US ARMY CORPS
OF ENGINEERS
New England District

Contract No. DACW33-03-D-0004

Delivery Order No. 22

June 2008

FINAL
Water Quality Monitoring Summary Report

2007 Remedial Dredging

Environmental Monitoring, Sampling, and Analysis

New Bedford Harbor Superfund Site

New Bedford Harbor, MA

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Submitted to:

Department of the Army
U.S. Army Corps of Engineers
North Atlantic Division
New England District

Contract Number: DACW33-03-D-0004
Delivery Order Number: 22

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June 2008

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EXECUTIVE SUMMARY

Remediation dredging was performed in New Bedford Harbor from August 6th through October 9th 2007. Dredge activities occurred primarily in two areas: 'Area G' encompassing sections of DMU-1 and DMU-102, and 'Area H' encompassing sections of DMU-9 and DMU-10, and DMU-11. The primary objective of the water quality monitoring program is to conduct boat-based monitoring to provide field reconnaissance information to the United States Army Corps of Engineers (USACE), United States Environmental Protection Agency (USEPA), and dredging operators, to gauge the extent of potential water quality impacts that may result from dredging operations. These data are used to guide project operations as necessary to minimize environmental impacts, limit potential recontamination of previously dredged areas, and ensure that the dredging activities are conducted in a manner which does not hinder the seasonal migration of anadromous fish to and from the Acushnet River.

Water quality monitoring started on August 6, 2007 prior to the dredge operations to establish background levels, and ended October 9, 2007, approximately two weeks after dredging stopped. Monitoring activities utilized YSI sondes to collect instantaneous real time data from the monitoring vessel. Additional YSI sondes were deployed on moorings to collect longer term data. Each YSI was equipped to measure turbidity, salinity, temperature, depth and dissolved oxygen. The project criterion, termed as a "reportable event", is defined as 50 Nephelometric Turbidity Units (NTU) above background measured 600 feet (ft) downstream of the dredging and associated activities. A warning level is defined as an exceedance of 50 NTU above background at 300 ft downstream of the dredging and associated activities. If the warning level was exceeded, the USACE was to be contacted immediately to determine what, if any, operational modifications might be warranted to abate the condition and to reduce the potential for a criteria exceedance at the 600-foot transect. Neither the warning level nor the project criterion was exceeded at any time during the 2007 monitoring.

Water samples were collected for turbidity and total suspended solids (TSS) analyses on six occasions during the dredge program. Samples from three of these events were also collected for polychlorinated biphenyls (PCB) and toxicity testing. Metals samples were collected during four of the sampling events and were archived for potential analysis. Samples were collected either to establish baseline conditions and/or re-establish relationships between field measurements (i.e. turbidity) and toxicity results to verify the protectiveness of the 50 NTU criteria. No samples were collected in response to an exceedance of the 50 NTU turbidity criteria. Data collected confirmed that the 50 NTU criterion continues to be ecologically protective, while still allowing remediation efforts to progress.

The deployment of the continuously recording water quality sensors (YSI sondes) provided additional information to compliment the adaptive monitoring approach discussed above. The location of sensors both north and south of the dredge areas provided information about tidal influences on sediment suspension and transport. Continuous readings provided water quality data for periods when adaptive boat-based sampling was not underway. This included inactive dredge periods such as nights and weekends, which provided a reasonable background condition for comparison.

As expected, turbidity correlated well with TSS ($R^2 = 0.9367$) in the two dredging areas. Samples collected from Area G showed higher correlation between total PCB with TSS and thus with turbidity than the samples from Area H. Dissolved PCB concentrations were generally low in both areas and did not correlate well with TSS.

1.0 INTRODUCTION

1.1 Site Description

The New Bedford Harbor Superfund Site (Site), located in Bristol County, Massachusetts (MA), extends from the shallow northern reaches of the Acushnet River estuary south through the commercial harbor of New Bedford and into 17,000 adjacent acres of Buzzards Bay (Figure 1). Industrial and urban development surrounding the harbor has resulted in sediments becoming contaminated with high concentrations of many pollutants, notably polychlorinated biphenyls (PCBs) and heavy metals. Two manufacturers in the area used PCBs while producing electronic devices from 1940 to the late 1970s, when the use of PCBs was banned by the U.S. Environmental Protection Agency (USEPA). Based on human health concerns and ecological risk assessments, USEPA added New Bedford Harbor to the National Priorities List in 1983 as a designated Superfund Site. Through an Interagency Agreement between the USEPA and the U.S. Army Corps of Engineers, New England District (USACE NAE), the USACE is responsible for carrying out the design and implementation of the remedial measures at the site. The Site has been divided into three areas – the upper, lower and outer harbors – consistent with geographical features of the area and gradients of contamination (Figure 2). All of the 2007 activities conducted under the Water Quality Monitoring occurred in the upper Harbor.

Aerovox Inc. in New Bedford, MA used PCBs in the manufacture of electrical capacitors from approximately 1940 to 1977. This facility is located in the upper harbor and is considered one of the major sources of historic PCB contamination to New Bedford Harbor. The highest concentrations of PCBs were found in sediments in a 5-acre area in the northern portion of the Acushnet River Estuary adjacent to the Aerovox facility. These 'hot spot' sediments, which contained PCBs upwards of 100,000 milligrams per kilogram (mg/kg), were removed between 1994 and 1995 as part of USEPA's 1990 "Hot Spot" Record of Decision (ROD). Full scale remediation dredging per the 1998 Upper and Lower Harbor ROD was initiated in 2004 and continued in 2005, 2006, and 2007. Another known source of PCB contamination in New Bedford Harbor is related to activities at the Cornell-Dubilier mill on the western shore of the outer harbor. In 2005, a 15 acre underwater cap pilot project (Figure 2) was implemented near Cornell-Dubilier to cap PCB contaminated sediments.

The Site is divided into a series of Dredge Management Units (DMU) based on contamination levels, contamination sources, topography, and other factors. In 2007, dredge activities were conducted at two areas: 'Area G' encompassing sections of DMU-1 and DMU-102 and 'Area H' encompassing sections of DMU-9 and DMU-10, and DMU-11 (Figure 3).

The remediation of this Site per the 1998 ROD involves the excavation and dredging of approximately 880,000 cubic yards of PCB contaminated sediment. The majority of contaminated material is being removed utilizing a hydraulic dredge that pumps dredge slurry to the project's Sawyer Street facility where it is mechanically processed to remove all sand, gravel, and debris material. The silt and clay size materials are then pumped to the Area D Dewatering Facility located on Herman Melville Boulevard where it is mechanically dewatered and transported off-site for disposal.

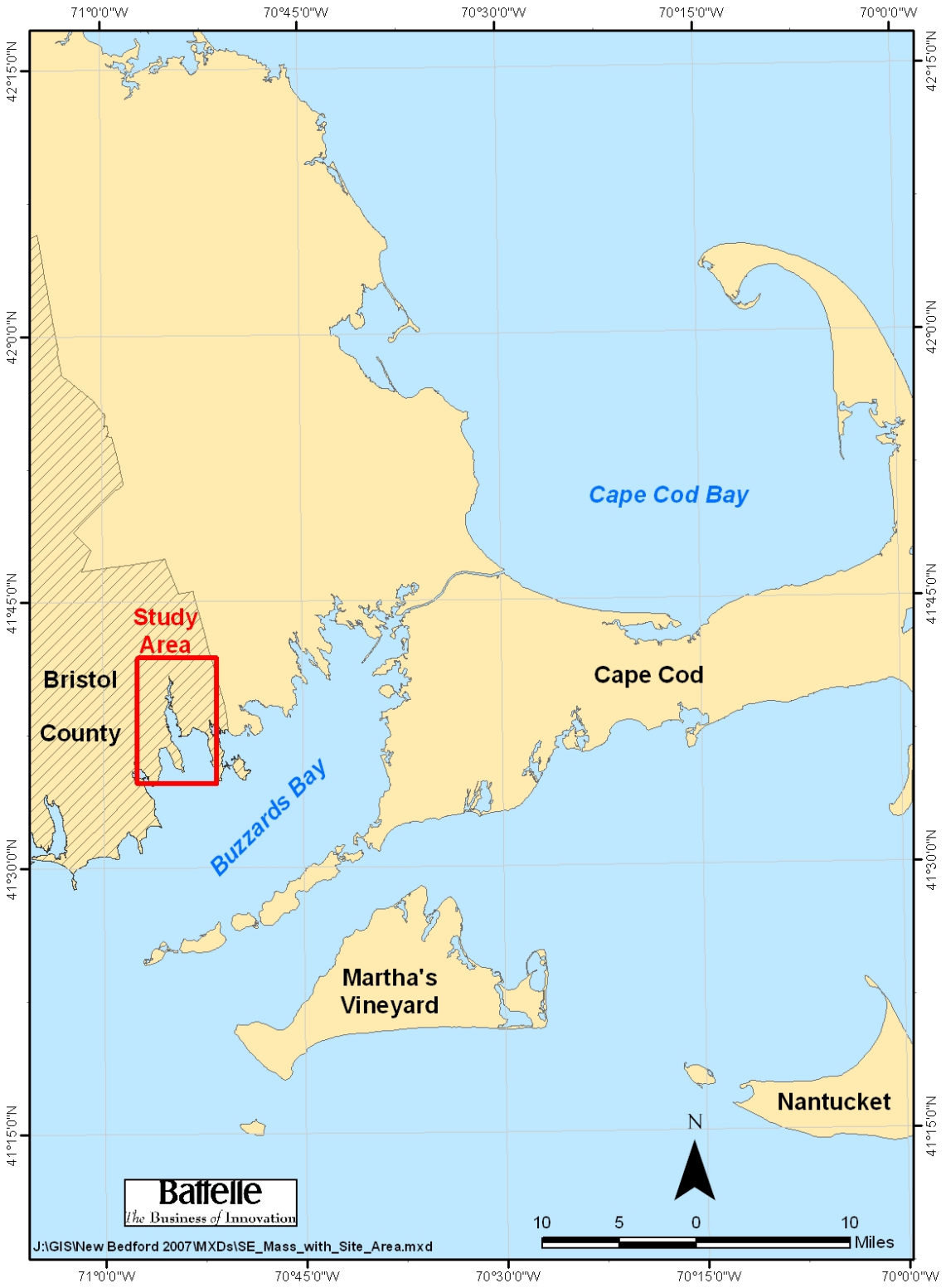


Figure 1. Location of the Site in Southeastern MA.

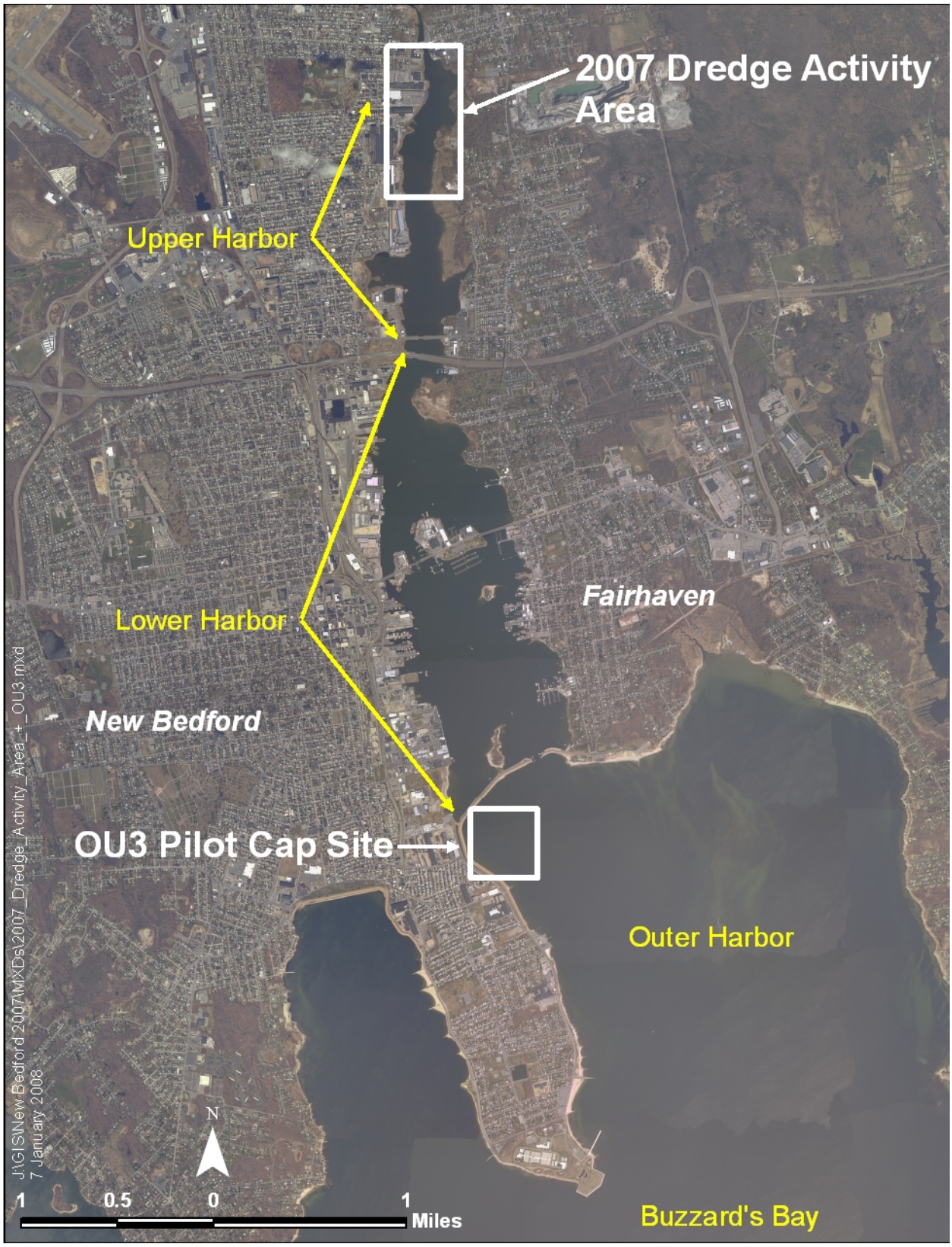


Figure 2. Location of the 2007 Dredge Activity Area within New Bedford Harbor.

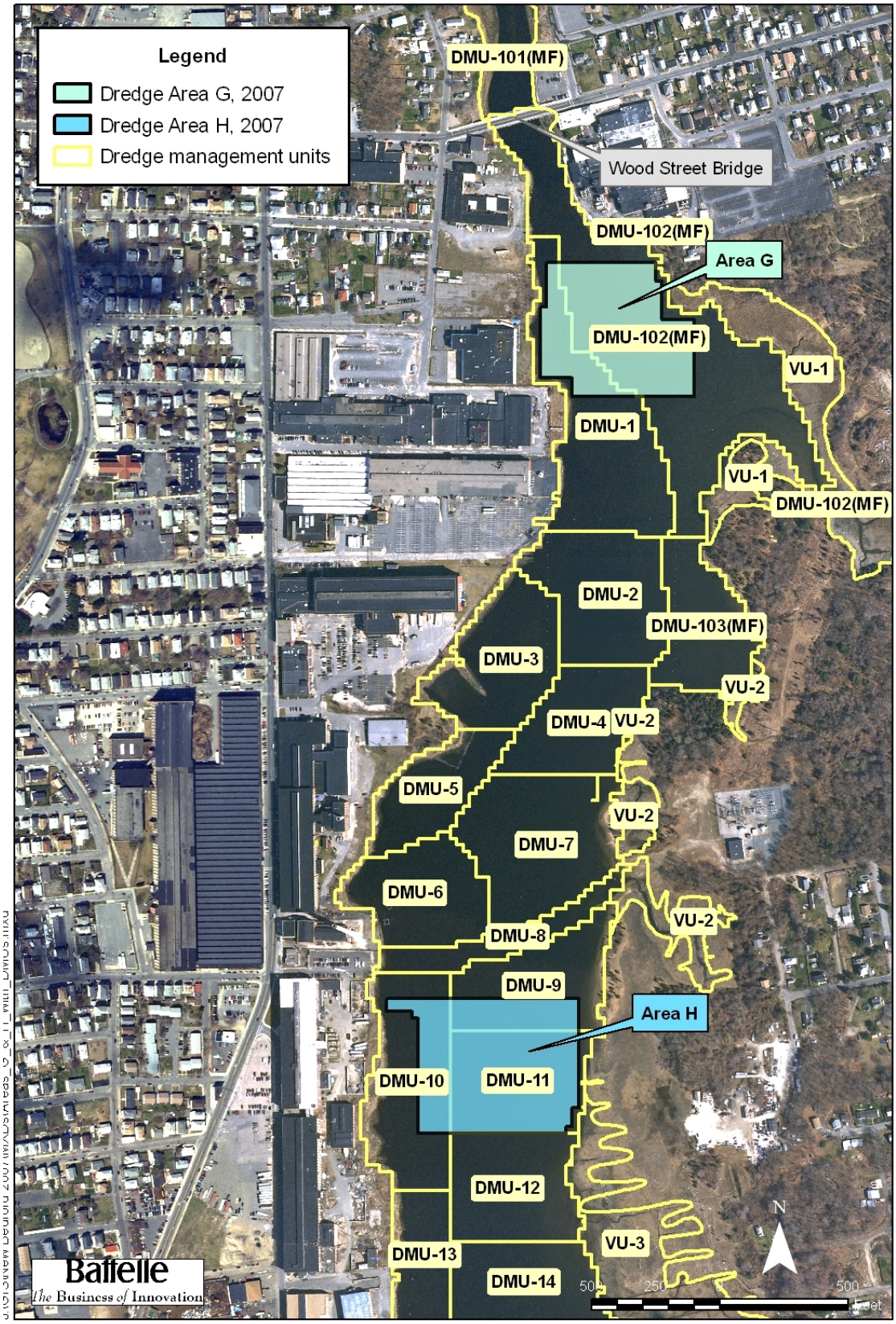


Figure 3. 2007 Dredge Areas

1.2 Project Objectives

The resuspension of sediments during dredging, and dredging related activities, can transport contaminated sediments away from the dredge area. Additionally, contaminated sediments suspended in the water column present a concern for potential toxicity to aquatic organisms in the project area. The primary objective of the 2007 monitoring effort was to conduct boat-based field monitoring to provide field reconnaissance information to the USACE, USEPA and dredging operators, to gauge the extent of water quality impacts resulting from dredging operations. This information may be used to make operational adjustments as needed to limit the dispersal of suspended sediments and their associated contaminants as well as limit the extent of biological impacts to the water column. An additional objective was to ensure that the dredging activities were conducted in a manner which did not hinder the seasonal migration of anadromous fish in the Acushnet River (i.e. fish are able to successfully navigate past dredging operations).

The project criterion, termed as a "reportable event", is defined as 50 Nephelometric Turbidity Units (NTU) above background measured 600 feet (ft) downstream of the dredging and associated activities. A warning level is defined as an exceedance of 50 NTU above background at 300 ft downstream of the dredging and associated activities. If the warning criteria was exceeded, the USACE was to be contacted immediately to determine what, if any, operational modifications may be warranted to abate the condition and to reduce the potential for a criteria exceedance at the 600-ft transect.

1.3 Water Quality Monitoring Program

The focus of the 2007 water quality monitoring program was on near-field water column impacts as well as assessment of the extent of sediment resuspension and transport away from the dredging operation. These data are used to guide project operations as necessary to minimize environmental impacts, limit potential recontamination of previously dredged areas, ensure that the dredging activities are conducted in a manner which does not hinder the seasonal migration of anadromous fish to and from the Acushnet River, and to determine the degree and extent of sediment plumes advecting away from the Site during dredging operations. To meet this objective, a tiered monitoring approach was employed which incorporated field measurements of turbidity and water quality parameters and water sampling for toxicity testing and laboratory analysis on a periodic basis as needed. Water column measurements were conducted along four transects for each of the dredge areas described below and illustrated in Figure 4. As dredging operations moved throughout the dredge areas, the monitoring locations moved relative to those activities as follows:

- **Reference:** A reference station 1,000 ft up-current of dredging operations to provide background conditions. A reference station was identified for each of the two dredge areas for both ebb and flood tide conditions.
- **Dredge Boundary:** Measurements were made at the edge of the dredge area. This is defined as a down-current location as close as practicable and as safety allows.
- **300 ft Downstream:** Defined as a transect set, 300 ft down-current from the dredging operation.
- **600 ft Downstream:** Defined as a transect set, 600 ft down-current from the dredging operation.

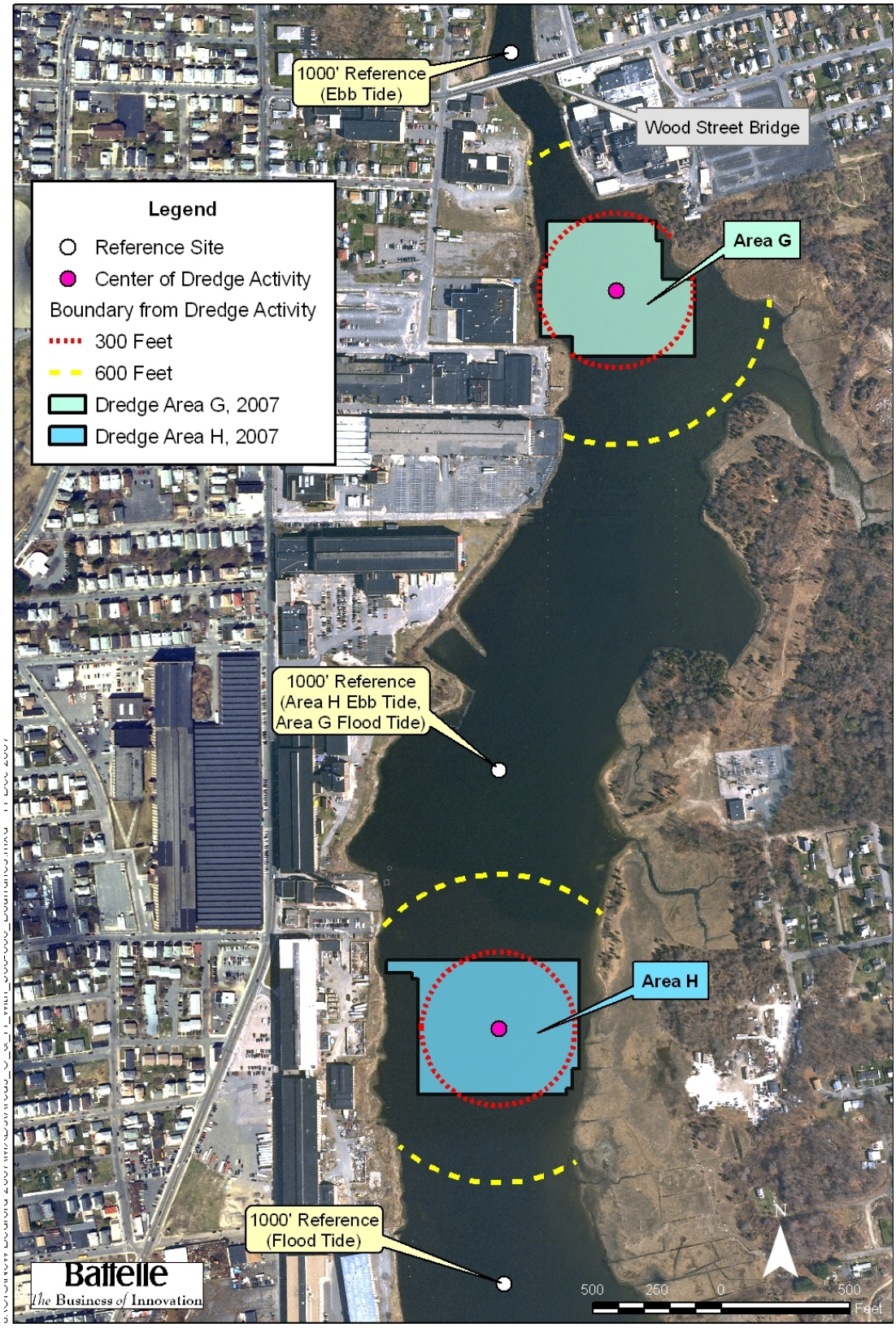


Figure 4. Example of Monitoring/Sampling Locations (Relative to Dredge Areas G & H).

2.0 METHODS

Methods used to establish the sampling approach, conduct *in-situ* measurements, and collect and analyze discrete samples are summarized below. Complete details are also provided in the project Quality Assurance Project Plan (QAPP, Battelle 2006a) and the Water Quality Field Sampling Plan (FSP) (Battelle, 2006b).

2.1 Sampling Approach

The established sampling approach for this program employs a variety of sampling methods to characterize sediment resuspension, sediment transport, and its potential impact on water quality. As with previous monitoring efforts, a tiered approach is employed using varying levels of monitoring intensity to assess and gauge project related water quality impacts as described in Section 2.1.1. Water quality monitoring is performed along transects immediately adjacent to the dredge operation, at defined distances down-current, and at an up-current reference station as described in Section 2.1.2.

2.1.1 Sampling Design

The overall approach utilizes an adaptive, criteria-based sampling scheme to monitor project-related water quality impacts. This is broken up into a series of sampling 'levels' which vary in the degree to which analytical samples are collected. The more intensive levels were utilized when there was greater potential for a specific dredging activity to have an impact on water quality. This was particularly true for new activities or activities in new areas. Based on information from these sampling levels, sampling was reduced to the lower intensity levels when appropriate. Sampling Levels I, II, and III are designed to collect water samples at designated distances away from the dredge operation to limit the extent of impact (Boundary, 300 ft, and 600 ft). A reference station located 1,000 feet up-current from the dredge area (see Section 2.1.2) is used to establish background turbidity readings. Based on results acquired throughout the monitoring season, a second type of sampling was added to the design. Under this approach, specific levels of turbidity were targeted for sampling regardless of their location relative to dredging. This approach was added to evaluate relationships, if any, among the turbidity, PCB, and toxicity data and to confirm that current criteria are adequately protective of the aquatic environment. These approaches are discussed below. The criteria-based sampling, which followed the decision sequence, is illustrated in Figure 5. Table 1 lists all sample collection information.

- **Level I:** Level I represents a sampling approach for discrete samples and was conducted for those activities considered to have the greatest potential to impact water quality or when new conditions were encountered. Initially discrete samples were collected at designated locations: Reference, Dredge Boundary, 300 ft downstream, and 600 ft downstream. At each station discrete water samples were collected for all parameters from the depth of highest turbidity, based on the *in situ* readings.

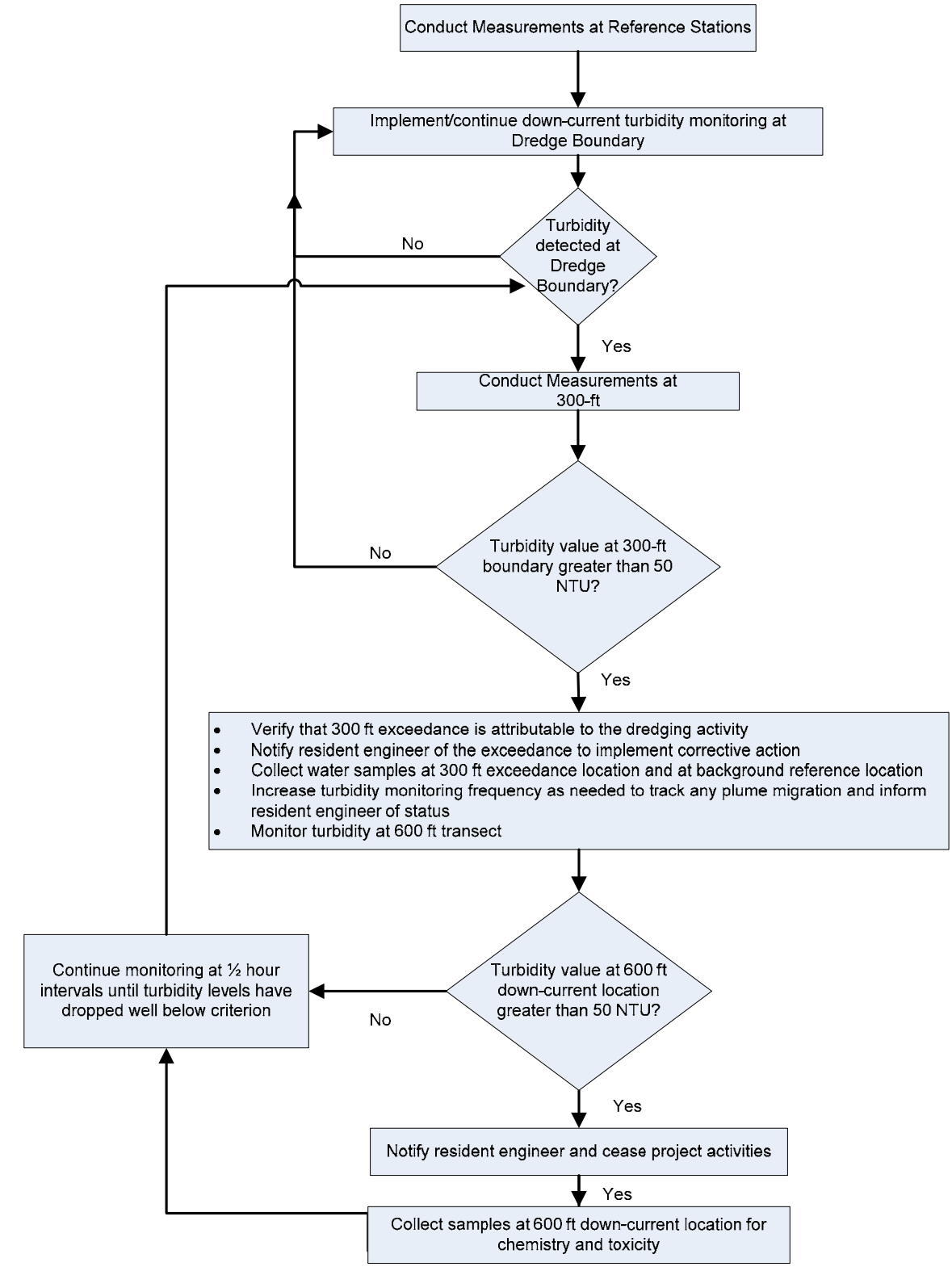
  During the 2006 monitoring season it was observed that sampling under Level I, while achieving its objectives, did not capture any significant elevated turbidity levels above background at the downfield transects. As a result, Level I sampling was modified to include additional discreet sample collections at locations having a full range of turbidities (25-100 NTU) that could be used to evaluate the protectiveness of the warning

and project turbidity criterion. This sampling modification was also conducted during the 2007 monitoring season. In all cases it was necessary to sample in close proximity (<300 ft) from debris removal operations to collect high turbidity samples; samples were often collected within 75 ft from dredge operations. These samples were obtained to evaluate turbidity/PCB/toxicity relationships and did not represent exceedances of water quality criteria.

- **Level II:** Level II represents a lower level of monitoring intensity compared to Level I, and is performed under conditions where there is a decreased concern for water quality impacts from an activity. Similar to Level I, Level II was designed to collect samples based on distance from dredge activities although 600 ft samples are not required due to the decreased concern for far-field impact(s). Similar to Level I, modifications were made during the dredge season to adequately characterize the sediment plume which was rarely found near the pre-established transects.

- **Level III**: Routine *in situ* monitoring. Sampling was conditional based on results of turbidity monitoring. Furthermore, a Level III monitoring effort was contingent upon any exceedance of the project-based criterion or based on detection of sheens or plumes emanating from the project area. It should be noted that at no point during the 2007 season were any of the Level III criteria exceeded. As a result no samples were analyzed under the Level III design.

- **Field QC**: Field duplicates were collected at a frequency of approximately one per twenty samples for PCB, TSS, and Turbidity analysis. Equipment blanks for water samples were collected at a frequency of one per twenty samples for PCB, TSS, and Turbidity analysis. QC samples were collected based upon opportunity during planned sampling events.



Notes: 1:50 NTU value was defined as 50 NTU above background turbidity level

Figure 5. Decision Sequence for Water Quality Monitoring.

Table 1. Samples Collected During the 2007 Monitoring Season.

Week	Date	Monitoring Level	Sample Description[1]	Sample ID	Parameters[2]
1	8/6/07	III	NA	NA	NA
	8/7/07	III	NA	NA	NA
	8/8/07	III	NA	NA	NA
	8/9/07	Level I (Background)	Mid-Reference-Area H	WQ-XXX-001-080907	DPC, TPC, TSS, TUR, TOX, MET
			13 NTU-Area H	WQ-XXX-002-080907	DPC, TPC, TSS, TUR, TOX, MET
			20 NTU-Area H	WQ-XXX-003-080907	DPC, TPC, TSS, TUR, TOX, MET
			55 NTU-Area H	WQ-XXX-004-080907	DPC, TPC, TSS, TUR, TOX, MET
2	8/13/07	III	NA	NA	NA
	8/14/07	III	NA	NA	NA
	8/16/07	II	Wood St. Reference-Area G	WQ-XXX-001-081607	TSS, TUR, MET
			200 ft S from Debris Removal-Area G	WQ-XXX-002-081607	TSS, TUR, MET
			Dredge Boundary, Area G	WQ-XXX-003-081607	TSS, TUR, MET
			300 ft S of Dredge Boundary, Area G	WQ-XXX-004-081607	TSS, TUR, MET
	8/17/07	III	NA	NA	NA
3	8/20/07	III	NA	NA	NA
	8/21/07	III	NA	NA	NA
	8/22/07	III	NA	NA	NA
4	8/27/07	III	NA	NA	NA
	8/28/07	III	NA	NA	NA
	8/29/07	II	Wood St. Reference-Area G	WQ-XXX-001-082907	TSS, TUR
			75 ft from Debris Removal-Area G	WQ-XXX-002-082907	TSS, TUR
			Dredge Boundary, Area G	WQ-XXX-003-082907	TSS, TUR
			300 ft from Dredge Boundary, Area G	WQ-XXX-004-082907	TSS, TUR
5	9/4/07	III	NA	NA	NA
	9/5/07	III	NA	NA	NA
6	9/10/07	III	NA	NA	NA
	9/11/07	I	Wood St. Reference-Area G	WQ-XXX-001-091107	DPC, TPC, TSS, TUR, TOX, MET
			23 NTU, 75 ft from Debris Removal-Area G	WQ-XXX-002-091107	DPC, TPC, TSS, TUR, TOX, MET
			60 NTU, Area G	WQ-XXX-003-091107	DPC, TPC, TSS, TUR, TOX, MET
	9/12/07	III	NA	NA	NA
	9/14/07	III	NA	NA	NA
7	9/17/07	III	NA	NA	NA
	9/19/07	III	NA	NA	NA
8	9/24/07	III	NA	NA	NA
	9/25/07	II	55 NTU-75 ft S of Dredge-Area H	WQ-XXX-001-092507	TSS, TUR
			90 NTU-50 ft S of Dredge-Area H	WQ-XXX-002-092507	TSS, TUR
			10 NTU-100 ft S of Dredge-Area H	WQ-XXX-003-092507	TSS, TUR
9	10/1/07	III	NA	NA	NA
	10/2/07	III	NA	NA	NA
	10/3/07	I	50 ft N of Dredge-Area H	WQ-XXX-001-100307	DPC, TPC, TSS, TUR, TOX, MET
			300 ft N of Dredge-Area H	WQ-XXX-002-100307	DPC, TPC, TSS, TUR, TOX, MET
			600 ft N of Dredge-Area H	WQ-XXX-003-100307	DPC, TPC, TSS, TUR, TOX, MET
10	10/8/07	III	NA	NA	NA
	10/9/07	III	NA	NA	NA

[1] Samples are collected either based on distance (i.e., 300 ft, 600 ft) or Turbidity levels (i.e., 25, 50 NTU), see Section 2.1 for further discussion on Sample Location.
[2] DPC =Dissolved PCB, TPC =Total PCB, TSS =Total Suspended Solids, TUR =Turbidity, TOX =Toxicity, MET =Metals
NA – Not Applicable

2.1.2 Sampling Stations

Boat-based monitoring focused on the following areas:

Reference Station: At the start of each sampling day the vessel transited to the reference location located 1,000 ft up-current from the active dredge area. This location was outside the influence of any localized turbidity sources (e.g., combined sewer overflow discharges or storm water drains), and was representative of the water flowing through the deeper channel areas up-current of the dredge area. Water depth was measured with a lead-line and the result recorded in the field log. The *in situ* sensors were lowered slowly and allowed to equilibrate at one foot intervals through the water column with care taken to avoid placing the instruments on the sediment bottom. As the sensors were lowered, the sampling personnel observed the turbidity readings and identified the depth of the highest turbidity values. After the full "downcast" was completed, the sensors were pulled back up through the water column and held at the location of highest turbidity. The *in situ* readings for all parameters at this depth were recorded on the Field Log Sheet. This reading served as the background value for subsequent turbidity readings taken throughout the day. Discrete samples were collected as required (see Section 2.1). Reference locations were re-sampled if conditions changed during the day. Examples of relevant changes include change in tidal flow; change in dredge operations; and changing weather conditions such as rain events which can dramatically alter ambient water quality conditions. Re-sampling of the reference location was conducted at the field team's discretion based on real-time data feedback and field observations.

Dredge Boundary: Following the collection of *in situ* and discrete samples at the reference location, the sampling team transited to the down-current side of dredging operations. *In situ* readings were collected as close to the dredge, or other operations, as safety allowed; *in situ* readings were collected in the same manner described above for the reference location. Discrete samples were collected (Section 2.1), if required based on the sampling requirements for that survey day (i.e. Levels I, II, and III).

300 ft Downstream: 300 ft downstream from the dredge operations, the vessel operated along a transect (Figure 4) across the width of the harbor collecting *in situ* readings. Real-time data was used to identify any suspended sediment plumes. The focus was on identifying the centroid of the plume (highest turbidity readings) as well as the plume boundaries (lowest turbidity readings above background). High and low readings along the transect were recorded to show the relative intensity of the plume as well as its spatial dimensions. Once the centroid was identified, subsequent readings were concentrated at this location to identify fluctuations in the plume intensity and potential exceedances of the warning criterion. Discrete samples were collected (Section 2.1), if required based on the sampling requirements for that survey day (i.e. Levels I, II, and III).

600 ft Downstream: 600 ft downstream from the dredge operations, *in situ* readings were collected along a transect across the width of the river (Figure 4). Discrete samples were collected (Section 2.1), if required based on the sampling requirements for that survey day (i.e. Levels I, II, and III).

Fixed point, continuous *in situ* sensors: *In situ* data were also collected using YSI sondes (6920 water quality sensors), with internal data logging, deployed at fixed locations for extended periods of time. The sensors recorded water temperature, salinity, dissolved oxygen, and turbidity. The sensors were deployed on August 14, 2007 during the first week of dredging and remained in use until October 16, 2007, approximately 1 week after the cessation of dredge related activities. Their location and depth were primarily distributed where the majority of dredging activities would be occurring each week. The objective of *in situ* sensor was to supplement the boat-based monitoring. Deployment locations included one upstream and one downstream of the active dredge area (Figure 6). The upstream sensor was located approximately 100 to 130 ft north of the active dredge area and the downstream sensor was located approximately 100 to 130 ft south of the active dredge area. The sensors were deployed on 'J'-shaped moorings with a surface marker buoy on a slack line and a subsurface buoy on a taught line from which the sensor was suspended (Figure 7). Tidal fluctuations resulted in water depths at the mooring locations ranging from approximately two to seven feet. Due to the relatively shallow water at the deployment locations and the large tidal fluctuation, a sampling configuration was designed which maximized characterization of the entire water column while keeping the sensors from resting on the bottom. Typically at low tide, the sensors were suspended within one foot of the water surface and at high tide the sensors were approximately three feet off the bottom.

The sensors were programmed to sample every 10 minutes. The instruments were retrieved and deployed as part of the boat-based monitoring program. The instruments were recovered periodically for data retrieval and routine maintenance. Between each deployment, the sensors were cleaned, recalibrated, the data were downloaded, and the batteries were replaced as needed.

2.2 *In Situ* Measurements

In situ measurements of depth, turbidity, temperature, salinity, and dissolved oxygen were acquired at a series of stations within the project site (see Section 2.1.2) using a YSI sonde (6920 water quality sensors) with real-time display and data logging. Monitoring combined preplanned measurements to support discrete sampling as described below and criteria-based sampling following the decision sequence in Figure 5.

The Acushnet River is tidally influenced and the tide together with variability in freshwater flow determines the current direction and its influence on transport of suspended sediments. On ebb tides, "downstream" is always to the south of dredging activities. However, on flood tides flow is often, though not always, to the north. Several times throughout the 2007 monitoring program a clear stratification of the water column was observed. In these cases lower density freshwater sat on top of higher density, more saline tidal waters. Frequently the incoming tidal water was moving north, while the freshwater lens was flowing south. These physical water properties were closely monitored throughout the day, and adjustments were made in the sampling design to accurately assess sediment resuspension and its transport in all directions. Throughout this report the terms "downstream" and "down-current" always refer to the direction of water movement relative to the dredging operations at that point in time regardless of geographical direction (north or south).

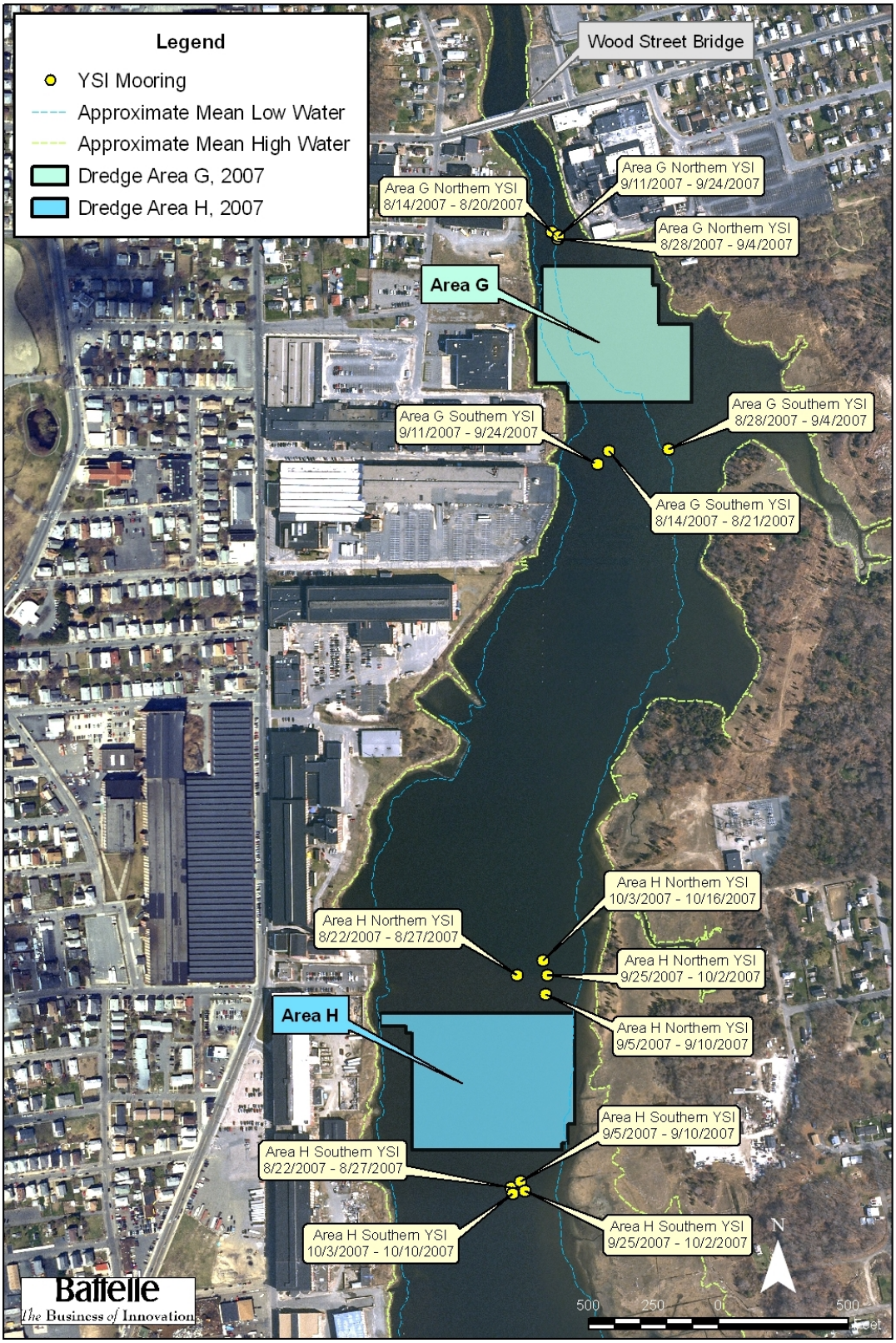


Figure 6. Location of Fixed Point, Continuous *In Situ* YSI Sensors

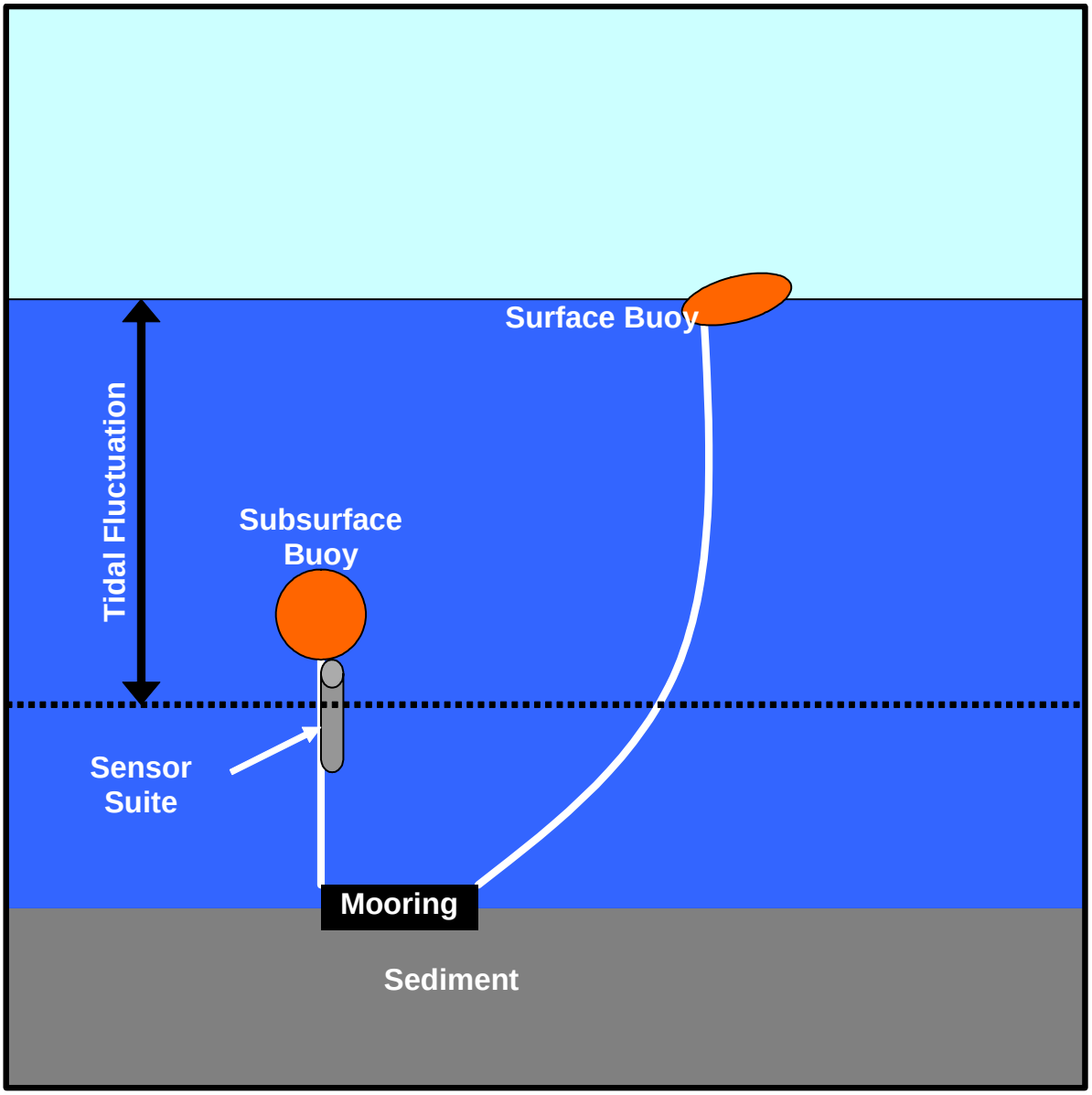


Figure 7. Depiction of the Continuous *In Situ* Sensor Mooring Configuration

2.3 Discrete Water Samples

Water samples collected for physical, chemical, and biological testing during the 2007 monitoring season are summarized in Table 1. The collection of discrete water quality samples was conducted using a water pump and instrument package during boat-based monitoring. Water samples were collected using a12-volt Teflon diaphragm pump and the appropriate length of Teflon® tubing. The inlet of the tubing was attached to the body of the YSI *in situ* sensors to ensure that the sensor measurements and the analytical results are representative of the same parcel of water. Prior to collecting samples at each location sample, water was pumped continuously through the system for approximately two to three minutes to purge the system. This purging ensured that the system was cleared prior to actual sample collection to avoid potential site to site cross-contamination.

Following purging, water from the pump outlet was collected directly into the appropriate sample containers for physical, chemical or biological analysis. Sample volume, container, preservation, storage conditions, holding time and participating laboratory is summarized in Table 2 for each analysis parameter. All samples collected in the field were placed in coolers on ice until transport to the field trailer. At the field trailer, samples were stored cold (4±2°C) in the sample refrigerator or on ice in the coolers until packaged for shipment to the participating laboratories. Samples were packaged in wet or blue ice and were hand delivered or shipped overnight to the appropriate laboratories.

Table 2. Sample Volumes, Containers, and Processing for Discrete Field Samples.

Parameter	Sample Volume	Sample Container	Preser-vation	Storage Condition	Holding Times[1]	Analytical Lab
TSS	1 L	HDPE Bottle	Ice	4 ± 2 °C	7 Days	**Alpha Woods Hole Lab** 375 Paramount Drive, Suite 2 Raynham, MA 02767 Ph:508-822-9300
Turbidity					48 Hours	
Aqueous Total PCB	1 L	Wide-mouth Amber Glass Bottle	Ice	4 ± 2 °C	7 Days	**Battelle Duxbury**[2] 397 Washington Street Duxbury, MA 02332 Ph: 781-952-5200
Aqueous Dissolved PCB[3]	1 L	Wide-mouth Amber Glass Bottle	Ice	4 ± 2 °C	7 Days	
Total Metals	500 mL	HDPE Bottle	HN03	4 ± 2 °C	6 Months	
Toxicity (all samples for toxicological analysis collected into one container)	5 gal	2.5 gallon Cubitainer	Ice	4 ± 2 °C	24 Hours	**EnviroSystems, Inc** One Lafayette Road P.O. Box 778 Hampton, NH 03843 Ph: 603-926-3345

[1] Holding time to initial Lab preparation.
[2] All metals samples were archived at Battelle, Duxbury. If analysis is required, samples will be analyzed by Battelle Marine Sciences Lab in Sequim, Washington.
[3] Samples for dissolved analysis were filtered at the analytical laboratory.

2.4 Sample Analysis

Like the field sampling, sample analysis includes both predefined samples and contingency based samples. Figure 8 shows the laboratory based decision sequence for analysis of samples. All samples were delivered to the respective laboratories defined in Table 2.

Requirements for chemical and biological testing can be found in the project QAPP Addendum *Environmental Monitoring, Sampling, and Analysis at the New Bedford Harbor Superfund Site, New Bedford, MA* for detailed analytical requirements (Battelle, 2006a). An overview of the methods used is provided below.

2.4.1 TSS/Turbidity Analyses

In addition to in-situ, real-time turbidity monitoring (Section 2.2), lab-based analyses of discrete water samples for TSS and turbidity were conducted by Alpha Woods Hole Group (AWHG). Water samples were analyzed for TSS following AWHG SOP *Total Suspended Solids (TSS) Non-Filterable Residue*, Rev. 5.0 which is based on EPA Method 160.2. Water samples were analyzed for turbidity following AWHG SOP *Turbidity 180.1*, Rev. 2.2, which is based on EPA Method 180.1. Sample results are reported in milligrams per liter (mg/L) for TSS and NTU for turbidity.

2.4.2 PCB Analyses

PCB analyses for the 18 National Status and Trends (NS&T) congeners were conducted by Battelle, using both whole water (unfiltered) and dissolved (filtered) samples. Water samples designated for dissolved PCB analysis were filtered through pre-baked glass fiber filters (1 micron pore size) at the analytical laboratory. The sample filtration was usually conducted within 24 hours of sample collection.

All water samples (total and filtered) were extracted following modified EPA Method 3510C (Battelle SOP 5-200). Approximately one liter of the water sample (total or filtered) was spiked with surrogates and extracted three times with dichloromethane using separatory funnel techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, and treated with copper for sulfur removal. The extract was then processed through disposable Florisil columns for further clean-up. The post Florisil extract was concentrated, fortified with internal standards (IS), and then analyzed for 18 NS&T PCB congeners using gas chromatography/electron capture detector (GC/ECD) using dual column confirmation, following modified EPA Method 8082 (Battelle SOP 5-128). Sample data were quantified by the method of internal standards, using the IS compounds. Due to the highly-contaminated nature of the samples, most of the water sample extracts were diluted and analyzed again to resolve concentrations of compounds that exceeded the calibration range during the initial GC/ECD runs. Sample results are reported in micrograms per liter (µg/L).

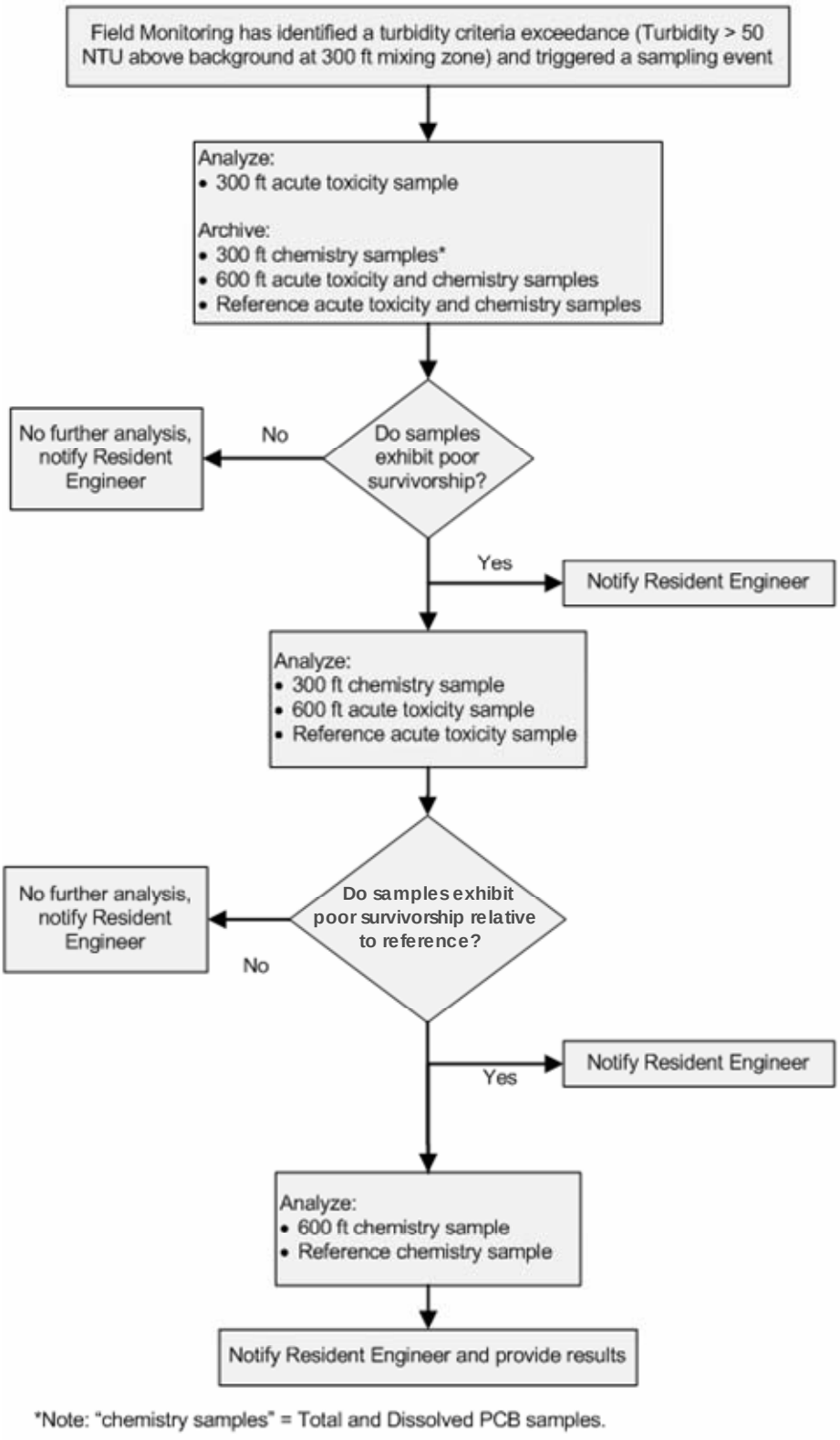


Figure 8. Decision Sequence for Sample Analysis

2.4.3 Toxicity Analyses

Acute and chronic (sub-lethal) exposure screening assays evaluating surface water samples collected from New Bedford Harbor were performed to evaluate the potential toxicity of surface water samples collected in New Bedford Harbor associated with dredging activities. Assay design included a laboratory control treatment and one or more surface water samples, generally including a site reference sample. Samples were evaluated "As Received" without dilutions. Testing was based on programs and protocols developed by the USEPA (2002) primarily designed to provide standard approaches for the evaluation of toxicological effects of discharges on aquatic organisms, and for the analysis of water samples. Testing included the following assays: modified 2 day acute and 7 day chronic assays conducted with the mysid shrimp, *Americamysis bahia*, and the red macro alga, *Champia parvula*, and 60 minute chronic fertilization assays conducted with the purple sea urchin, *Arbacia punctulata*. All mysid and urchin fertilization assays and a portion of the algal assays were conducted by EnviroSystems, Inc. (ESI) located in Hampton, New Hampshire. Additionally, the algal assays were conducted by the Saskatchewan Research Council, SRC, Saskatoon, Saskatchewan, Canada. Supporting data including laboratory bench sheets, full statistical reports, custody forms, sample receipt forms and water quality data are provided in Appendix D.

2.4.3.1 Test Species

A. bahia, #5 days old, were obtained from cultures maintained by Aquatic Research Organisms (ARO), Hampton, New Hampshire. Juvenile shrimp were collected daily, isolated, and placed in a rearing tank for up to 6 days. Holding tanks were maintained in a flow-through culture mode at a temperature of 25±2°C. At the start of the assays the mysids were 7 days old. Juveniles were fed #24 hour old brine shrimp on a daily basis. Water temperature, salinity, and pH were monitored on a daily basis. Prior to testing organisms were siphoned from the rearing tanks to a holding vessel, and then transferred to test chambers using a large bore pipet, minimizing the amount of water added to test solutions.

A. punctulata adults were from cultures maintained by ESI. Original stock was obtained from commercial supply. Male and female urchins were maintained in separate chambers as recommended by protocol (USEPA 2002) and ESI. Adult urchins were induced to spawn by the injection of a potassium chloride solution. The viability of gametes obtained was determined prior to their addition to the test solutions. Eggs and/or sperm that would not result in a fertilized egg were rejected from the pool of gametes used in the assay.

C. parvula biomass was obtained from stock cultures maintained by the Saskatchewan Research Council. Original stocks were obtained from the University of Texas algal collection. The male and female plants were maintained in separate culture vessels under sterile conditions. Algal cultures were maintained on an orbital shaker (100 rpm) at 23±2°C under 16 hour light: 8 hours dark at 40 to 75 foot candles light intensity. Cultures are "cropped" and transferred to fresh nutrient solutions on a weekly basis.

2.4.3.2 Surface Water Samples and Laboratory Control Water

Grab surface water samples were collected by Battelle staff on each of the three Level I surveys in the Harbor (see Toxicity in Table 1). Samples were placed in polyethylene cubitainers for

shipment to the laboratory. Two 2.5-gal cubitainers were collected for each of the chronic assays. Prior to testing in the lab, samples were evaluated to document salinity, conductivity, and total residual chlorine. Total residual chlorine was measured by amperometric titration (MDL 0.05 milligrams per liter, mg/L). Prior to use in the assays the salinity of the samples was adjusted, if necessary, to predetermined levels using artificial sea salts for *A. bahia* and *A. punctulata* assays, and GP-2 salts (USEPA 2002) for the *C. parvula* assays. The salinity of samples for the *A. bahia* acute and chronic exposure assays was adjusted to 25±2‰ while the salinity for samples used for the *A. punctulata* and *C. parvula* assays was adjusted to 30±2‰. Samples with initial salinity measurements above these levels were not adjusted.

Laboratory control water used for mysid and sea urchin assays was collected from the Hampton/Seabrook Estuary. This water is classified as SA-1 and has been used to culture marine test organisms since 1981. The laboratory control water used in the algal assay, collected from Rye, New Hampshire, is the same water used in culture maintenance. Prior to use, seawater used in the algal assays was filtered through glass fiber filters and sterilized. Dilution water used in the algal assays conducted by SRC was natural seawater collected from the West Coast of Canada. Salinity of the surface water samples was adjusted using commercial sea salts.

2.4.3.3 Bioassay Tests

***Americamysis bahia* Modified Acute and Chronic Exposure Bioassays**

Modified acute and chronic exposure screening assays were conducted in a static renewal test mode with renewals made at 24-hour intervals. The 7 day assays were conducted at a temperature of 26 ±1°C with a photoperiod of 16:8 hours light:dark. Mysids were maintained in 250 mL beakers containing 150 mL of test solution. Approximately 100 mL of the test solution were replaced each day. The assay incorporated 8 replicates with 5 organisms/replicate. Survival and dissolved oxygen were measured daily in each replicate prior to test solution renewal. Salinity, temperature and pH were recorded in a composite sample of the "old" test solution and in the "new" test solution prior to being added to the test chamber. Incubator temperatures were also recorded on a daily basis.

During the test, mysids were fed 24 hour old *Artemia* nauplii. On Day 7 of the assay, surviving mysids were removed from test solutions, rinsed to remove any surface detritus and salts, and transferred to tared foils and dried for 24 hours at 103°C. Foils were weighed to the nearest 0.01 mg. Mean dry weights per individual were obtained by dividing the net dry weight of all surviving organisms by the number of organisms added at the start of the assay.

***Arbacia punctulata* Chronic Exposure Fertilization Assays**

Gametes were obtained by potassium chloride injection to induce spawning. Sperm were collected dry, diluted to achieve a concentration of approximately 5.0×10^7 sperm/mL in the surface water treatments. Actual sperm concentrations are provided on laboratory bench sheets in Appendix D. Sperm solutions were added to 5 mL aliquots of each sample being evaluated and allowed to remain in the test solutions for 60 minutes before the addition of unfertilized eggs.

Each treatment incorporated a total of four replicates. After 20 minutes of exposure the assay was terminated by the addition of 0.2 mL of preservative. Aliquots of preserved solution were

counted to determine numbers of fertilized and unfertilized eggs. Fertilization was accepted based on the presence or absence of a fertilization membrane around the egg.

Champia parvula Modified Acute and Chronic Exposure Assays

The 7 day red algae assay was conducted with a 2 day exposure period to the surface waters and laboratory control treatments. Each treatment used four replicates with five female branches and one male branch per replicate. Temperature was maintained at 23±1°C. The light source was cool white and fluorescent bulbs set on a 16:8 hours light:dark cycle, with a light intensity of 40 to 75 foot candles. Light intensity was checked at the start of each assay. Temperatures were monitored on a daily basis. Test chambers were 200 mL borosilicate glass beakers. After 2 days exposure, female branch tips were transferred to approximately 100 mL of recovery medium with added nutrients and allowed to recover and mature for 5 days. During transfer, plants were examined to determine the physical condition of the individual branches. Branches showing signs of degeneration were noted and used to establish an acute endpoint. After the recovery period, the number of cystocarps (reproductive bodies) on each female branch were counted.

2.4.3.4 Data Analysis

Statistical analysis of acute and chronic exposure data was completed using CETIS (Comprehensive Environmental Toxicity Testing System) software. The program computes acute and chronic exposure endpoints based on EPA decision tree guidelines specified in individual test methods. For chronic exposure endpoints statistical significance was accepted at **"**<0.05.

2.4.3.5 Quality Control

As part of the toxicity testing laboratory quality control program, standard reference toxicant assays are conducted on a regular basis for each test species to provide relative health and response data while allowing for comparison with historic data sets.

3.0 SURVEY CHRONOLOGY AND DAILY OBSERVATIONS

All turbidity readings referenced in this section are the actual values from the sensor and are not corrected for background levels. High and low tide data for each day that water quality monitoring was performed during operations is summarized below; all times are Eastern Daylight Time (EDT). Complete tide data over the course of the entire 2007 dredge season are also provided in Appendix A.

Week of August 6, 2007 (Week 1)

August 6, 2007:

- **Tidal stage:** High tide at 2:13 and 14:51 EDT; low tide at 7:38 and 20:57 EDT.
- **Dredge activity:** No active dredging, testing of dredge lines. Debris removal in Area H.
- **Monitoring activity**: First day of water quality monitoring. Monitored low water and flood tide. Shakedown of equipment, identifying sample locations, and site access.
- **Fishery and Wildlife Observations:** Bait fish active throughout area with gulls and terns feeding.
- **Results summary:** Readings collected at reference locations, values 4.5 NTU. Elevated turbidity values in close proximity to debris removal, <20 NTU from distance greater than 200'. No samples collected. Oil sheen observed around debris removal activity moving up to 1,000' North of debris removal.

August 7, 2007:

- **Tidal stage:** High tide at 3:18 and 15:55 EDT; low tide at 8:44 and 22:25 EDT.
- **Dredge activity:** No active dredging, testing of dredge lines. Debris removal in Area H.
- **Monitoring activity:** Level III monitoring. Monitored low water and flood tide.
- **Fishery and Wildlife Observations:** Bait fish activity noted within and outside of dredge area. 2-3 small fish were noted near southern oil boom.
- **Results summary:** Readings collected at reference location, value of 2-4 NTU, 150 ft down-current of debris removal value of 30-40 NTU, and 400 ft down-current a value of 5-10 NTU. No samples collected. Slight oil sheen observed outside boom in the morning. Oil sheen increased later in the morning, turbidity remained low.

August 8, 2007:

- **Tidal stage:** High tide at 4:23 and 16:57 EDT; low tide at 10:00 and 23:42 EDT.
- **Dredge activity:** Actively dredging in Area H. Debris removal in Area H. Dredge in Area H broken. Moved working dredge from Area G to Area H and broken dredge from Area H to dock.
- **Monitoring activity:** Level III monitoring, ebb tide to low water and 1.5 hours of flood.
- **Fishery and Wildlife Observations:** A few small fish observed outside of Area H. Numerous birds were observed South of Area H.
- **Results summary:** No significant turbidity plumes around dredge activities. Readings collected at reference locations, value 4.8 NTU, North Dredge Boundary Area value of 20.3 NTU, South Dredge Boundary Area value of 8-9 NTU, and North Dredge Boundary Area value of 30-40 NTU about 150 ft down-current of active dredge. No samples

collected. Some oil sheen observed around debris removal. Localized sheen observed North of Area H when actively dredging in morning, contained by oil booms and dissipated quickly.

August 9, 2007:

- **Tidal stage:** High tide at 5:25 and 17:55 EDT; low tide at 11:16 EDT.
- **Dredge activity:** Actively dredging in Area H. Debris removal in Area H. Dredge repair.
- **Monitoring activity:** Level I monitoring ebb tide.
- **Fishery and Wildlife Observations:** Birds observed above and below dredge area.
- **Results summary:** No significant turbidity plumes around dredge activities. In order to obtain consistent readings near 55 NTU, the monitoring had to get within about 100-150 ft of debris removal area. Prop wash in shallow water resulted in spikes of 90-100 NTU, which dissipated very quickly. Collected toxicity, TSS, Turbidity, total and dissolved PCBs, and metals samples based on turbidity. No oil sheen observed.

Week of August 13, 2007 (Week 2)

August 13, 2007:

- **Tidal stage:** High tide at 8:45 and 21:06 EDT; low tide at 2:42 and 14:47 EDT.
- **Dredge activity:** Actively dredging in Area H. Debris removal in Area H.
- **Monitoring activity**: Level III monitoring. Monitored ebb tide.
- **Fishery and Wildlife Observations:** No negative impacts to fish passage observed, fish noted within and outside dredge area moving freely.
- **Results summary:** Turbidity readings collected at reference locations and out to 600 ft South of Dredge Area H, turbidity readings were <20 NTU (range 1.4-14.3 NTU) at all locations. Turbidity levels detected were mainly associated with debris removal. Very minor oil sheen observed around debris removal, contained by oil boom.
- **Exceedances and sample collections:** None.

August 14, 2007:

- **Tidal stage:** High tide at 9:28 and 21:46 EDT; low tide at 3:13 and 15:24 EDT.
- **Dredge activity:** No active dredging. Debris removal in Area G.
- **Monitoring activity**: Level III monitoring. Monitored ebb tide. Deployed moorings north and south of Area G.
- **Fishery and Wildlife Observations:** No evidence of fish damming or dead or impaired fish observed as well as any indications of fish passage obstruction observed along pipeline between the two active dredge areas or within Area G. Birds observed above and below dredge Area G.
- **Results summary:** Turbidity readings collected at Wood St. reference location and mooring locations North and South of Area G, turbidity readings were <20 NTU (range 7.3-15.8 NTU) at all locations. Oil sheen and small debris observed during debris removal, all contained by oil boom.
- **Exceedances and sample collections:** None.

August 16, 2007:

- **Tidal stage:** High tide at 10:50 and 23:06 EDT; low tide at 4:09 and 16:31 EDT.
- **Dredge activity:** No active dredging in Area G, dredge set up. Debris removal in Area G.
- **Monitoring activity**: Level II monitoring. Monitored high water, ebb and flood tide.
- **Fishery and Wildlife Observations:** Birds observed in all areas. Several dozen dead fish were observed along western shore of the Acushnet River, approximately 800-900 ft North of Wood St. A dead bird was observed tangled in the oil boom and a dead duck was observed approximately 800 ft north of Wood St.
- **Results summary:** Turbidity readings collected at Wood St. reference location, North of Wood St., 200 ft from debris removal in Area G, and dredge boundary, turbidity readings were <20 NTU (range 3.4-16 NTU) at all locations. Heavy oil sheen observed in northern part of area and migrating up river, wind dissipated sheen slightly by mid-day. Oil sheen also observed along shore line North of Wood St.; notified S. Fox, M. Gouveia, and P. L'Heureux that sheen was not being contained by oil booms and that dead fish had been observed north of Wood Street.
- **Exceedances and sample collections:** No exceedances of the turbidity criteria were noted. Under Level II sampling pre-planned samples were collected for TSS, turbidity, and metals analysis.

August 17, 2007:

- **Tidal stage:** High tide at 11:32 and 23:46 EDT; low tide at 4:37 and 17:04 EDT.
- **Dredge activity:** Actively dredging in Area G. Debris removal in Area G.
- **Monitoring activity**: Level III monitoring. Monitored high water, ebb tide.
- **Fishery and Wildlife Observations:** Schooling and feeding fish at North of Wood St. Bridge. Dead fish were noted in dredge Area G.
- **Results summary:** Turbidity readings were 20-50 NTU within 100 ft of debris removal to <20 NTU throughout the dredge area. Light to heavy oil sheen observed moving northwest to southeast corner of the dredge area from debris removal.
- **Exceedances and sample collections:** None.

Week of August 20, 2007 (Week 3)

August 20, 2007:

- **Tidal stage:** High tide at 1:18 and 13:54 EDT; low tide at 6:21 and 19:10 EDT.
- **Dredge activity:** Actively dredging in Area G. Debris removal in Area G.
- **Monitoring activity**: Level III monitoring. Monitored flood tide.
- **Fishery and Wildlife Observations:** Birds observed north and south of the dredge area. Dead fish were not observed.
- **Results summary:** Retrieved moorings from north of dredge area. Observed localized high turbidity values near dredge and debris removal (50-60 NTU with spikes of 80-100 NTU). A very thin plume layer traveled down current, as the plume reached the dredge boundary, the turbidity dropped to 15-20 NTU. Turbidity readings collected at reference location, north dredge boundary, and 300 ft down-current, turbidity readings were ≤20 NTU (range 5-20 NTU). Light oil sheen observed in the morning southwest of the debris removal, contained by oil booms.

- **Exceedances and sample collections:** None.

August 21, 2007:

- **Tidal stage:** High tide at 2:14 and 14:51 EDT; low tide at 7:08 and 20:11 EDT.
- **Dredge activity:** Actively dredging in Area H. Debris removal in Area H.
- **Monitoring activity**: Level III monitoring. Monitored flood tide.
- **Fishery and Wildlife Observations:** No evidence of fish damming or dead or impaired fish observed as well as any indications of fish passage obstruction observed along pipeline between the two active dredge areas or within Area H. Birds observed above and below dredge Area H. Fish were observed within and outside of dredge area.
- **Results summary:** Turbidity readings collected at the reference location south of Area H, the northern boundary of H, 300 ft north of Area H and 600' north of Area H. Turbidity readings were <26 NTU (range 3.2-25.1 NTU) at all locations. Small oil sheen was observed south of debris removal; all was contained by oil boom. A fairly large, but low level turbidity plume was observed during the morning but began to dissipate around 11:30am. The turbidity was around 20-25 NTU at boundary but dropped to approximately 15 NTU at 300 ft outside of the boundary.
- **Exceedances and sample collections:** None.

August 22, 2007:

- **Tidal stage:** High tide at 3:16 and 15:50 EDT; low tide at 8:06 and 21:25 EDT.
- **Dredge activity:** Debris removal and dredging in Area H.
- **Monitoring activity**: Level III monitoring. Monitored flood tide.
- **Fishery and Wildlife Observations:** Birds observed in and around area H.
- **Results summary:** North and South moorings were deployed. Turbidity readings collected at reference location south of Area H, post mooring deployment, dredge gate north, and 300 ft from gate, turbidity readings were <43 NTU (range 3.3-42.5 NTU) at all locations. No oil sheen was observed. A plume similar to the one observed on 8/21/07 was also observed. The turbidity levels were averaging around 18-25 NTU with occasional spikes to 40-60 NTU. When the plume was observed at 300 ft the turbidity dropped to 10-15 NTU and continued to drop rapidly at 550-600 ft from the boundary.
- **Exceedances and sample collections:** None.

Week of August 27, 2007 (Week 4)

Debris removal and push boats working in shallow waters of Area G create elevated turbidity nearing turbidity action levels. Short-lived nature of these plumes resulted in no sample collections driven by criteria exceedances. Widespread surface oil sheens generated by activities in both dredge areas.

August 27, 2007:

- **Tidal stage:** High tide at 7:39 and 19:59 EDT; low tide at 1:11 and 13:18 EDT.
- **Dredge activity:** Debris removal in Area H. Dredging in Areas H and G.
- **Monitoring activity:** Level III monitoring at both dredge areas. Monitored ebb tide.
- **Fishery and Wildlife Observations:** Birds seen working after bait fish between areas G & H. No obstructions to fish passage observed.

- **Results summary:**
  - **Area H:** Widespread, low level suspended sediment plume coming from debris removal activities: 15-25 NTU at 300 ft downstream, 5-10 NTU at 600 ft downstream. Values returned to background levels 700-750 ft from debris removal.
  - **Area G:** Turbidity levels at 15-20 NTU within 300 ft of dredge, 5-10 NTU beyond dredge, and near background at 600 ft. Highest turbidity values associated with push boat activity in shallow water.
- **Exceedances and sample collections:** None.

August 28, 2007:

- **Tidal stage:** High tide at 8:23 and 20:44 EDT; low tide at 1:52 and 14:07 EDT.
- **Dredge activity:** Debris removal and dredging in Area G.
- **Monitoring activity:** Level III monitoring during ebb tide.
- **Fishery and Wildlife Observations:** Several small schools and individual fish noted. No obstructions to fish passage observed.
- **Results summary:** Oil sheens observed as thin films with concentrated areas near dredge and debris removal. Sheen expanded to west by wind. Heavy sheens seen when moving the debris removal equipment. Elevated turbidity was also associated with this activity. Turbidity values of 40-120 NTU were seen 200-400 ft from debris removal. Plumes were very short lived leaving no opportunity to collect elevated turbidity water samples out at the criteria distances.
- **Exceedances and sample collections**: None.

August 29, 2007:

- **Tidal stage:** High tide at 9:08 and 21:29 EDT; low tide at 2:33 and 14:54 EDT.
- **Dredge activity:** Debris removal and dredging in Area H. Debris removal in Area G.
- **Monitoring activity:** Level II during ebb tide.
- **Fishery and Wildlife Observations:** Birds seen working north and south of Area H. Observed numerous bait fish south of Areas H. Also, large numbers of bait fish observed immediately south of Wood St. bridge.
- **Results summary:**
  - **Area H:** Little to no elevated turbidity associated with dredging. Moderately elevated turbidity (15-35 NTU) associated with debris removal.
  - **Area G:** Oil sheen noted north of Wood St. (approximately 350 ft north of bridge). Oil sheen observed prior to peak ebb flow and not contiguous with sheens seen in dredge area. Turbidity associated with debris removal was generally low: 30-40 NTU at 75 ft from debris removal, 15-25 NTU at 300 ft, 10-15 NTU at 600 ft.
- **Exceedances and sample collections**: No exceedances. Samples collected for TSS and turbidity.

Week of September 3, 2007 (Week 5)

Debris removal and push boats working in Area H created elevated turbidity nearing turbidity action levels. Short-lived nature of these plumes resulted in no sample collections driven by criteria exceedances. Surface oil sheens generated by debris removal activities in dredge area H.

September 4, 2007:

- **Tidal stage:** High tide at 1:55 and 14:32 EDT; low tide at 7:19 and 20:53 EDT.
- **Dredge activity:** Debris removal in Area H.
- **Monitoring activity:** Level III monitoring at dredge area H. Monitored flood tide.
- **Fishery and Wildlife Observations:** Birds observed above and below work area. No obstructions to fish passage observed.
- **Results summary:** Oil sheen observed northeast of debris removal. Slight, turbidity elevations associated with debris removal activities: 6-10 NTU at 75-80 ft.
- **Exceedances and sample collections:** None.

September 5, 2007:

- **Tidal stage:** High tide at 3:04 and 15:40 EDT; low tide at 8:35 and 22:29 EDT.
- **Dredge activity:** Debris removal and dredging in Area H.
- **Monitoring activity:** Level III monitoring at dredge area H. Monitored flood tide.
- **Fishery and Wildlife Observations:** Birds observed above and below work area. No obstructions to fish passage observed.
- **Results summary:** Oil sheen observed southeast of debris removal. Observed a widespread turbidity plume northeast of the debris removal. Turbidity values ranged from 25-35 NTU at 200 ft and 10-20 NTU at approximately 300 ft from the debris removal activities. Higher spikes were observed were values reached 40-50 NTU at 275-300 ft. Plumes were very short lived leaving no opportunity to collect elevated turbidity water samples out at the criteria distances.
- **Exceedances and sample collections**: None.

Week of September 10, 2007 (Week 6)

Localized turbidity plume observed with dredge activities in Area G, while higher turbidity values were observed with debris removal in Area H. The turbidity plumes resulted in no sample collections driven by criteria exceedances. In both areas, surface oil sheens were observed. On 9/11/07, very heavy oil sheen, high turbidity values, and fish kills were all observed. Planned samples were collected during this time-frame. Low turbidity values were measured and no oil sheens were observed the remainder of the week.

September 10, 2007:
Area G

- **Tidal stage:** High tide at 7:38 and 19:59 EDT; low tide at 1:44 and 13:54 EDT.
- **Dredge activity:** Debris removal and dredging in Area G. Debris removal barge moved to Area H in the early morning.
- **Monitoring activity:** Level III monitoring at dredge Area G. Monitored ebb tide.
- **Fishery and Wildlife Observations:** Large numbers of gulls were observed working in and around the dredge unit. No obstructions to fish passage observed.

- **Results summary:** Heavy oil sheen observed south of dredge area. Localized turbidity plume of 18-25 NTU observed 75-100 ft from dredge unit, however, the turbidity values returned to background beyond 100 ft.
- **Exceedances and sample collections**: None.

Area H

- **Tidal stage:** High tide at 7:38 and 19:59 EDT; low tide at 1:44 and 13:54 EDT.
- **Dredge activity:** Debris removal in Area H. The dredge was also moved and set-up.
- **Monitoring activity:** Level III monitoring at dredge Area H. Monitored ebb tide.
- **Fishery and Wildlife Observations:** Birds observed south of dredge unit. Large numbers of fish jumping in southwest corner. No obstructions to fish passage observed.
- **Results summary:** Small, but heavy oil sheen observed south of debris removal. Extra booms added to contain sheen. Turbidity values ranged from 25-35 NTU at 50 ft from the debris removal activities with higher spikes of 50-60 NTU. Furthermore, a narrow turbidity plume from debris removal was detected out to approximately 700 ft. Turbidity elevations associated with dredge activities were 10-14 NTU at approximately 200 ft and dropped rapidly.
- **Exceedances and sample collections:** None.

September 11, 2007:

- **Tidal stage:** High tide at 8:19 and 20:39 EDT; low tide at 2:11 and 14:28 EDT.
- **Dredge activity:** Debris removal and dredging in Area G.
- **Monitoring activity:** Level I monitoring at dredge Area G. Monitored high, ebb, and flood tide.
- **Fishery and Wildlife Observations:** Several hundred dead fish were observed within and south of the dredge area. COE was notified of fish kill and corrective action was taken immediately, including cessation of debris removal activities and deployment of additional oil booms.
- **Results summary:** Very heavy oil sheen observed, possibly associated with debris removal. Localized low-level turbidity (10-15 NTU) observed south of dredge activities. Turbidity values ranged from 23-29 NTU at 75 ft from the debris removal and higher spikes of 59-60 NTU observed beyond 75 ft from debris removal activities. Dissolved oxygen levels in dredge Area G ranged from 1.4 to 2.8 mg/L.
- **Exceedances and sample collections**: No exceedances. Pre-planned, discrete water samples were collected for toxicity, TSS, turbidity, total and dissolved PCBs, and metals analyses based on a gradient of *in-situ* turbidity readings (low to higher concentrations).

September 12, 2007:
Area H

- **Tidal stage:** High tide at 8:59 and 21:17 EDT; low tide at 2:37 and 14:58 EDT.
- **Dredge activity:** Debris removal and dredging in Area H. No active dredging in the morning, dredge moved in Area G in the early morning.
- **Monitoring activity:** Level III monitoring at dredge Area H. Monitored flood tide.
- **Fishery and Wildlife Observations:** Occasional fish observed swimming at surface.

- **Results summary:** No oil sheen observed. Thin band of turbidity observed 15-40 NTU associated with debris removal, decreasing north to south. Dissolved oxygen values at the north and south moorings were around 3 mg/L.
- **Exceedances and sample collections**: None.

Area G

- **Tidal stage:** High tide at 8:59 and 21:17 EDT; low tide at 2:37 and 14:58 EDT.
- **Dredge activity:** Dredging in Area G in early morning.
- **Monitoring activity:** Level III monitoring at dredge Area G. Monitored flood tide.
- **Fishery and Wildlife Observations:** Sporadic fish swimming at surface, occasional dead fish observed.
- **Results summary:** No oil sheen observed with dredge removal. Turbidity values ranged from 4-8 NTU at 100 ft from the debris removal.
- **Exceedances and sample collections**: None.

September 14, 2007:

- **Tidal stage:** High tide at 10:16 and 22:31 EDT; low tide at 3:28 and 15:56 EDT.
- **Dredge activity:** Dredging in Area G.
- **Monitoring activity:** Level III monitoring at dredge Area H. Monitored flood, high, and ebb tide.
- **Fishery and Wildlife Observations:** Large numbers of birds observed north of, within, and south of the dredge unit. Large numbers of fish were observed north of the bridge; many appeared strained. Low oxygen levels were measured in the area. Some dead fish were noted, but not in large numbers.
- **Results summary:** No oil sheen observed. Small turbidity plume associated with the dredge; values typically ranged from 15-25 NTU with occasional spikes to near 40 within 150 ft of dredge. Dissolved oxygen values in the overall area were low, ranging from 2.5 in the northern dredge area to 3.5 mg/L south of Area H. Oxygen values fell sharply at approximately 900' upstream from the Wood Street bridge to 1.5-1.8 mg/L.
- **Exceedances and sample collections**: None.

Week of September 17, 2007 (Week 7)

Slight elevated turbidity was observed in the area of the debris removal and dredge activities in Area H and Area G. No exceedances were observed, therefore, there were no sample collections driven by criteria exceedances. Oil sheen was observed in dredge Area G immediately after dredging operations had ceased on 9/19.

September 17, 2007:

- **Tidal stage:** High tide at 12:20 EDT; low tide at 5:01 and 17:42 EDT.
- **Dredge activity:** Debris removal in Area H. Dredging in Area G.
- **Monitoring activity:** Level III monitoring at dredge Area H and Area G. Monitored flood tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Large numbers of birds working above, within, and south of dredge Area G. Numerous fish observed north of Wood St. bridge.

- **Results summary:**
  - **Area H:** No oil sheen observed. Observed narrow plume on eastern shoreline. No exceedances, turbidity at 300 ft from debris removal ranged from 25-35 NTU. Turbidity values at the southern reference site were 2.5 NTU and at 200 ft from the debris removal activities was 45 NTU. Dissolved oxygen in this area (within and outside dredge Area H) ranged from 5 to 5.5 mg/L.
  - **Area G:** No oil sheen observed. Turbidity values were <20 NTU; at the reference site turbidity was 2.5 NTU and at 75 ft from the dredge activities was 15 NTU. Dissolved oxygen in dredge Area G ranged from 7.5 to 8.0 mg/L; north of Wood St. values dropped to approximately 3.5 mg/L.
- **Exceedances and sample collections**: None.

September 19, 2007:

- **Tidal stage:** High tide at 1:37 and 14:10 EDT; low tide at 6:29 and 19:28 EDT.
- **Dredge activity:** Dredging in Area G. Dredging was completed just prior to monitoring. Debris removal in Area H.
- **Monitoring activity:** Level III monitoring at dredge Area G and Area H. Monitored flood tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Fish were observed in all areas north of Area H and within dredge Area H.
- **Results summary:**
  - **Area G:** Heavy oil sheen observed in area of southern boom inside the dredge boundary and a light sheen observed throughout the dredge area. No exceedances, turbidity observed in the central area of the dredge boundary were <20 NTU (range 16-18 NTU) and north of the dredge ranged from 30-40 NTU.
  - **Area H:** No oil sheen observed. No exceedances, turbidity at 50-100 ft south of the debris removal ranged from 16-22 NTU and 50-100 ft north of the debris removal ranged from 20-40 NTU.
- **Exceedances and sample collections**: None.

Week of September 24, 2007 (Week 8)

Slight elevated turbidity was observed in the area of the debris removal and dredge activities in Area H and Area G during monitoring on both days. No exceedances were observed, therefore, there were no sample collections driven by criteria exceedances. However, planned level II samples (TSS/Turbidity) were collected in Area H on 9/25/07.

September 24, 2007:

- **Tidal stage:** High tide at 6:25 and 18:47 EDT; low tide at 12:08 EDT.
- **Dredge activity:** Debris removal and dredging in Area H. Dredging in Area G.
- **Monitoring activity:** Level III monitoring at dredge Area H and Area G. Monitored ebb tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Occasional fish observed on surface in Area H and Area G.
- **Results summary:**
  - **Area H:** Slight sheen observed near dredge activities. High turbidity values observed close to the dredge and debris removal activities. The plume of turbidity

traveled south with the wind and tide. High turbidity associated with support vessel traffic due to low tide. Turbidity diminished away from sources and south of Area H boundary. Turbidity values observed at Area H boundary was 17 NTU, 75 ft south of debris removal was 122 NTU, and 100 ft south of debris removal was 88 NTU.
    - **Area G:** No oil sheen observed. Dredge activity ceased due to low tide. No monitoring in the area.
- **Exceedances and sample collections**: None.

September 25, 2007:

- **Tidal stage:** High tide at 7:11 and 19:33 EDT; low tide at 0:37 and 13:00 EDT.
- **Dredge activity:** Debris removal and dredging in Area H. Dredging in Area G.
- **Monitoring activity:** Level II monitoring at dredge Area G and Area H. Monitored ebb tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Occasional fish observed on surface in Area H and Area G.
- **Results summary:**
    - **Area H:** Occasional oil sheen noted around dredge activities. Background turbidity observed in dredge and debris removal area ranged from 5-10 NTU. Turbidity readings above background confined to dredge path. Turbidity values 50 ft south of the dredge were 90-100 NTU, 75 ft south of the dredge were 55-65 NTU, and 100 ft south of the dredge were 10-20 NTU.
    - **Area G:** Slight oil sheen observed to the east and northeast of dredge. Dredge working very tight in northeast corner of dredge area. Higher turbidity concentrated to the northeast area with a slight sheen observed. Turbidity dropped off to background values of 6-10 NTU approximately 50 feet to the south and east of dredge activity.
- **Exceedances and sample collections**: No exceedances. TSS and turbidity samples collected during monitoring in Area H.

Week of October 1, 2007 (Week 9)

Monitoring focused on area H (no activity occurred in Area G). No turbidity exceedances were observed at 300 ft or 600 ft from dredge activity. Elevated turbidity readings were observed in close proximity (within 50 ft) of dredge activities in Area H however, readings diminished with distance from the dredge activities. Occasional oil sheen was observed on 10/3/07. Planned level I samples (toxicity, TSS/Turbidity, and total and dissolved PCBs) were collected in Area H on 10/3/07 adjacent to dredging activities, at 300 ft and at 600 ft from dredging activities.

October 1, 2007:

- **Tidal stage:** High tide at 12:06 EDT; low tide at 5:06 and 18:06 EDT.
- **Dredge activity:** Debris removal and dredging in Area H.
- **Monitoring activity:** Level III monitoring at dredge Area H. Monitored flood tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Many fish observed on surface in Area H.
- **Results summary:** No oil sheen observed. Turbidity ranges of 75-85 NTU were confined to within dredge area and in close proximity to debris removal. Short lived plumes of

turbidity (20-60 NTU) were observed north of dredge area and in close proximity to the dredge activities. Values dropped quickly to background levels. Dissolved oxygen levels ranged from 4.5-6 mg/L throughout the dredge area.

- **Exceedances and sample collections**: None.

October 2, 2007:

- **Tidal stage:** High tide at 0:34 and 13:08 EDT; low tide at 6:01 and 19:16 EDT.
- **Dredge activity:** Dredging in Area H.
- **Monitoring activity:** Level III monitoring at dredge Area H. Monitored flood tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Large schools of fish observed in all areas of the river and transiting though the dredge area.
- **Results summary:** No oil sheen observed. Turbidity values ranged between 10-70 NTU, which corresponded with dredge pass from east to west. Elevated turbidity (70 NTU) was observed in area of support vessels. Higher turbidity values dropped off quickly with distance from dredging activities. Dissolved oxygen values ranged from 9.21-13.73 mg/L both north and south of dredge area.
- **Exceedances and sample collections**: None.

October 3, 2007:

- **Tidal stage:** High tide at 1:39 and 14:14 EDT; low tide at 7:07 and 20:47 EDT.
- **Dredge activity:** Dredging in Area H.
- **Monitoring activity:** Level I monitoring at dredge Area H. Monitored flood tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Schools of fish observed within Area H and outside dredge area.
- **Results summary:** Occasional oil sheen noted around dredge activities. Turbidity readings in close proximity to dredge activities (approximately 50 ft) were 15-110 NTU. There was a broad range of turbidity readings due to stop and go dredge activities. These broad ranges continued but diminished with distance away from the dredge. Turbidity values 300 ft from the dredge were 11.6-20 NTU and 600 ft from dredge area were 11-13 NTU. Dissolved oxygen ranged from 6.84-11.91 mg/L within the northern area of the dredge boundary and north of the dredge boundary with a wide-range of turbidity readings (11-110 NTU). Dissolved oxygen readings south of the dredge area ranged between 9.65-14.6 mg/L with associated lower turbidity readings.
- **Exceedances and sample collections**: No exceedances. Collected toxicity, TSS, Turbidity, total and dissolved PCBs, and metals samples based on turbidity.

Week of October 8, 2007 (Week 10)

Dredging was limited to Area H. No turbidity exceedances were observed at 300 ft or 600 ft from dredge activity and no samples were collected. Elevated turbidity readings were observed in close proximity (within 50 ft) of dredge activities in Area H however, readings diminished with distance from the dredge activities. No debris removal occurred although the barge was present for dredge support on 10/9/07. Occasional oil sheen was observed on both days.

October 8, 2007:

- **Tidal stage:** High tide at 6:30 and 18:52 EDT; low tide at 0:42 and 13:03 EDT.
- **Dredge activity:** Dredging in Area H. No debris removal.

- **Monitoring activity:** Level III monitoring at dredge Area H. Monitored Ebb tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Fish observed in all areas of the river and transiting though the dredge area.
- **Results summary:** Occasional oil sheen observed. Overall turbidity was low, ranging from 4-30 NTU within close proximity to dredge area, with an occasional spike to 50 NTU. Turbidity ranged from 3-17 NTU 50 ft from the dredge boundary. Values dropped to background levels (2.5-9.8 NTU) at 130 ft to 300 ft south of dredge area. Dissolved oxygen levels ranged from 3.5-4 mg/L throughout the dredge area and 3-6.6 mg/L outside the dredge area.
- **Exceedances and sample collections**: None.

October 9, 2007:

- **Tidal stage:** High tide at 7:12 and 19:32 EDT; low tide at 1:10 and 13:35 EDT.
- **Dredge activity:** Dredging in Area H. Debris removal barge present for support only.
- **Monitoring activity:** Level III monitoring at dredge Area H. Monitored ebb tide.
- **Fishery and Wildlife Observations:** No obstructions to fish passage observed. Occasional fish observed on the surface.
- **Results summary:** Occasional oil sheen observed. Crew did not enter dredge area due to close proximity of dredge debris removal barge and other support vessels. Highest turbidity levels (9-50 NTU) observed between 200 ft and 300 ft downstream of dredge activity. Values were dependent on dredge passage location. Turbidity values dropped off quickly at 300 ft from the dredge activity to just above background levels (4 NTU) with spikes to 26 NTU depending on dredge location. Dissolved oxygen values ranged from 5.5-6.4 mg/L within 300 ft from dredge activity.
- **Exceedances and sample collections**: None.

4.0 RESULTS

4.1 Dredging and Field Monitoring Summary

Dredging was conducted from mid-August to mid-October 2007. Dredging was initiated in Area H encompassing sections of DMU-9 and DMU-10, and DMU-11 and Area G, which encompasses sections of DMU-1 and DMU-102. The eastern portion of Area G (in DMU-102) is intertidal. As a result, dredging could not always be conducted in that area (dredge area G) during lower tides. To maintain efficiency a second dredge was set up. When low water prevented dredging in Area G, dredge crews moved over to the second dredge. This approach meant that the dredging location was variable from day to day and even within days. Dredging in Areas H and G was conducted in a North-South orientation during most of the dredging season. During the last two weeks of dredging in Area H, dredging was conducted East-West in the eastern portion of the dredge area only.

Once the dredge areas were determined, sheet piling was placed around the perimeter, at approximately 50 ft spacing. A perimeter cable was run around the sheet piles at approximately the high tide mark. Also along the perimeter, floating, absorbent oil booms were placed to contain any surface oil slicks. A 'gate' in the south end of the dredge area was used for all vessels entering or leaving the operation.

Dredging was performed using a Mud Cat™ hydraulic dredge equipped with a horizontal auger (Figure 9). The dredge was propelled by winching itself along a transverse cable which spans the dredge area to opposite sides of the perimeter cable. As a pass is completed, support crews relocated the cable to position for the next pass. Dredged material was pumped through a pipeline to a booster pump, then to the desanding facility at Sawyer Street. Following desanding, the remaining fine material was pumped via a separate pipeline to the dewatering, treatment, and handling facility in the Lower Harbor. In total, Jacobs estimated that dredging removed 23,300 cubic yards of material in 2007.

Figure 9. Mud CatTM Hydraulic Dredge

Because hydraulic dredges can not process large debris it was necessary to conduct separate removal operations prior to the dredging of a particular area. Debris removal was accomplished by 'raking' the bottom with a barge-mounted excavator (Figure 10). The end of the excavator has two forked jaws that open and close. The jaws are deployed to the bottom, once on the bottom the two jaws scrape the bottom and then close into each other and capture the debris. Debris scows secured to the side of the debris removal platform stored the debris and were moved offsite as needed. Support boats were used throughout the operation to transport crews, maintain dredges, handle the pipeline, and move barges.

Water quality monitoring was conducted in an adaptive manner in response to changing operational and weather related conditions. The monitoring approach was modified as tides and winds changed; as dredges changed areas; as debris removal activities changed; and as warranted based on support activities. The monitoring activities were also largely influenced by tidal conditions and safety. The dredge areas and the associated perimeter cable spanned most of the width of the river limiting access to northern portions of the river, including potential reference locations. Only at high tide was the east side of the river passable. At low tides it was often possible to pass under the perimeter cable, but sampling time was limited. All of these activities (dredging, debris removal, and support activities) had the potential to impact water quality. The monitoring program incorporated assessment of the entire operation.

Figure 10. Debris Removal Excavator

4.2 Boat-based Measurements and Sample Collection

Boat-based monitoring followed the protocols outlined in Sections 2.1 and 2.2. Under these protocols the sampling teams functioned in an adaptive sampling mode, utilizing real-time *in situ* data to guide monitoring and sample collection. Depending on the objectives for each survey day, the real-time data either supported a criteria-based sampling approach (Figure 5) or guided the planned collection of water samples. Because no water quality exceedances of the established monitoring thresholds were identified at the 600-ft transect throughout the entire 2007 dredge season, no criteria-based samples were collected. However, non-exceedance data gathered within the 600-ft project boundary provides valuable information as to the potential effects of dredging and related activities on water quality during dredge operations. This is discussed further in Section 5. The results below describe the discrete sampling activities by collection date. Results of chemical and biological testing are provided in Section 4.4.

Water samples were collected either to establish baseline conditions and/or re-establish relationships between field measurements (i.e. turbidity) and toxicity results to verify the protectiveness of the 50 NTU criteria. No samples were collected in response to an exceedance of the 50 NTU turbidity criteria at the 600-ft transect. Water samples were collected for turbidity and TSS analyses on six occasions during the dredge season as detailed in the following paragraph. During three of these events samples were also collected for PCB and toxicity testing (Table 1). Metals samples were collected during four of the sampling events and were archived for potential analysis. None of the metals samples required analysis based on results of the other monitoring results.

The first sampling event was conducted on August 9, 2007 following Level I protocol (turbidity, TSS, PCBs, toxicity, and metals testing) during dredging and debris removal activities in Area H.

Four samples were collected: one reference sample, collected approximately 1,000 ft south of the dredging operations; one sample targeting the 55-60 NTU range, collected within approximately 100-150 ft from debris removal activity occurring on-site; and two samples targeting an intermediate turbidity (10-30 NTU), collected less than 300 ft south of the Area H dredge boundary.

The second sampling event was conducted on August 16, 2007 in response to observance of elevated turbidity plumes in Area G during debris removal activities (though below the 50 NTU at 300 ft criteria). Level II protocols were followed and four samples were collected for turbidity, TSS, and metals: one reference sample, collected at the Wood St. Bridge reference site; one sample collected 200 ft south of the debris removal; one sample from the Area G dredge boundary; and one sample collected 300 ft south of the Area G dredge boundary.

The third sampling event was conducted on August 29, 2007 during debris removal activities conducted at Area G. Level II protocols were followed and four samples were collected for turbidity and TSS analysis only: one sample was collected at the Wood St. Bridge reference site; one sample 75 ft from the debris removal activity; one sample at the Area G dredge boundary; and one sample 300 ft from the Area G dredge boundary.

The fourth sampling event was conducted on September 11, 2007 during dredging and debris removal activities at Area G. Level I protocols were followed and three samples were collected for the full suite of analyses. While unacceptable turbidity levels were not observed at the predefined boundary locations, the sampling team collected samples from a reference area and locations with higher turbidity close to the operations to evaluate turbidity/toxicity relationships and levels of protection. The reference sample was collected at the Wood St. Bridge, north of dredging activities. The other two samples were collected within 300 ft of dredging and debris removal activities; samples were collected from two turbidity ranges (23-29 NTU and 59-60 NTU). The team also observed several hundred dead fish south of dredge Area G. Dissolved oxygen readings in the survey area measured during this period ranged between 1.47 to 2.75 mg/L. COE was notified of fish kill and corrective action was taken immediately, including cessation of debris removal activities and deployment of additional oil booms.

The fifth sampling event was conducted at Area H on September 25, 2007 following Level II protocols. Three samples were collected for analysis of turbidity and TSS only, across a range of turbidity levels to generate a correlation curve of *in situ* turbidity readings to TSS values. Samples were collected in Area H, at locations targeting 10-20 NTU, 55-65 NTU, and 90-100 NTU during dredging activities.

The final sampling event was conducted on October 3, 2007 during dredging at Area H. Level I protocols were followed and three samples were collected for the full suite of analyses: one sample was collected approximately 50 ft, 300 ft, and 600 ft north of the dredge activities during the flood tide. Relatively low turbidity was measured in samples collected at all locations.

4.3 Continuous *In Situ* Data

The deployment of the continuously recording water quality sensors provided additional information that complimented the adaptive monitoring approach discussed above. The location of sensors both north and south of the dredge areas provides information regarding tidal

influences on sediment suspension and transport. The moorings were located between the 300 and 600 foot boundary lines of the active dredging area. Continuous readings provided water quality data for periods when adaptive sampling was not performed, such as inactive dredge periods (nights and weekends), thereby providing background condition for data comparison. Dredging operations frequently stopped and started due to mechanical or physical issues and the location of activities was highly variable. As a result, it is not always possible to ascertain how specific time periods in the continuous record relate to dredge activities. However, since no dredging took place on nights or weekends it is appropriate to use these time periods to define 'inactivity' and to use daytime to define 'activity' of the dredging operation. In this way, it is possible to distinguish dredging related water characteristics from background conditions. Appendix B provides plots of turbidity at both locations for the entire monitoring period. Additionally, these figures indicate tidal cycles and highlight nighttime and weekend periods. Individual examples are provided along with the results below.

In the discussion below and in the figures provided in Appendix B, a horizontal red line is indicated on each plot representing 50 NTU. A water quality criterion for the New Bedford Harbor Environmental Monitoring program has been established at 50 NTU above background, or natural turbidity. The background turbidity signal in the river is influenced by tidal conditions, stream flow, wind, and other factors. As a result the background turbidity signal can fluctuate on scales from minutes to days. In general, the background turbidity signal was between 3 and 20 NTU. Background values have NOT been removed from the continuous data presented in the following figures. As a result, the 50 NTU line should be viewed strictly as a guideline. For example, a value of 50 NTU represents a turbidity reading that is typically 40-47 NTU above background.

Turbidity signals related to dredge activity were clearly observed in the continuous *in situ* data. These signals manifest as peaks in turbidity above background. Figure 11 and Figure 12 in this section are provided as examples of these effects. The influences of tidal height and flow direction on sediment plume transport are also evident in these figures. Figure 11 shows the turbidity record from both moorings during Week 1 of dredging, including the following weekend. Nights and weekends are shaded on the figure to indicate periods of inactivity in the dredging operation. The following details water quality characteristics observed in the continuous record during this first week of dredging. The letters below correspond to the letters shown on Figure 11.

A. On an incoming tide, current flow is predominately towards the north. As a result, any suspended sediment plumes related to dredging would be expected to be evident at the northern mooring and would not be expected at the southern mooring. This was observed to some extent on all three days with active dredge (8/15-8/17) where, during the rising tide, the northern turbidity was greater than the southern turbidity (labeled 'A'). The peaks observed on August 17, 2007 provide the clearest example of this, as dredging operations were active for a complete tide cycle. Note that the YSI was set to take a thirty second sample every 10 minutes.

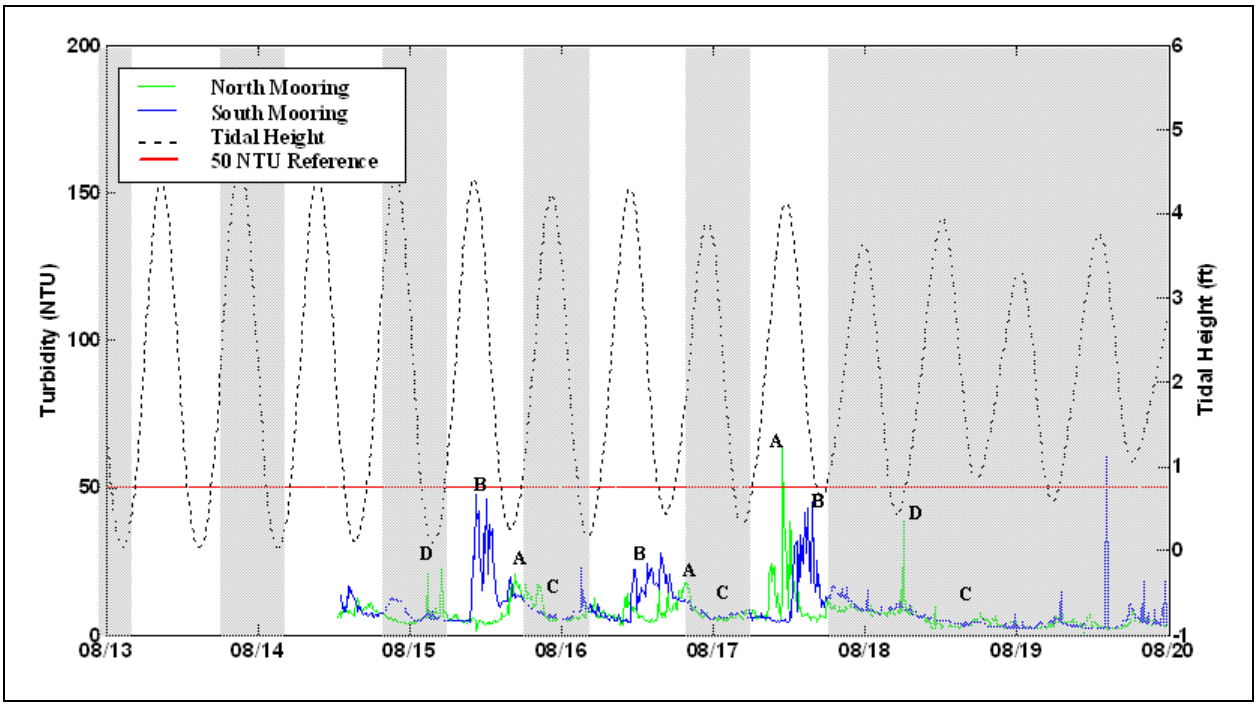
B. During the outgoing tide, the effect is reversed so that the southern mooring registers a turbidity peak ('B') while the turbidity measured at the northern mooring returns to background.

C. Weak turbidity peaks seen on days with no dredging activities (8/18-8/19) are indicative of background levels of turbidity. They generally occur at low tide and may be indicative of more turbid outgoing river water or they may be a result of the fact that the sensor is nearer the bottom during low tide where any naturally occurring sediment resuspension is most evident.

D. Throughout the record, occasional spurious readings are evident (narrow peaks such as the >50 NTU reading on 8/19). These are typically a single reading caused by momentary blockage of the turbidity sensor and do not indicate actual water column turbidity.

The correlation between low tide and background peaks in turbidity was occasionally very strong. This was true during extreme astronomical tides during the week of August 27, 2007. Figure 12 shows the effect of the exceptionally low tides on the turbidity signal at both moorings. Note that even during periods of no dredge activity (nights and weekend) high turbidity signals were observed during the low tides. Available weather data was reviewed for this time period, however, no apparent correlations existed between wind or precipitation and turbidity.

The 2007 dredge plan encompassed two geographic areas. These areas were active at various times during any given week as tides and other factors dictated. On occasions, the dredge would be working in one area while the debris removal was in the other area. When tides were below working conditions in the northern area, the dredge would work in the southern area. As a result, it is somewhat difficult to assess the location of dredging activities relative to particular data points in the continuous record. However, since the debris removal was active during August 16, 2007 in the southern area at high tide, and the dredge was not, it is reasonable to conclude that the relatively large plume observed by the south mooring that day was caused by the debris removal. Large turbidity plumes were also observed on October 8 and 9, 2007 at low tide in the southern section of Area H, however the debris removal barge was not operational, and only the dredge was in use. On September 14, 2007, the debris removal was not active, and the dredge crew was actively working in the northern area, however no apparent plume was observed (high tide). This indicates that both the debris removal and the dredge/support boats at times create significant turbidity plumes.



* Letters Correspond to Text.

Figure 11. Example of Turbidity Signals Related to Dredging and Tidal Direction, August 2007 (shaded areas indicate nights and weekends).

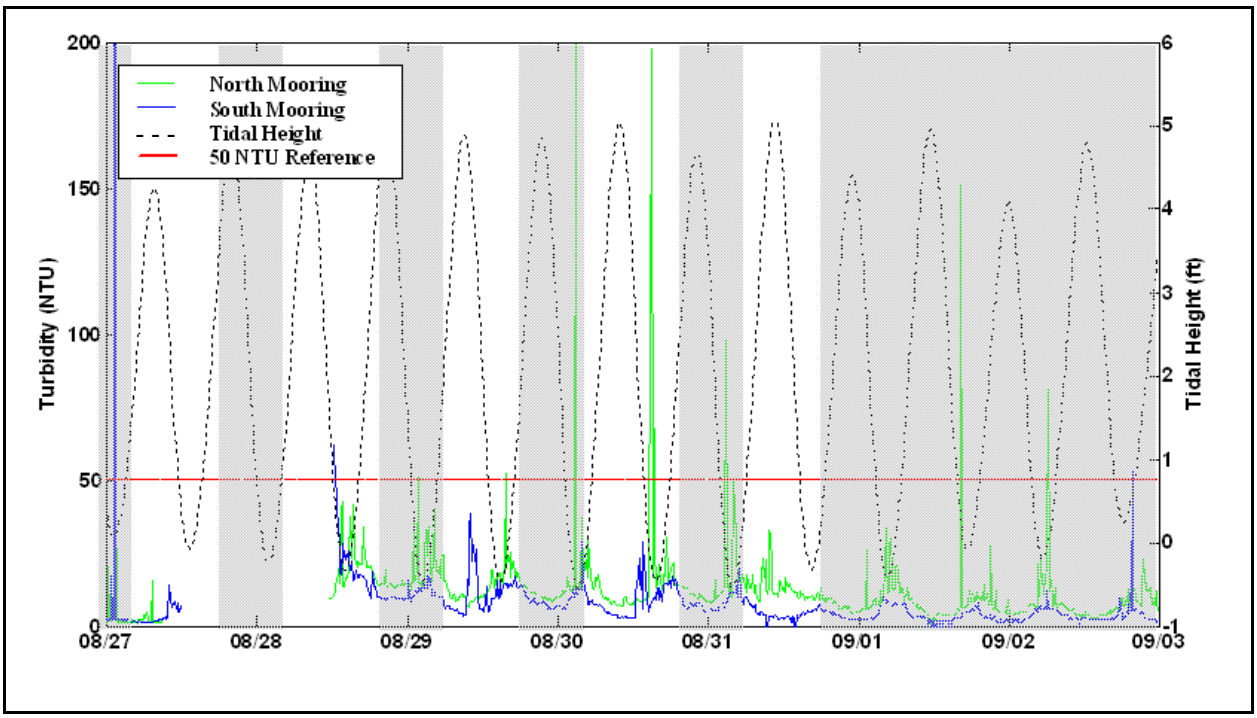


Figure 12. Example of Turbidity Signals Related to Extreme Low Tides, August and September 2007 (shaded areas indicate nights and weekends).

Continuous *in-situ* dissolved oxygen data were collected at both moorings throughout the majority of the deployments (Figure 13). Dissolved oxygen readings were typically higher during midday and decreased at night and throughout the early morning. The lowest dissolved oxygen readings recorded at the north and south moorings occurred early in the week of September 9, 2007 (Figure 13). Midday readings increased to approximately 5 mg/L, and the overnight readings decreased to approximately 2 mg/L. The low dissolved oxygen readings that occurred for 2-3 days, may have contributed to the fish kill that was observed on September 11, 2007 (see Section 5.1).

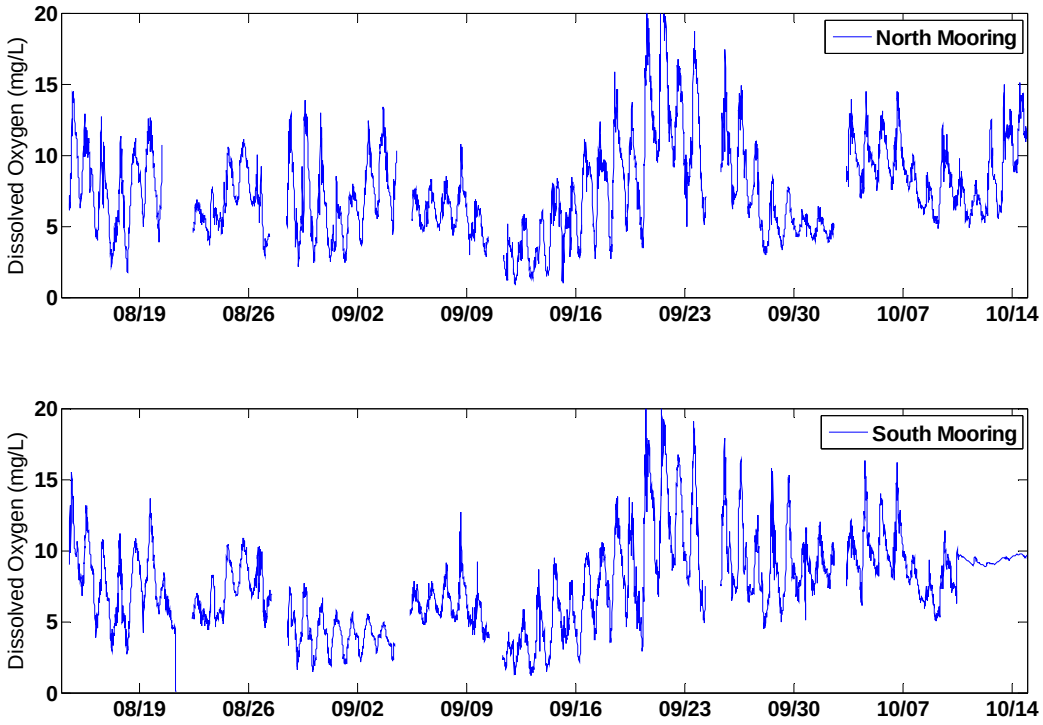


Figure 13. Continuous Dissolved Oxygen Data at the North and South Moorings, August to October, 2007.

4.4 Analysis of Discrete Water Samples

4.4.1 TSS/Turbidity Analyses

TSS and turbidity results for discrete water samples collected during the 2007 monitoring season are presented in Table 3. Field-based, *in-situ* turbidity data are also reported in Table 3 for comparison to the lab-based results. TSS and turbidity samples were collected based on distance from the dredging operation or debris removal (e.g., Reference, Boundary, 300 ft from Dredge Boundary, 200 ft from Debris Removal) and targeted turbidity levels (e.g., 13 NTU, 60 NTU).

In the field samples, TSS results ranged from 10.3 mg/L to 227 mg/L and turbidity results ranged from 4.6 NTU to 108 NTU. Samples collected from reference sites, which were generally located 1000 ft south or north of the dredging operation, showed relatively low TSS and turbidity measurements. TSS and turbidity values decreased with distance from the dredging operation (Table 3 and Figure 14). The highest TSS and turbidity values were observed in samples collected to target specific turbidity ranges (e.g., WQ-TSS/TUR-001-092507, WQ- TSS/TUR -002-092507). These samples were collected to confirm relationship between turbidity, TSS, PCB, and toxicity as described in Section 2.1.

In addition, an equipment blank sample (WQ-TSS/TUR-005-081607-EB) was collected on August 16, 2007. The TSS and turbidity values in the equipment blank were approximately an order of magnitude lower than the lowest values observed in the field samples, indicating minimal impact of equipment and sampling procedure contamination on the field sample data. Furthermore, four field duplicate samples were collected during the dredge season. The results from the duplicate samples were similar to the sample results for both TSS and Turbidity with exception of a TSS sample collected on September 11, 2007. The duplicate TSS sample value was four times higher than the initial sample collected.

4.4.2 PCB Analyses

PCB results are presented in Table 4. Water samples for PCB analysis were collected during three of the six sampling events. Ten water samples, plus two field duplicates were analyzed for total (dissolved + particulate) PCBs (sample ID with prefix "WQ-TPC") and dissolved PCBs (sample ID with prefix "WQ-DPC"). One equipment blank sample was collected and analyzed for total PCBs.

The sum of 18 NS&T congeners (referred to as "SUM 18 CONG" in the text) for all the collected water samples are presented in Table 4. Because no appropriate multiplier is available from previous studies to correlate SUM 18 CONG to total PCB concentration in the water samples of the New Bedford Harbor, SUM 18 CONG is used in this report as an indicator of the relative level of PCB contamination in the water samples. Note that SUM 18 CONG only represents a fraction of the total PCB concentration in the water samples. The detailed analytical results of the water samples, including the concentrations for individual 18 congeners, as well as SUM 18 CONG, are presented in Appendix C. The SUM 18 CONG ranges from 0.25 µg/L to 24 µg/L in the total (dissolved + particulate) water samples, and from 0.12 µg/L to 1.7 µg/L in the dissolved phase samples (Table 4).

Table 3. Summary of TSS and Turbidity Results

Date	Sample ID	Sample Description[1]	Lab-based		Field-based, *in-situ* reading
			TSS (mg/L)	Turbidity (NTU)	Turbidity (NTU)
8/9/07	WQ-TSS/TUR-001-080907	Mid-Reference-Area H	10.5	4.6	2.2
8/9/07	WQ- TSS/TUR -002-080907	13 NTU-Area H	31.5	18	13.2
8/9/07	WQ- TSS/TUR -003-080907	20 NTU-Area H	40.7	24	19.6
8/9/07	WQ- TSS/TUR -004-080907	55 NTU-Area H	117	63	~55[2]
8/16/07	WQ- TSS/TUR -001-081607	Wood St. Reference-Area G	18.7	8.65	5.8
8/16/07	WQ- TSS/TUR -002-081607	200 ft from Debris Removal-Area G	26	14.7	16
8/16/07	WQ- TSS/TUR -003-081607	Dredge Boundary-Area G	24.5	12.4	11.1
8/16/07	WQ- TSS/TUR -004-081607	300 ft S of Dredge Boundary-Area G	10.5	5.14	3.4
8/29/07	WQ- TSS/TUR -001-082907-DUP	Wood St. Reference-Area G	27	12.3	9.1
8/29/07	WQ- TSS/TUR -001-082907	Wood St. Reference-Area G	24	12.1	9.1
8/29/07	WQ- TSS/TUR -002-082907	75 ft from Debris Removal-Area G	57	32.9	30.5
8/29/07	WQ- TSS/TUR -003-082907	Dredge Boundary-Area G	23.5	13.4	17.2
8/29/07	WQ- TSS/TUR -004-082907	300 ft from Dredge Boundary-Area G	24	18.4	16.7
9/11/07	WQ- TSS/TUR -001-091107	Wood St. Reference-Area G	10.3	5.91	4.9
9/11/07	WQ- TSS/TUR -001-091107-DUP	Wood St. Reference-Area G	43.8	6.04	4.9
9/11/07	WQ- TSS/TUR -002-091107	23 NTU, 75 ft from Debris Removal-Area G	41	19.2	23-29[2]
9/11/07	WQ- TSS/TUR -003-091107	60 NTU-Area G	129	52	59-60[2]
9/25/07	WQ- TSS/TUR -001-092507	55 NTU-75 ft S of Dredge-Area H	188	63.8	57.6
9/25/07	WQ- TSS/TUR -002-092507	90 NTU-50 ft S of Dredge-Area H	227	108	94.6
9/25/07	WQ- TSS/TUR -003-092507	10 NTU-100 ft S of Dredge-Area H	27.5	13.8	13.2
9/25/07	WQ- TSS/TUR -003-092507-DUP	10 NTU-100 ft S of Dredge-Area H	34.5	12.4	13.2
10/3/07	WQ- TSS/TUR -001-100307	50 ft N of Dredge-Area H	144	71.6	65-100[2]
10/3/07	WQ- TSS/TUR -002-100307	300 ft N of Dredge-Area H	34.3	15.5	13-20[2]
10/3/07	WQ- TSS/TUR -002-100307-DUP	300 ft N of Dredge-Area H	28.5	16.7	13-20[2]
10/3/07	WQ- TSS/TUR -003-100307	600 ft N of Dredge-Area H	19	14	11-13[2]
8/16/07	WQ- TSS/TUR -005-081607-EB	Equipment Blank	1	0.4	NA

[1] Samples are collected either based on distance (e.g., 300 ft from Dredge Boundary, 200 ft from Debris Removal) or Turbidity levels (e.g., 13 NTU, 60 NTU), see Section 2.1 for further discussion on Sample Location.

[2] *In situ* readings were erratic and varied during sample collection

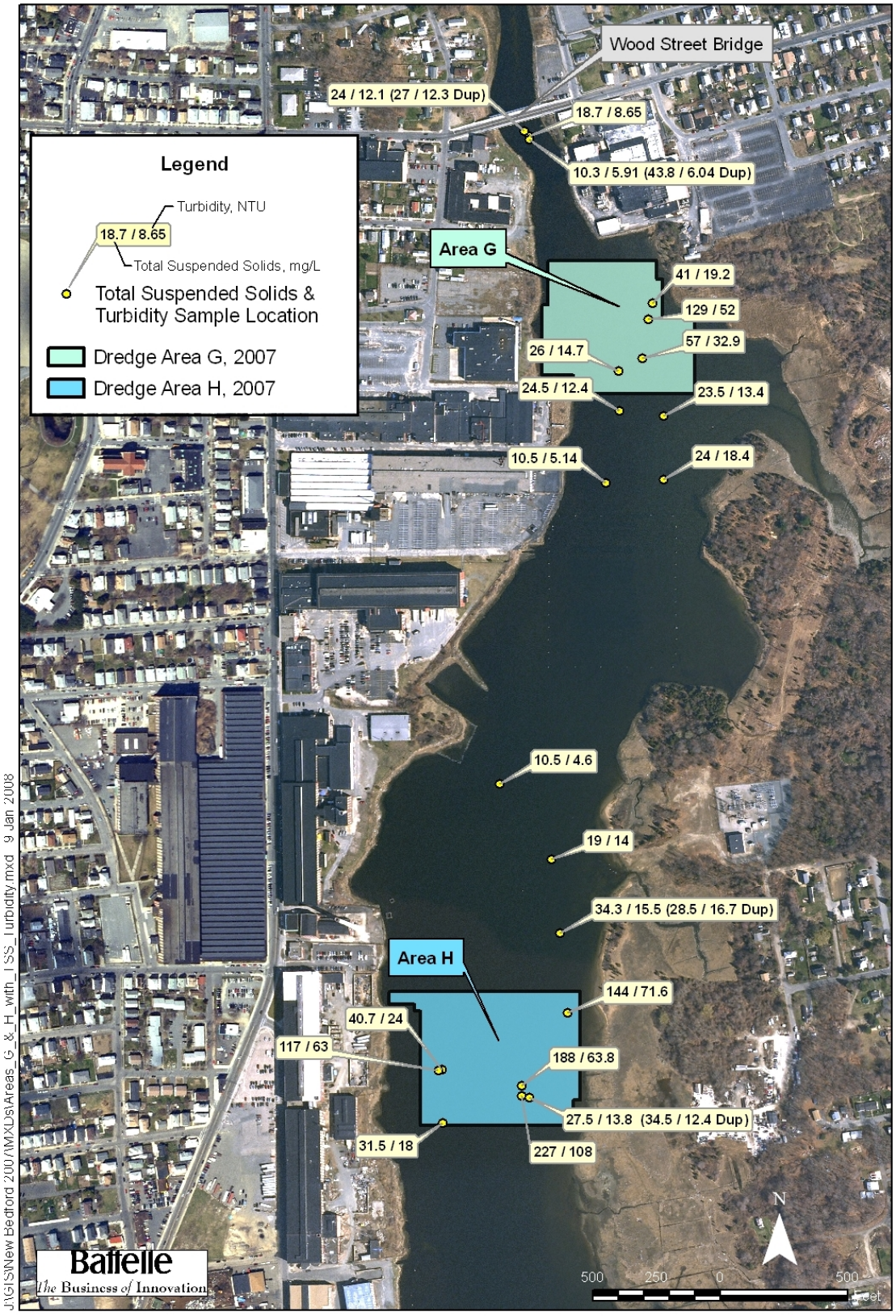


Figure 14. TSS and Turbidity Results.

The concentration of PCBs (SUM 18 CONG) measured in the equipment blank (WQ-TPC-004-091107-EB) collected on September 11, 2007 is 0.015 µg/L, which is one or more orders of magnitude lower compared to the field samples. This indicates that the equipment and sampling procedure contamination, if any, had minimal impact on the field sample data quality. Furthermore, the results from the two duplicate samples were similar to the initial sample results.

4.4.3 Toxicity Analyses

Toxicity samples were collected following Level I protocols during 3 of the 6 sampling events (Table 1), resulting in a total of 10 samples for biological testing. All toxicity samples were collected in support of pre-planned sampling events; none were triggered by turbidity exceedances. Each sampling event included an upstream reference sample and testing included a laboratory control sample. Results for test endpoints for each sample were statistically compared to those from both the event-specific site reference sample and the laboratory control. Toxicity results, including a summary of survival, growth, development and reproduction endpoints and associated statistical analyses for all tests conducted, are presented in Table 4. Supporting data, including laboratory bench sheets, water quality data, statistical analyses and custody forms are provided in Appendix D. Review of reference toxicant data associated with the tests showed all results within the acceptable ranges.

4.4.3.1 Sea Urchin (Arbacia punctalata)

1-hr sperm cell fertilization – Percent fertilization was greater than 90% for all but two samples, and one of those was the control for the September 11, 2007 tests. Statistically, percent fertilization was never significantly lower than the laboratory control sample, however, two samples exhibited statistically significantly lower percent fertilization than the site-specific reference samples. Percent fertilization was consistently high (> 85%) indicating that while some impact relative to the reference samples was observed, the impact was relatively small.

4.4.3.2 Mysid (Americamysis bahia)

48-hr survival – All 10 samples tested for mysid 48-hr survival were within 5% of the laboratory controls and overall survival was excellent.

7-day mean survival - All but one of the samples tested for mysid 7-day survival were within 5 % of the laboratory controls. Only one sample, the 59-60 NTU sample collected on September 11, 2007, showed significant reduction in survival compared to both the laboratory control and the site reference sample. This sample contained the highest dissolved and whole water PCB concentrations collected during the monitoring period.

7-day mean growth – mean growth ranged from 0.09 to 0.58 mg/mysid. Growth was similar to/or greater than the laboratory control and site reference for all but three samples tested. Only one sample showed statistically significantly reduced growth relative to the laboratory control while all three showed reduced growth relative to the site specific reference samples.

4.4.3.3 Red alga (Champia parvula)

48-hr mean survival – All samples showed 100% survival indicating no acute impact to the alga.

7-day mean reproduction – Champia reproduction, measured as the number of cystocarps produced, was found to be statistically reduced in 5 of the 10 site samples tested. All five of these samples showed reduced reproduction relative to the laboratory controls and three of these samples also showed reduced reproduction relative to the site reference samples. In general, reduced reproduction was found associated with samples of higher turbidity or those samples collected closest to the dredging activities. Cystocarp production in the site sample collected within 50 feet of dredging activities on October 3, 2007, showed no cystocarp production at all.

Table 4. Summary of TSS, Turbidity, PCB, and Toxicity

Dredge Area and Sample Date	Estimated Distance from Dredge (ft)	Sample Description[1]	TSS (mg/L)	Turbidity (NTU)	Total PCB[2] Results (µg/L)		Toxicity Results					
							Sea Urchin (*A. punctulata*)	Mysid (*A. bahia*)			Red alga (*C. parvula*)	
					Total	Dissolved	mean fertilization (%)	48-hr mean survival (%)	7-day mean survival (%)	7-day mean growth (mg/mysid)	48-hr mean survival (%)	7-day mean reproduction (cystocarp/tip)
Area H 8/09/07	N/A	Lab Control	N/A	N/A	N/A	N/A	96.9	92.5	92.5	0.350	100	38.6
	1000-1100	Reference	10.5	4.6	0.31	0.17	97.3	97.5	97.5	0.473	100	34.2
	500	13 NTU	31.5	18	0.28	0.12	96.7	97.5	97.5	0.423	100	**19.5** [3,4]
	200	20 NTU	40.7	24	0.25	0.14	97.8	97.5	95.0	0.436	100	40.4
	200	55 NTU	117	63	0.32	0.17	95.0	97.5	95.0	**0.372** [4]	100	**24.4** [3]
Area G 9/11/07	N/A	Lab Control	N/A	N/A	N/A	N/A	86.3	100	100	0.278	100	19.0
	570	Reference	10.3 (43.8[5])	5.91 (6.04[5])	2 (1.5[5])	1.1 (0.91[5])	92.7	100	98.8	0.322	100	20.8
	75	23-29 NTU	41	19.2	5.9	1.5	94.1	100	98.8	**0.283** [4]	100	27.4
	140	59-60 NTU	129	52	24	1.7	**84.8** [4]	100	**45** [3,4]	**0.090** [3,4]	100	**5.45** [3,4]
Area H 10/03/07	N/A	Lab Control	N/A	N/A	N/A	N/A	93.2	97.5	97.5	0.352	100	16.55
	50	50 ft.	144	71.6	8.2	1	94.7	100	100	0.580	100	**0** [3,4]
	300	300 ft.	34.3 (28.5[5])	15.5 (16.7[5])	1.7 (1.9[5])	1.7 (0.75[5])	**92.3** [4]	100	97.5	0.431	100	**9.65** [3]
	600	600 ft.	19	14	1.8	0.68	95.5	100	100	0.415	100	11.4
	N/A	Equipment Blank	1	0.4	0.015	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A – Not Applicable

[1] Samples are collected either based on distance (e.g., 300 ft from Dredge Boundary, 200 ft from Debris Removal) or Turbidity levels (e.g., 13 NTU, 60 NTU), see Section 2.1 for further discussion on Sample Location.

[2] Sum of 18 NS&T congeners.

[3] **Bold values** are significantly different from associated laboratory control sample.

[4] **Bold values** are significantly different from associated reference sample.

[5] Replicate value.

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5.0 DISCUSSION

The field monitoring program was designed to assess the potential impacts of dredging on water quality with an ultimate goal of minimizing harm to biological components of the system. To achieve that goal the monitoring was carried out in several ways;

- Adaptive *in situ* monitoring was used to track sediment plumes in real-time. This design allowed for immediate feedback to the dredging operation so that potential issues could be addressed before ecological harm was incurred.
- Pre-defined sampling provided guidelines for collection of analytical samples. The results of these analyses provide critical data regarding the chemical and biological impacts of dredging related activities on the system.
- Continuous data collection provided long-term information during periods when human-based sampling was not possible and when potential anthropogenic disturbances to the systems were minimal.
- Observational monitoring was conducted during all aspects of the program. This included anecdotal observations of fish passage and behavior, and observations of non-targeted parameters such as oil sheens and air quality. Like the adaptive *in situ* monitoring, observational monitoring provides rapid feedback to managers and operators and can help to minimize ecological risk.

5.1 Fishery and Wildlife Observations

Information pertaining to fish passage and behavior are based on visual observations recorded by field staff throughout the 2007 monitoring season. Throughout the dredge season large numbers of fish were observed in the study area. Lower trophic level baitfish were consistently observed moving throughout the river from Sawyer St. to Wood Street. Larger predatory fish such as striped bass and bluefish were also sporadically seen. Heron, egret, and other wading birds were observed feeding along the shoreline during these weeks. Terns, cormorants, and gulls were seen in fairly large numbers as well (Figure 15). During this time period, when fish were most abundant, there appeared to be no restriction of movement past the dredge area.

Figure 15. A Flock of Seagulls Observed in Area of Dredging Operations.

During the water quality monitoring, sporadic dead fish were observed in the dredge areas. On September 11, 2007, several hundred dead fish were observed south of dredge Area G and corrective action was taken as described in Section 3.0. Dissolved oxygen readings at Area G measured during this period ranged between 1.47 to 2.75 mg/L. While sensitivity to low levels of dissolved oxygen is species specific, most species of fish are distressed when levels decrease to 2-4 mg/L and mortality usually occurs at levels below 2 mg/L. The dissolved oxygen level and duration of the oxygen depletion event will impact the number of fish that can die. Larger fish are usually impacted by low dissolved oxygen before smaller fish (http://edis.ifas.ufl.edu/FA002). Approximately 10 days after the fish kill on September 11, 2007, the dissolved oxygen readings increased to above 15 mg/L (Figure 13). Based on routine observations dredging operations did not appear to impact fish passage.

5.2 Suspended Sediment and Sediment Transport from Dredging Activities

As in previous years a project-specific warning level of 50 NTUs above background 300 ft down current of dredging operations was set as a threshold for sample collection and assessment of operations. A project criterion of 50 NTUs above background at 600 ft down current was set as a threshold for immediate cessation of operations related to the exceedance. During the 2007 dredge season there were no exceedances of either the warning level or the project turbidity criterion.

During operations there were three general activities with potential to generate suspended sediment plumes; 1) dredging, 2) debris removal, and 3) support activities. Dredging itself created virtually no measurable sediment plumes. When safety allowed, the monitoring team worked in tight radiuses (<30 ft) around the active dredges. Debris removal generated the most consistent suspended sediment plumes. The act of 'raking' the bottom generated smaller plumes that tended to settle quickly. The largest impacts were associated with pulling the equipment (with or without debris) up through the water column (Figure 16). As sediment cascaded off of the equipment, sediment plumes could be seen down current. This was particularly true for the sediment fractions which were often observed in the upper water column (above the halocline) for extended periods and distances. Because the sampling effort was targeting areas of elevated turbidity, some of the of water quality monitoring was focused around debris removal activities. Support activities included transport of people and gear, dredge maintenance, and moving of debris removal equipment both on routine basis and as a result of inclement weather. This last activity required greater propeller power from the larger boats and was the only support activity which tended to re-suspend sediments. This was generally only a problem at low tide when prop wash reached the bottom. While this was an infrequent problem it tended to generate the largest, most sustained turbidity plumes.

Turbidity plumes generated by all activities tended to be extremely short lived, both spatially and temporally. Suspended sediment plumes related to debris removal tended to be pulsed in nature. For example, monitoring crews would conduct radial transects around the operation at approximately 100 ft. When the debris removal bucket would come up through the water column turbidity would quickly begin to increase. Sensors towed from the bow of the boat at slow speeds (<2 knots) were used to obtain real-time readings to track the movement of the plume away from the source towards the criterion boundaries. In general, turbidity would drop back down to background levels well before the 300 ft line was reached. In cases where elevated turbidity persisted out towards the boundary, the readings would generally persist for less than 5-

10 minutes. Even within close proximity to operations, the plumes tended to be of short duration. A good example of this was observed on August 9, 2007. On this date, sampling crews targeted elevated turbidity for sample collection, and operated in close proximity to the dredge and debris removal to find high values. One sample was collected within 50 ft and two samples were collected within 100 ft south of the dredge and debris removal activities. The first sample was collected in a high turbidity (55-60 NTU) condition with final TSS concentrations of 117 mg/L. In the two samples that were collected within 100 ft of the dredge and debris removal activities, the turbidity values decreased to 13-20 NTU and TSS values were an order of magnitude lower (30-40 mg/L). In an effort to characterize the toxicity effect of elevated turbidity (discussed previously) the team attempted to target the high NTU areas for discrete sample collection. However, this sampling effort proved to be fairly difficult as turbidity plumes did not usually persist for long enough to collect a full suite of discrete samples.

Figure 16. Debris Removal Generated the Majority of Turbidity Plumes

The short term, pulsed nature of the suspended sediment plumes is also observed in the continuous *in situ* data record (Figures 11 and 12). Turbidity peaks at the northern and southern mooring locations between the 300 ft and 600 ft lines were always below 50 NTU when compared to background. On an incoming tide, current flow is predominately towards the north and as a result, any suspended sediment plumes related to dredging was observed at the northern mooring. During the outgoing tide, the effect was reversed so that any suspended sediment plumes were observed at the southern mooring. Weak turbidity peaks seen on days with no dredging activities are indicative of background levels of turbidity. They generally occur at low tide and may be indicative of more turbid outgoing river water or they may be a result of the fact that the sensor was nearer the bottom during low tide where any naturally occurring sediment resuspension is most evident. Individual spikes are visible in the record above 50 NTU, but as discussed earlier, these are spurious single readings caused by momentary blockage of the turbidity sensor and not representative of water column turbidity. The only extended periods of

elevated turbidity occurred during extreme low tides. However, comparable signals were seen during inactive dredge periods.

As noted in the 2006 Water Quality Monitoring report (Battelle, 2007), one of the more subtle characteristics of sediment transport observed during the monitoring period was the tendency for very fine sediments to become entrained in the upper water column. This was first observed visually during the monitoring program. Sampling crews observed 'clouds' of fine sediment and targeted these features for *in situ* readings. This revealed a thin layer of elevated turbidity associated with the low salinity surface water. Immediately below this layer turbidity declined to background levels. The lighter surface layer usually only represented about the upper one foot of the water column. The elevated turbidity associated with this layer was often even thinner, comprising only a few inches resting on top of the sharp density gradient. This may have been caused by shear in the water column where the surface layer was moving in a different direction or at a different speed than the bottom layer. Alternatively, the estuarine turbidity maximum (ETM) is a common property of estuaries resulting as tidal water moves upriver creating turbulence and resuspending sediments from the bottom while particulates in the outflowing river are trapped against the density gradient, adding to the turbidity levels. Additionally, as the freshwater contacts the more saline water dissolved material can flocculate creating more particulates which add to the turbidity levels. In either case, turbidity readings in these surface layers were generally only about 15-30 NTU, well below the warning criterion, but at times these levels persisted for several hundred feet away from the source.

5.3 Impacts to the Water Column

As expected, turbidity correlated well with TSS ($R^2 = 0.9367$) in the two dredging areas (Figure 17). Samples collected from Area G (Figure 18) showed better correlation between total PCB (as SUM 18 CONG) and TSS, and thus with turbidity, than the samples from Area H (Figure 19). This may be an indication of different levels of PCB contamination in the sediments from the two dredging areas. Resuspended sediments from Area G may be relatively contaminated, resulting in the total PCB increase with TSS (Figure 18). On the other hand, Area H sediment may be less contaminated, and therefore a TSS and total PCB correlation was not apparent in the water samples from the area (Figure 19). As observed in the 2006 Water Quality Monitoring program, dissolved PCB concentrations were generally low and did not correlate well with TSS (Figure 20).

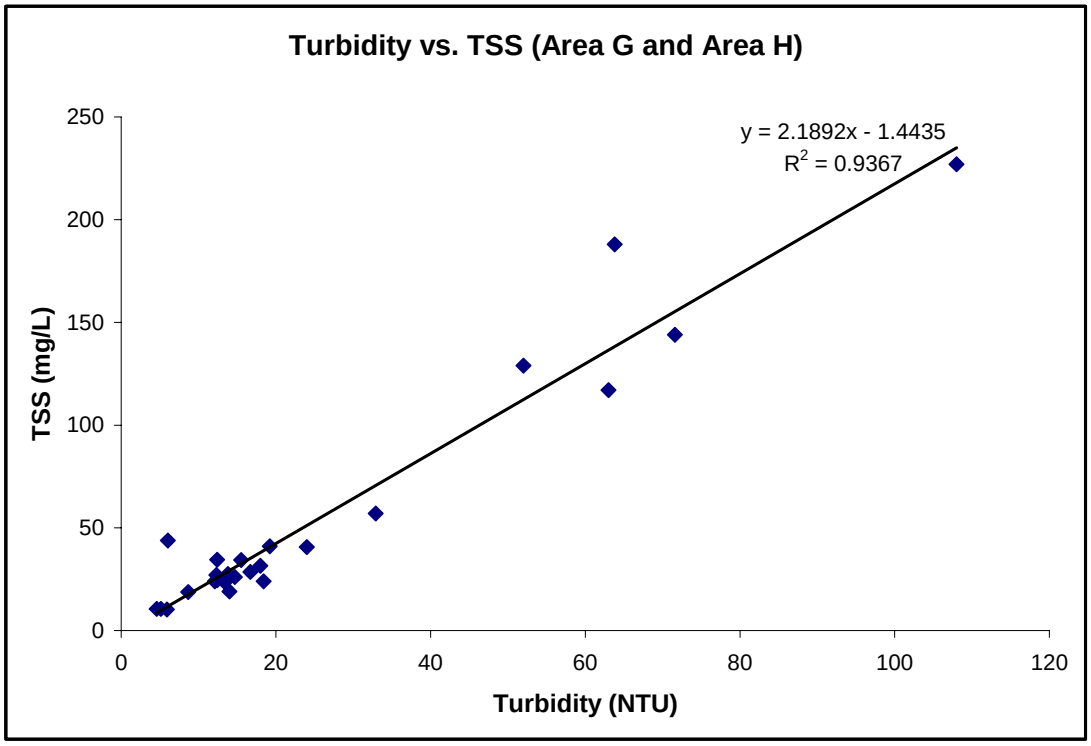

Figure 17. Turbidity vs. TSS Plot (Area G and Area H)

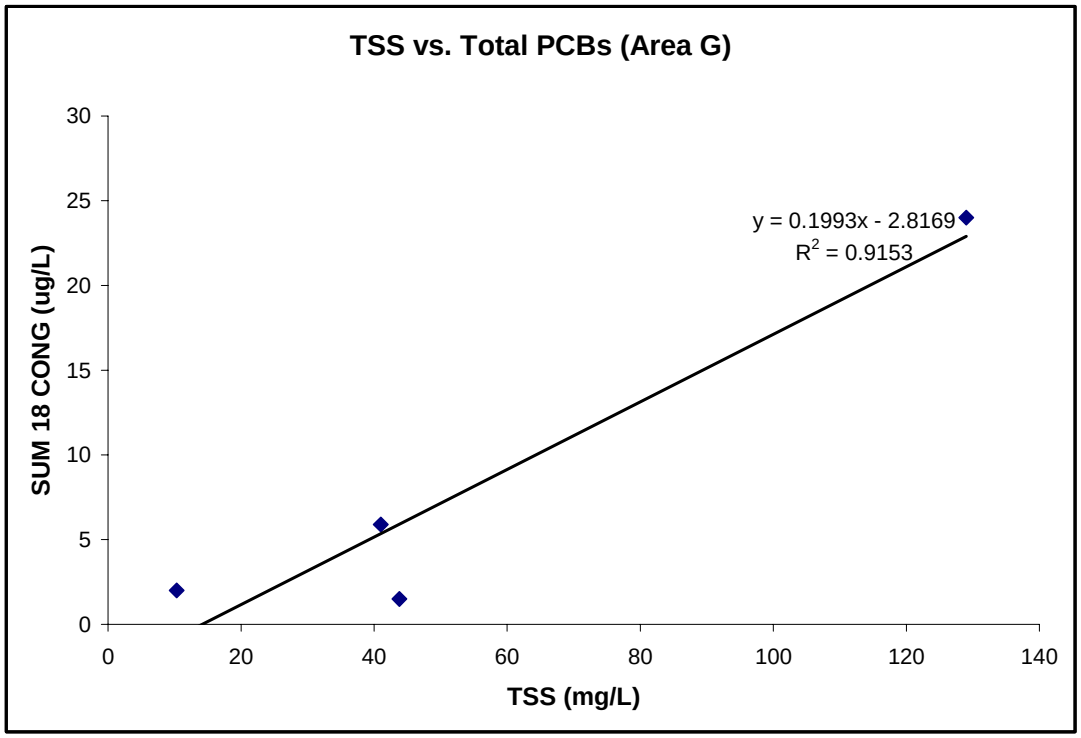

Figure 18. TSS vs. Total PCB Plot (Area G)

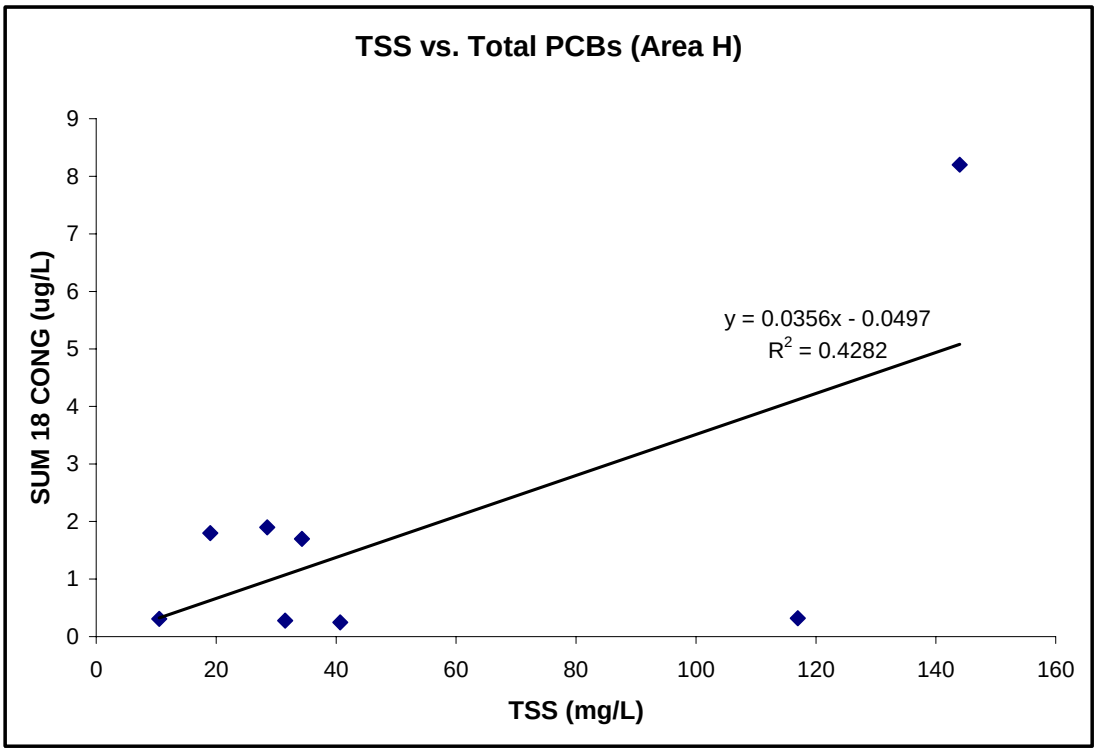

Figure 19. TSS vs. Total PCB Plot (Area H)

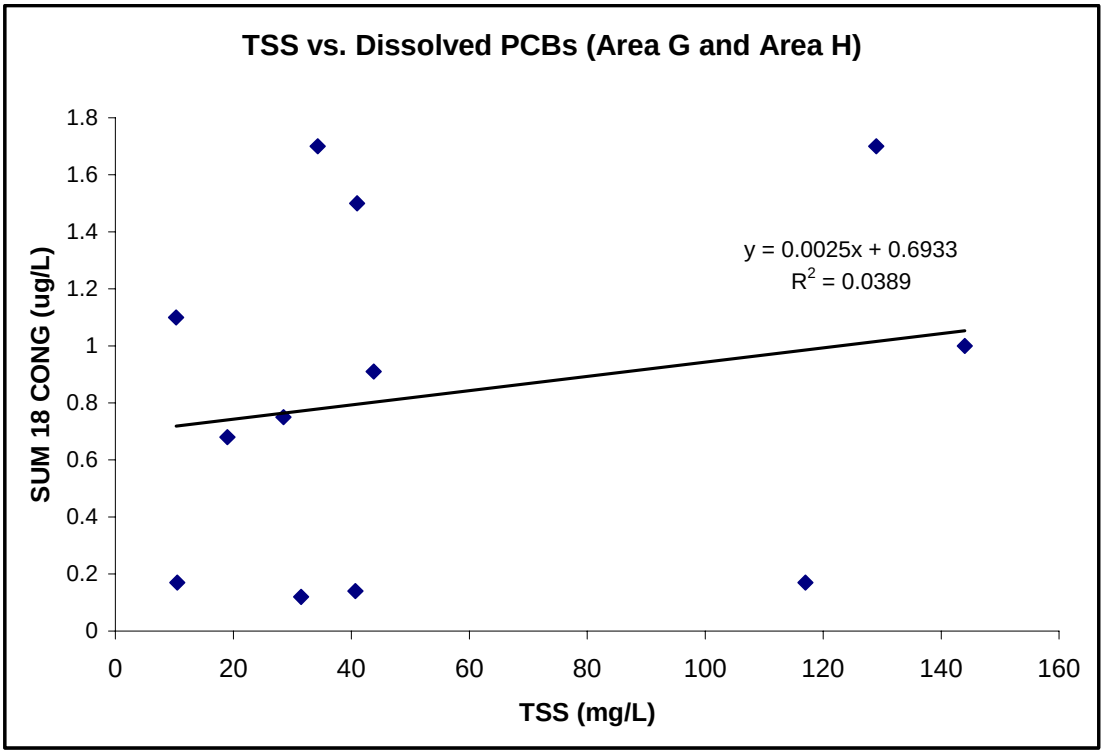

Figure 20. TSS vs. Dissolved PCB Plot (Area G and Area H)

Toxicity testing showed limited significant reduction in endpoints for all species (Table 4). Mean survival in the 48-hr mysid and red alga tests were not significantly different compared to reference (or laboratory control), indicating that there were no measurable acute impacts from exposure of the test species, *A. bahia* and *C. parvula,* to surface water collected at Areas H and G during dredging activities. In contrast, sublethal effects were observed for the 60-minute fertilization and 7-day survival, growth and reproduction tests. For example, *A. punctalata* fertilization was significantly lower than reference for the two surface water samples with the highest concentrations of dissolved PCBs (Table 4), albeit the magnitude of the reductions was small. *Americamysis bahia* mean survival and mean growth and *C. parvula* mean reproduction were significantly lower than reference (and control) for the surface water sample collected at Area G on September 11, 2007. Notably, this sample had the highest turbidity, TSS, and PCB (total and dissolved) concentrations measured during the monitoring season (at dredge Area G). Moreover, several hundred dead fish were observed south of Area G on this date. *Champia parvula* exposed to surface water collected 50-ft down-current of dredging activities at Area H on October 3, 2007 had the lowest cystocarp production. While there does appear to be measurable water column impacts, they appear to be limited to samples containing elevated turbidity, TSS and PCBs, and to areas well within the acceptable project boundaries.

As noted previously, *in situ* turbidity measurements indicated that these turbidity plumes, representing high suspended solids loads and elevated total PCB concentrations, were isolated to the area immediately adjacent to dredging and debris removal and were also relatively short lived. Total PCB concentrations remained relatively low at the dredge boundary and beyond. Dissolved PCBs, which are thought to be the fraction that causes direct toxicity to marine organisms and may be subjected to long range transport, remained low even in the samples with the highest TSS and total PCB concentrations. Overall, no exceedances of the turbidity criterion of 50 NTU above background were observed outside of the 300 ft boundary. While measurable water column impacts were observed based on toxicity testing, these were isolated to samples collected well within the project boundaries. Data collected confirmed that the 50 NTU criterion continues to be ecologically protective, while still allowing remediation efforts to progress.

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