 ft
Average Solids Concentration of Dredge Slurry [2]	10% - 20% solids by weight
Use of Recirculation System for reuse of Dredge Effluent Water from CDF	Recommended

[1] Based on minimum of 10 hr. operating day

[2] Will vary depending on *in situ* density of dredged sediment

Water quality monitoring revealed only a very limited impact on the water column from the actual dredging in terms of both PCBs and suspended solids. The detected elevations of these parameters were within the range of fluctuations normally found in the Harbor with changing environmental conditions. This limited impact was attributed to the bucket design and the method of operation. Larger increases in water column suspended solids and PCB concentrations were attributed to dredging support activities.

Flux chamber samples and ambient air samples were collected to achieve various objectives during the PDFT. Overall, this air sampling indicated that CDFs will be a more significant PCB emissions source than the dredging platform.

Results of the wastewater treatment pilot study showed that granular activated carbon when used with clarification and filtration can remove PCB concentrations to below the site-specific discharge limit of 0.065 milligrams per liter (mg/L) per Aroclor. The study also showed that sludge generated from wastewater treatment plant operations could be dewatered using a plate and frame filter press.

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) entered into an Interagency Agreement with the U.S. Army Corps of Engineers, New England District (USACE) for the New Bedford Harbor (NBH) Superfund Site. Under this Interagency Agreement the USACE is providing EPA with technical assistance to implement the remediation plan selected in EPA's September 25, 1998 Record of Decision.

The remediation plan involves dredging of polychlorinated biphenyl (PCB) contaminated sediments throughout the Acushnet River estuary and New Bedford Harbor and placement of dredged material in shoreline confined disposal facilities (CDFs). Figures 1-1 and 1-2 provide site location maps of the New Bedford Harbor Superfund Site.

Prior dredging activities have been performed in the New Bedford Upper Harbor during the Pilot Dredging study in 1988 and 1989, and for the Hot Spot dredging in 1995. While these dredging events did demonstrate the use of a number of conventional and alternative hydraulic dredging systems, it was felt that changes in dredge technology over the years could improve upon past dredge production and other performance values.

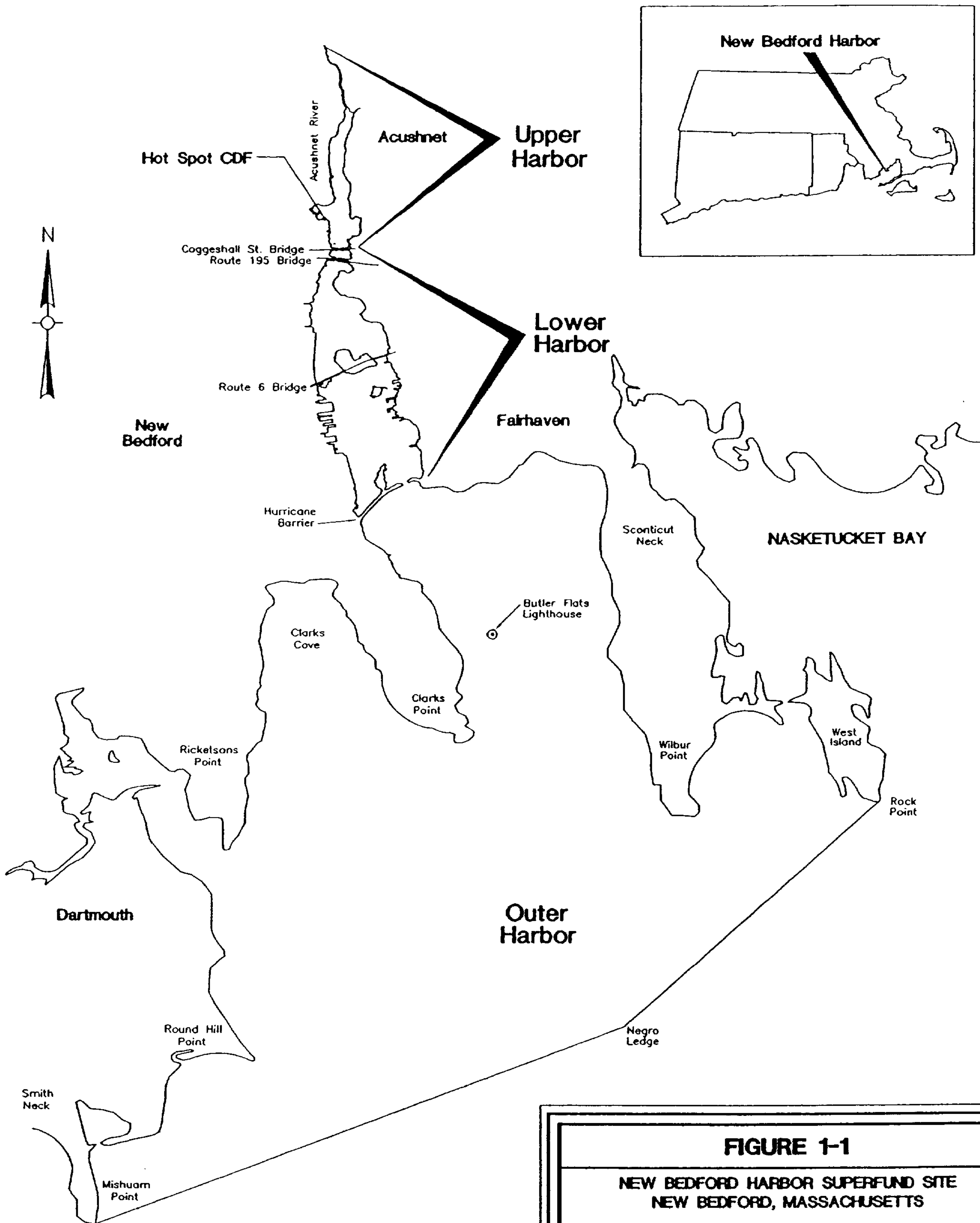
In 2000, Foster Wheeler Environmental Corporation (Foster Wheeler) working with the USACE performed preliminary and detailed evaluations of available dredge technologies to meet the specific requirements of the full scale remediation project. The primary requirements of the dredge equipment for the New Bedford Harbor cleanup were to demonstrate accessibility for dredging of the Upper Harbor given the low bridge clearance and shallow water depths, minimize resuspension of contaminated sediments, provide acceptable dredging production, minimize water added during the dredging process and demonstrate necessary dredging accuracy. From review and discussion of these evaluations with USACE and EPA, it was decided to field test the most promising dredging systems, in a Pre-Design Field Test (PDFT) before final selection of the dredge system(s) for the full scale cleanup is finalized.

1.1 Objectives

To evaluate the performance improvements of a state-of-the-art environmental dredge technology over conventional dredge technology previously used at the site several performance areas were evaluated:

- Percent (%) solids concentrations in the dredge slurry and slurry pumping capabilities;
- Horizontal and vertical dredging;
- Dredge production rates in shallow water and sediment with debris;
- Potential impacts to water quality;
- Potential impacts to air quality; and
- Removal of the contaminated sediments to a given depth.

A secondary goal of the PDFT was to evaluate this new technology with regard to site specific cleanup levels. Additional objectives of the PDFT were to evaluate the effectiveness of applying contaminant dispersants and flocculents within the CDF to reduce PCB losses to air from the CDF, to evaluate mechanical dewatering methods for water treatment sludges and to evaluate the use of granulated activated carbon (GAC) to treat decanted seawater.



NOT TO SCALE

FIGURE 1-1

NEW BEDFORD HARBOR SUPERFUND SITE
NEW BEDFORD, MASSACHUSETTS

SITE LOCATION MAP

FOSTER WHEELER ENVIRONMENTAL CORPORATION
TERC PROGRAM

CADDFILE: SUPERFUNDSITE.DWG

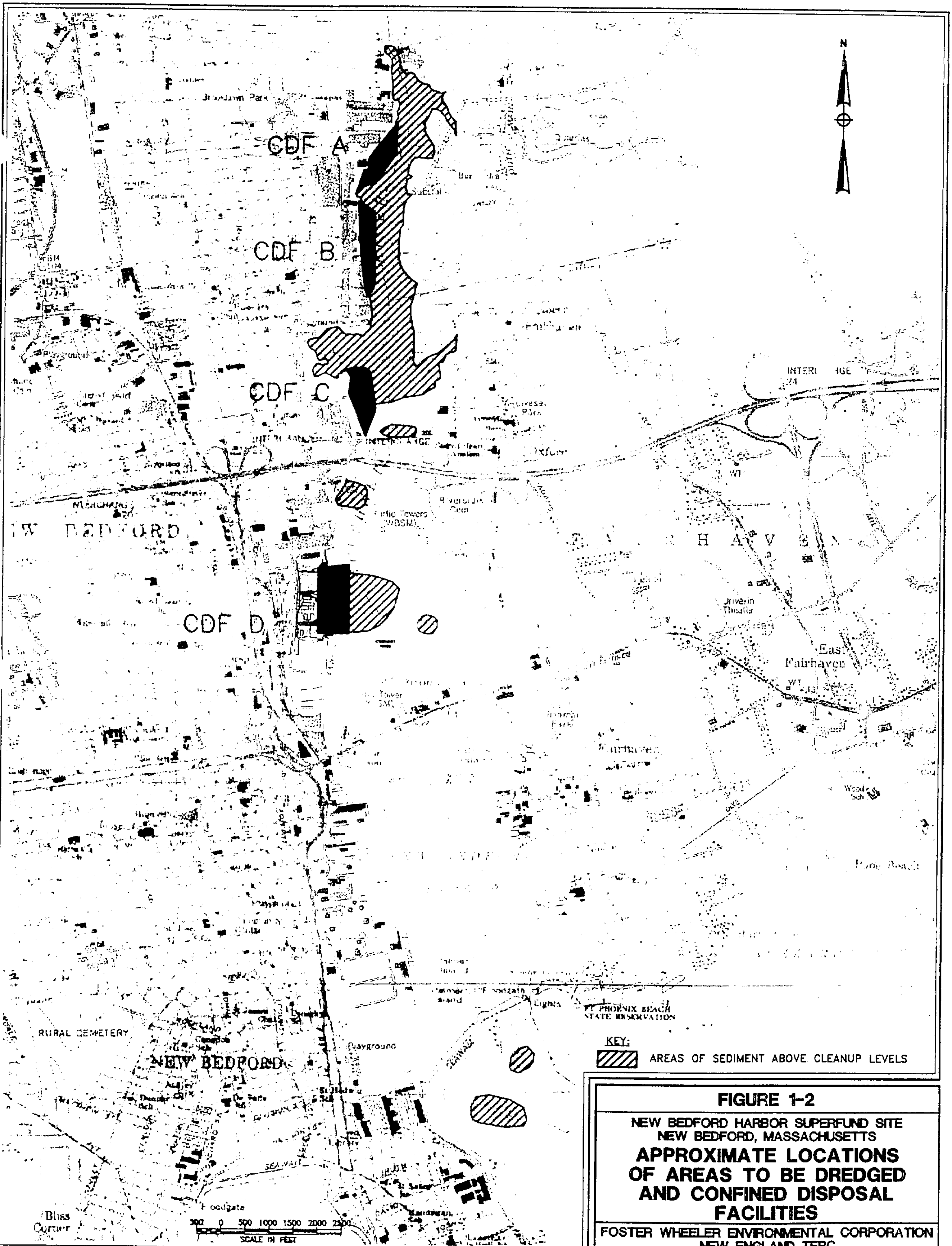


FIGURE 1-2

NEW BEDFORD HARBOR SUPERFUND SITE
NEW BEDFORD, MASSACHUSETTS

APPROXIMATE LOCATIONS OF AREAS TO BE DREDGED AND CONFINED DISPOSAL FACILITIES

FOSTER WHEELER ENVIRONMENTAL CORPORATION
NEW ENGLAND TERC

CADDFILE: 5197NB13.DWG

Originals in color.

1.2 Pre-Design Field Test Plan

1.2.1 Dredge Technology Selection

The reports *New Bedford Harbor Cleanup Dredge Technology Review* (FWENC, 1999) and *Evaluation of Dredge Technologies, Phase Two - Detailed Evaluation* (FWENC, 2000a) were prepared to assist in the dredge technology selection for the full scale remediation project.

The report *New Bedford Harbor Cleanup Dredge Technology Review* (FWENC, 1999) provides a current assessment of the available dredge plant and support equipment that can be considered in determining how the environmental remediation dredging will be performed in New Bedford Harbor. The report evaluates potential dredging technologies that can address a set of specific challenges and criteria that have been identified in previous studies. These include the following:

- Maximize solids content and thereby reduce water volume and water treatment;
- Minimize re-suspension of contaminated marine sediments while dredging;
- Dredge in water depths of 1 to 4 feet (ft.) and intertidal areas;
- Perform precision dredging to minimize overdredging, which would add to the volumes of material requiring disposal in CDFs;
- Dredge in sediment having significant debris;
- Attain relatively high production rates; and
- Minimize or eliminate odors and PCB volatilization (control floatables and oils with specific emphasis on controlling contaminated oil releases during dredging).

As part of the *New Bedford Harbor Cleanup Dredge Technology Review* (FWENC, 1999) a dredge systems matrix was developed to organize and summarize the technologies that could meet the criteria established for the project. The following categories of information were investigated and summarized in the matrix for each dredge technology originally screened (Table 1-1).

Table 1-1
Dredge Technology Evaluation Matrix

Category	Specification
Dredge Type	Mechanical, Hydraulic, or Mechanical / Hydraulic (Hybrid)
Dredge Size (Plant)	Length x Beam x Height
Draft (ft.)	Loaded Draft (ft.)
Dredge Size (Pump / Bucket)	Pump Discharge Diameter (in.) or bucket size (cy)
Production Capacity	Working Production Capacity (cy/hr)
Debris Handling	Very Good, Fair or Poor
Vertical Cutting Accuracy (ft.)	Attainable Vertical Cutting Accuracy
Slurry Density	Advertised Slurry Density (% solids by weight)
Positioning / Monitoring System	Type, Accuracy
Surface oil collector	(Yes / No)
Sediment Re-suspension Minimization	(Good / Poor)
Projects Completed	Project Name Location Project Start / Completion Dates Volume of Sediment Dredged (cy) Pipeline / Haul Distance (ft.) Unit Cost ($/cy)
Dredge Cost	Cost to Purchase / Maintain Dredge

Over sixty (60+) dredge technologies available in the United States and internationally were initially screened for application on the New Bedford Harbor project in the report. Several preferred dredging systems and components were proposed for further evaluation by Foster Wheeler. Based on the project constraints, described above, the following dredge systems and components were proposed for further investigation.

Table 1-2
Dredge Technologies Selected in *Dredge Technology Review*

Manufacturer / Operator	Dredge Technology
Bean Technical Excavation Corporation	*Bonacavor* Hydraulic Excavator
Normrock Industries	*Amphibex* Amphibious Excavator
Aquarius Industries	Amphibious Excavator
DRE-Technologies	Dry-Dredge
Ellicott International	Series 370HP Hydraulic Cutterhead IHC Holland
WILCO Marsh Buggies Inc.	LGP Track Mounted Excavator
Quality Industries	LGP Track Mounted Excavator
Cable Arm Inc.	Cable Arm Environmental Clamshell
Miscellaneous	Land-based Earthmoving Equipment

These dredge systems and components represent existing available technology that have completed full scale environmental remediation projects and are believed to meet many of the New Bedford Harbor Cleanup Project parameters. These technologies were further screened and evaluated against the project criteria in the report *Evaluation of Dredge Technologies, Phase Two - Detailed Evaluation* (FWENC, 2000a). In this study contact was made with dredge technology representatives and project managers who are most familiar with the technologies. In some cases a site visit was made. Based on this intermediate evaluation, the dredge technologies having the highest probability for success in meeting the New Bedford Harbor project constraints were identified and proposed for further investigation by site demonstration or meetings with technology representatives.

These technologies were selected by Foster Wheeler and USACE project staff knowledgeable of the New Bedford Harbor project and performance parameters. They included the following:

- Bean Technical Excavation Corporation (Bean TEC) *Bonacavor*
- Normrock Industries *Amphibex*
- Ellicott International Series 370 hydraulic cutterhead dredge

Photographs of and technical data for these dredge systems are provided in Appendix P.

The studies concluded that dredging technology used for environmental remediation dredging has changed substantially since completion of both the New Bedford Harbor Pilot Dredging Study in 1988-1989 and the Hot Spot Dredging event in 1995. Prior studies had excluded mechanical dredging techniques for use on these two events due primarily to the inefficiency of barge transport to the disposal facility, because of shallow operating depths, the perception that a hydraulic system left a more uniform bottom surface, and concern over resuspension of contaminated sediments.

In the 1990's, in response to a growing number of environmental remediation projects, hybrid dredging systems (the mating of a mechanical excavation system and a hydraulic transport system) have been developed and used to successfully complete a number of full scale sediment remediation projects. The Bean TEC environmental hydraulic excavator *Bonacavor* and the Normrock Industries *Amphibex*, are two such systems that have completed full-scale projects, and would likely be well suited to complete portions of the full scale cleanup at New Bedford Harbor. Conventional hydraulic cutterhead dredge systems have also been successfully used to complete contaminated sediment removal projects, including the New Bedford Harbor Hot Spot Dredging, and could complete portions of the full scale cleanup successfully.

The Ellicott 370 hydraulic cutterhead dredge had been used during both the Pilot and Hot Spot dredging events, and to date, had provided the best all around performance results at the site. Significant testing and data collection regarding the dredge performance had been achieved for this dredge and documented. The Ellicott 370 hydraulic cutterhead dredge was therefore established as the baseline for comparison of the newer dredge technologies to be tested.

The Normrock Industries *Amphibex* was concluded to represent the most applicable type of "amphibious" dredge technology for the full scale cleanup in shallow and intertidal areas, and the manufacturer was approached to coordinate a field demonstration during the PDFT. At the time however, Normrock Industries, a Canadian firm, had manufacturing operations located only in Canada. Therefore, it's dredge, having been built on a foreign hull, was prohibited from operating in navigable waters of the U.S. under the Jones Act, and thereby precluded from participation in the PDFT. The company has since opened a manufacturing facility for the *Amphibex* in the United States, and as the hull is now not foreign built, it may be further considered for use on the New Bedford Harbor Cleanup, and other dredging operations in the U.S.

The PDFT therefore focused on the Bean type environmental hydraulic excavator for testing on the New Bedford Upper Harbor. Coordination between the Bean Dredging Corporation, the parent company of Bean Environmental LLC (BELLC), and Foster Wheeler was initiated in early 2000, for participation in development and demonstration of a Bean type environmental hydraulic excavator.

Foster Wheeler contracted with BELLC to develop a dredging system that enables selective dredging of the contaminated sediment, minimizes the amount of water added during the slurry pumping process, and recycles the dredge slurry effluent. This dredge system was a modification of the original Bean type environmental hydraulic excavator *Bonacavor*, used successfully on the Bayou Bonfouca Superfund project.

1.2.2 Dredge Performance Tests

The BELLC dredge and support systems were mobilized to the project site in late July 2000. With final assembly of the dredge system and movement into the dredge test area, the BELLC dredge underwent a series of performance tests. Dredge performance parameters monitored by Foster Wheeler and USACE during the field test are described below. Performance monitoring performed by BELLC is also described.

Production Monitoring

Dredge production monitoring was performed over the course of dredge operations in the PDFT test area. Dredging was performed both with and without operational controls (reductions in advance speed and dredge cycle time) to obtain representative production rates over a range of conditions, including varying water depths, depth of cut (bank height), and chemical and geotechnical conditions. BELLC collected production data using a number of electronic data collectors for the dredge systems, including flow meters, production meters, crane monitoring system, and slurry processing data. Foster Wheeler and BELLC production engineers also recorded excavator cycle time, and production delay data throughout the duration of the tests. Production monitoring data was summarized daily, and used as baseline for the following days tests. All production monitoring data collected over the course of the PDFT was assimilated, checked for quality, and screened for use in developing production ranges for the dredge that would be reflective of a full scale operation. The dredge production monitoring program results are presented in Section 3.0, Dredge Performance.

Dredging Accuracy

The BELLC dredge tested was specified to achieve average horizontal positioning and dredging accuracy of +/- 2 ft. or better and average vertical dredging accuracy of +/- 0.5 ft. or better. Initially it was planned that the USACE would measure the horizontal and vertical dredging accuracy, and to ascertain smoothness of the dredge cut including development of windrows, and "potholing" with daily post dredge bathymetric surveys. BELLC's bathymetric survey system however was setup to acquire the pre-dredge survey data for use as part of their dredge positioning and guidance system. The BELLC surveys were used for the PDFT. BELLC recorded the horizontal and vertical dredge excavation position on a continuous basis, as daily progress surveys. A final post-dredge bathymetric survey was conducted by BELLC over the test area, and verified by the USACE survey team. The dredging accuracy results and project surveys are presented in Section 3.0, Dredge Performance.

1.2.3 Environmental Monitoring

Water Quality Monitoring

Water quality monitoring was performed by the USACE subcontractor ENSR International (ENSR) during field testing of the BELLC dredge, to assess sediment resuspension at the point of dredging and downstream of the dredging operation. The dredge system to be tested, including support equipment, was capable of modifying dredge performance with operational controls to minimize resuspension of bottom sediments. The water quality monitoring program results are presented in Section 4.0, Environmental Monitoring.

Air Sampling

Foster Wheeler's subcontractor, The Kevric Company, performed ambient air sampling and analysis during the PDFT to document concentrations during operations. Locations were selected based on the proximity to dredging and CDF filling operations and included those around the CDF and near dredging operations on the eastern shore of the harbor. In addition, Foster Wheeler's subcontractor URS Corporation collected flux chamber samples to provide a measure of emissions as an indication of the relative contributions from the various operations to the ambient air concentrations. Flux chamber data will also be used to support the emissions and dispersion modeling calculations performed as part of developing ambient air action levels for upcoming construction work. Flux chamber and ambient air sample results are presented in Section 4.4.