Laboratory Testing In Support of *Site Specific Water Quality Criteria Assessment and Hydrographic Data Collection for New Bedford Harbor*

TASK 2A
SUSPENDED PARTICULATE PHASE
ACUTE TOXICITY TESTING WITH MYSIDS

Data Report

Prepared for:

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CZM

Submitted by:

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MAGUIRE GROUP

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Prepared for:

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Introduction

Task 2 of SAIC's *Site Specific Water Quality Assessment Study* involves toxicity testing and chemical analyses to determine risks to aquatic organisms from potential resuspension of sediments during dredging operations in New Bedford Harbor. These data will provide site-specific measures of the allowable chemical concentrations in water associated with the sediment resuspension during dredging. To date these concentrations have been derived through modeling exercises (ASA, 2001; 2002), and thus represents a data gap.

In Task 2A, toxicity testing of Suspended Particulate Phase (SPP) mixtures is performed to document the occurrence and magnitude of toxicity, as well as to select samples for further evaluation of the cause of toxicity using Toxicity Identification Evaluations (TIE, Task 2B). Also, the chemical exposure concentrations corresponding to non-toxic SPP samples are used to as a precursor to the derivation of Water Effect Ratios (Task 2C), which, when applied to the default water quality criteria values, represents an adjusted criteria for site specific conditions.

This document reports on Task 2A, including SPP testing, and data obtained from chemical analyses of SPP and elutriates. Minimal interpretation of the chemistry data is provided here, as this aspect of the Water Quality Criteria Assessment will be further addressed in Task 2B and Task 2C.

Approach

SPP testing is a standard and generally required activity for evaluation of dredged materials to determine the potential impact of dissolved and suspended contaminants on water column organisms (USEPA and USACE, 1991; 1998). For New Bedford Harbor, the SPP testing was conducted with six sediment samples collected from candidate CAD cell areas and navigation dredging areas with the intention of representing the most highly contaminated sediments that would be involved in navigation dredging operations. Background data on these locations were obtained from the draft EIS (Office of Coastal Zone Management, 2002). An SPP consisting of reference sediment was tested for toxicity, resulting in a total of seven toxicity evaluations; the chemical composition of the reference sample was not analyzed.

Methods

Sample Collection and Transport

Samples were collected by Maguire Group as part of an ongoing 'Nature and Extent' study. Three sediments from the Pope's Island CAD cell (PI-CAD; NBH-204, NBH-205 and NBH-206) and two from the more southerly CAD cell area (LH--CAD; NBH-201 and NBH-202) were selected for testing, along with one station (NBH-207) to the west of Pope's Island, a near-shore site that had been identified as a PCB hot-spot (Figure 1). The samples were collected on 10 October 2002, and were shipped in one-gallon polyethylene buckets, filled with no head space, on 11 October, arriving at the toxicity testing laboratory (SAIC's subcontractor, Aquatec Biological in Williston, VT) on 12 October. Standard chain-of-custody procedures were followed. Chain-of custody (CoC) forms were signed and copied. SAIC retains copies of the CoCs, along with test data in experiment binders and project files. Upon arrival, samples were inspected to determine

their temperature and condition (e.g., caps in place or leakage). When coolers were received on 12 October, temperatures slightly exceeded recommended storage conditions (4 $\pm$ 2°C) to varying degrees. However, because the transit time was < 24 hrs and the exceedences were generally small, we believe that results from toxicity tests with the samples are valid.
Samples were stored at 4 $\pm$ 2°C in the dark until testing.

Organism Selection and Source

The test species chosen for SPP testing was the saltwater mysid, *Americamysis bahia.* This species has been shown to be sensitive to New Bedford Harbor sediments in previous studies (Nelson et al. 1991; Ho et al., 1997). The mysid was also selected for its relatively high sensitivity to PCBs, and because their sensitivity to a wide variety of other toxicants has also been documented (USEPA AQUIRE). Mysids for testing were supplied by Aquatic Biosystems in Fort Collins Colorado. They were hatched14 October, received at Aquatec on 16 October and the test was initiated on 17 October. Newly hatched *Artemia* were fed to mysids on each day prior to test initiation, and daily feeding continued during the test.

Mysids were evaluated using a standard reference toxicant water-only test with potassium chloride. In this test, survival is determined in each of two replicate chambers to which ten animals have been added. The reference test uses a six dilution series with concentrations ranging between 0.1 and 1.0 g/L, and is used to determine LC50 values for comparison with Control Chart values. Aquatec's Control Chart for the mysid *(A. bahia)* includes > 20 tests from mysid tests conducted since 1999.

Suspended Particulate Phase Preparation and Testing

Suspended Particulate Phase samples were prepared by adding homogenized sediment to site water in a 1:4 volumetric ratio. The solution was stirred with a mixer for 30 minutes, and every 10 minutes by hand, and then allowed to settle for one hour. The supernatant was siphoned off for toxicity testing as well as for total suspended solids (TSS) and total organic carbon (TOC) analyses. For other chemical analyses (TAL metals, PAHs and PCBs), the supernatant (SPP) was centrifuged for approximately 10 minutes at 6000 rpm. Samples were preserved, as appropriate and were air-freighted to SAIC's subcontractor for chemical Analyses, Severn Trent Laboratories in Burlington, VT. The following EPA-recommended analytical methods (U.S. EPA, 1997) were employed: TOC (9060); TSS (160.2); PCB congeners (8082); TAL metals (6010B). PAHs were measured using NOAA Status and Trends methods (NOAA, 1998).

Dilutions of the SPP for toxicity testing were prepared by mixing the centrifuged supernatant with Forty Fathoms@ artificial seawater. Elutriate dilutions (1%, 10%, 25%, 50%, and 100%) as well as Control Water (artificial seawater) and a Long Island Sound Reference Site SPP were tested using mysid exposures.

Ninety-six hour tests using the mysid *(A. bahia)* were conducted according to the accepted proposal. The test chambers were glass jars. Two hundred milliliters of full strength or diluted elutriate was added to each of five replicate chambers per concentration. In addition, a Forty Fathoms® seawater performance control was tested. The performance control and the LIS reference SPP were tested using 100% SPP only. All other SPP samples were tested using the 1%, 10%, 25%, 50% and 100% dilution series. Test temperature ranged from 24 to 25 °C.

At the beginning of each test series, mysids were transferred from acclimating chambers into test chambers using a wide-bore pipette. Ten mysids were randomly distributed into each chamber. Animals were fed during testing. Test chambers were monitored daily and dead mysids were recorded and removed.

Acceptable dissolved oxygen concentrations were documented to be in the range of 7.8 to 8.2 mg/L at the start of the test, and 5.3 to 6.6 mg/L at the end of the test. Salinity increased by ≤3 mg/Kg, from 31 mg/Kg at test initiation, pH ranged between 7.8 and 8.2, across samples, with no apparent temporal trend. All water quality parameters were acceptable (U.S. EPA/U.S. ACE, 1998; U.S. ACE, 1991). Ambient laboratory lighting was set for a 16 hr light and 8 hr dark photoperiod. Full strength SPP solutions were analyzed for ammonia on day 0. Samples were diluted 1 to 10 with deionized water. Total ammonia was measured spectrophotometrically.

Data Analysis

Data analysis was performed with SPP results using a one-way heteroscedastic t-test (alpha=0.05) assuming normal distribution of the data. In addition, for each of the samples with statistically significant reductions in survival, estimated effect concentrations ("LC" values) were calculated using data from the dilution series. Values were calculated using linear interpolation, with bootstrapping to generate confidence intervals. Statistics were generated with the ToxCalc® statistical package from Tidepool Software. Results of the analyses were interpreted within the context of the following decision points, as follows (also see Fig. 1 of the proposal for this project):

- A finding of no toxicity and chemical measures below water quality criteria (WQC) values indicates that default WQC criteria may be used in monitoring and that no further testing is required.
- A finding of toxicity and chemical concentrations above WQC indicates that a specific chemical is causing toxicity or several chemicals are causing toxicity, or that confounding factors (e.g., ammonia toxicity) are contributing, such that a TIE (Task 2B) should be conducted to resolve the toxicity sources.
- A finding of toxicity but chemical concentrations below WQC will indicate that site-specific toxicity of chemicals is greater than presumed by default WQC. This result, generally indicative of confounding factors such as ammonia, and will also be further evaluated through the Task 2B TIE study.

Results

Quality Assurance/Quality Control

The summary report for reference toxicant (potassium chloride) testing conducted by Aquatec is presented in Appendix A. The LC50 was 0.373 g/L, well within the Control Chart lower and upper boundaries of 0.11 and 0.56 g/L, established the normal response of these organisms (Appendix A). During the SPP testing, water quality measurements of temperature, salinity, pH and dissolved oxygen were within normal the normal range for mysid exposures (U.S. EPA, 1991). All QA/QC parameters measured for chemical analyses were within acceptable ranges. SAIC maintains a copy of the full Toxicity Test Data Report provided by Aquatec and the analytical chemistry data report provided by Severn Trent Laboratories.

Site Sample SPP Toxicity Test Results

Mean survival for mysids was greater than 95% in all but one of the six SPP samples (Table 1). For NBH-202, toxicity was observed in the 100% SPP, but not in any of the dilution series. The calculated LC50 value was 76%; the ToxCalc summary report for the statistical analysis is presented at the end of Appendix B. Time series mortality in the NBH-202 100% SPP over each day of the four day test were as follows: No mortality had occurred by Day 1, while exposures through Day 2, Day 3 and Day 4 resulted in mean survival of 42%, 20% and 2%, respectively. Ammonia concentrations (Table 1) measured as a routine practice at the start of SPP testing indicate that NPH-202 had the highest concentration of total and unionized ammonia (37.9 and 1.6 mg/L, respectively), with the unionized concentration approaching the LC50 value for this species (1.94 mg/L). Relationships between toxicity and chemical exposure concentrations are discussed in the following section.

Analytical Chemistry Results and Exposure Characterization

<u>Comparisons with Aquatic Life Criteria and Species-specific Benchmarks.</u>

Results from chemical analyses of elutriates derived from SPP are presented in Appendix C. Hazard Quotients (HQ) derived from Chronic and Acute Water Quality Criteria values or equivalent are presented in Table 2 and Table 3, respectively. The values presented are simply the quotient of measured chemical concentrations (from Appendix C-1; Metals and PAHs and C-2; PCBs), divided by the respective Water Quality screening value.

In Table 2, chronic HQs for aluminum, copper, nickel, silver, benzo(k)fluoranthene and Total PCBs are > 1 for all stations (except NBH-204 for benzo(k) fluoranthene). Among these, the copper and PCB concentrations are likely to be the most toxicologically relevant; as aluminum, is likely biased by the solids component while nickel and silver concentrations were non-detect. Station NBH-202 had the highest chronic HQs.

Using Acute Water Quality Criteria as benchmarks (Table 3), proportionately lower exceedences (HQs> 1) are calculated to represent risks associated with short duration exposures. Because dilution will occur during dredging operations, these Acute HQs are more appropriate than chronic criteria values for interpretation of elutriate concentrations. Acute HQs for PAHs and Total PCBs are less than unity at all stations other than NBH-202. For NBH-202, the sum PAH HQ is 1.33 and the Total PCBs HQ is 2.31, suggesting probable toxicity. The highest HQ for NBH-202 is for copper (HQ=20). Four of the other five stations also exceeded the acute criteria for copper, with (HQ range 1.48 to 8.13). Only NBH-204 had an elutriate copper concentration less than the Acute Criteria value.

Hazard Quotients based on the known sensitivity of mysids *(A. bahia)* to metals, including copper, as well as PCBs and ammonia, are presented in Table 4. Based on available information (i.e., published LC50 values), the major contributors to toxicity in NHB-202 appear to be PCBs (HQ= 1.36), unionized ammonia (HQ=0.82), and copper (HQ=0.64). The sum HQ was less than unity for the remaining stations, suggesting that acute toxicity is not likely to occur.

The sum HQ for NBH-202 mysid exposures, based on measured concentrations of PCBs, ammonia and metals is 2.9 (Table 4), with PCBs being the largest contributor. There is relatively high uncertainty associated with the HQ for PCBs, given that it is based on exposures to Aroclor 1242 (Ho et al., 1997). While Aroclor 1242 and Aroclor 1254 are believed to be the major PCB mixtures present in New Bedford Harbor sediments, mixtures of congeners changes over time due to natural physical and biological processes. Toxicity of PCB mixtures is also expected to change somewhat over time, but parent compound toxicity is generally used to estimate potential toxicity in field samples because no other approach is practical. The mysid LC50 for Aroclor 1242 was used as a conservative value to derive species-specific HQs, and it is about three times more toxic to mysids than Aroclor 1254 (Ho et al., 1997). The value used is particularly conservative because it was derived from a 96 hr test that was renewed with freshly prepared solution at 48 hrs, while the SPP tests for the present study were not renewed, and reduction in exposure concentrations are expected over time. The estimate of total PCBs (Appendix C-2) used in the HQ calculations was calculated from individual congeners using NOAA Status and Trends protocol (1998).

With regard to ammonia, reported LC50s from a single study range over a factor of two-three, based on total and unionized values, respectively. Therefore, the HQ for ammonia for NBH-202 could be as low as 0.5 or as high as 1.6. For copper, the range between two reported LC50s is relatively narrow (141 μg/L, Bay et al. 1993; 164 μ/L, SAIC 1993). In summary, toxicity and chemical concentrations above WQC indicated a likelihood that toxicity could be attributable to metals, PCBs and confounding factors (e.g., ammonia toxicity), but the relative roles of each in toxicity associated with the NBH-202 sample remains uncertain. Task 2B involving the conduct of a Toxicity Identification Evaluation is directed at resolving the relative sources of toxicity. It is also important to consider that the three most likely sources of toxicity may contribute synergistically to observed effects.

Elutriate Concentrations Relative to Predicted Values

Table 5 presents measured concentrations of metals, PCBs and PAHs for each elutriate tested compared with predictions of elutriate concentrations that used equilibrium partitioning and sediment concentrations to derive computed estimates (ASA, 2001 ;U.S. EPA, 1991). Only one elutriate concentration is reported by ASA, representing the highest sediment loading (Fish Island Area; mean of 16 stations) found in the bulk sediment survey conducted by Lecco (1998). Only metals with measured concentrations above detection limits are presented.

For metals, measured values for copper in FI-A (near NBH-207) were a factor of 4.4 less than the estimated elutriate value. For Total PCBs the measured value was three orders of magnitude higher than the elutriate value based on ASA's reported estimate. A review of the ASA result is underway to evaluate potential causes for this large difference. The sum of measured PAH values (used as a surrogate for TPH) were all much lower than estimated values, and represent lower acute and chronic limits than measured PCBs. Massachusetts currently does not apply a standard for TPH.

Summary of Findings for Site Specific Water Quality Study

Results for the SPP tests determined that only NBH-202 was toxic to mysids. In this sample, the absence of toxicity in any of the dilutions indicates a relatively low level of acute toxicity. None of the other samples were acutely toxic. Given the close range of species-specific HQs (0.6-1.4) for the three predominant toxicants in NBH-202, attendant uncertainties associated with each, and the effects of ambient (site-specific) water quality on each, it is not possible to determine if one, two, or all three of the constituents (copper, Total PCBs, ammonia) are important contributors to toxicity. As described in SAIC's "Proposal for Site Specific Water Quality Criteria Assessment and Hydrographic Data Collection for New Bedford Harbor," sample NBH-202 is in the process of further evaluation, using Toxicity Identification Evaluation (TIE) methods as an effort to resolve the potential sources of the observed toxicity.

In addition, it would be useful to obtain estimates of elutriate concentrations derived from sediments representing areas other than Fish Island, and including the sediment chemistry data recently produced for characterization of sediment cores.

References

Nelson, W.G., R.J.Pruell (SAIC) and D.J. Hansen (EPA). 1991. Monitoring plan for remediation of the first operable unit ("hot spot") at the New Bedford Harbor Superfund Site. Document prepared for EPA Region 1 and the US Army Corp. of Engineers, New England Division.

Applied Science Associates. 2001. Preliminary dredged material transport modeling in New Bedford Harbor. ASA Report 01-100.

Applied Science Associates. 2002. Memorandum from Craig Swanson, Hyun-Sook Kim (ASA) to Hank Merrill (Maguire Group Inc.). Description of Field Data Requirements for Modeling the Dispersion of Sediment and Contaminants During Dredged Disposal Operations in New Bedford Harbor. 25 September 2002.

Ho. K.T., R.A. McKinney, A. Kuhn, M.C. Pelletier, R.M. Burgess. Identification of acute toxicants in New Bedford Harbor Sediments. Environmental Toxicology and Chemistry. 16: 551-557.

Lecco, Steven. 1998. Summary Tables for New Bedford/Fairhaven Sediment Chemistry Results. Massachusetts Dredged Material Management Plan MGI # 14912. October, 1998.

Miller, D.C., S. Poucher, J.A. Cardin and D. Hansen. 1990. The acute and chronic toxicity of ammonia to marine fish and a mysid. Arch. Environ. Contam. Toxicol. 19: 40-48.

National Biological Service. 1996. Sediment porewater toxicity survey and Phase I Sediment Toxicity Identification Evaluation studies in Lavaca Bay, Texas. Corpus Christi, TX.

Nelson, W.G., R.J.Pruell (SAIC) and D.J. Hansen (EPA). 1991. Monitoring plan for remediation of the first operable unit ("hot spot") at the New Bedford Harbor Superfund Site. Document prepared for EPA Region 1 and the US Army Corp. of Engineers, New England Division.

NOAA, 1993. Sampling and Analytical Methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects, 1984-1992. NOAA Tech Memo NOS ORCA 71. July.

NOAA, 1998. National Oceanic and Atmospheric Administration, 1998. Sampling and Analytical Methods of the National Status and Trends Program Mussel Watch Project: 1993-1996 Update, NOAA Technical Memorandum NOS ORCA 130

U.S. EPA. 1997. United States Environmental Protection Agency. June 1997. Test Methods for Evaluating Solid Waste. Physical/Chemical Methods. EPA SWL~846, 3rd edition, including Final Update III. U.S. EPA, Washington, D.C.

Office of Coastal Zone Management. 2002. Dredged Material Management Plan (DMMP) Draft Environmental Impact Report (DEIR) for New Bedford and Fairhaven, MA. Prepared under EOEA No. 11669 to Maguire Group. April.

SAIC 1993. Toxicity testing to support the New York/New Jersey Harbor Site specific criteria study. Science Applications Intl. Corp. Final Report to EPA. Contract No. 68-C8-0066. Work Assignment C-4-94. Internal Report # 1037.

SAIC. 1993. Draft data report on comparative sensitivity of four amphipod species to aqueous ammonia. Submitted to USEPA. EPA contract No. 68-CO-0044. Prepared by Science Applications International Corporation, Narragansett, RI. 30 pp.

US EPA. 1991. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. EPA/600/4-90/027.

U. S. Environmental Protection Agency and United States Army Corps of Engineers. 1998. "Evaluation of dredged material proposed for inland disposal: Testing manual," Washington, DC.

U. S. Environmental Protection Agency and United States Army Corps of Engineers. 1991. "Evaluation of dredged material proposed for ocean disposal: Testing manual," EPA/503R 91/001 Washington, DC.

EPA-823-B-94-001 ..."Interim Guidance on Determination and Use of Water-Effect Ratios for Metals," February 1994.

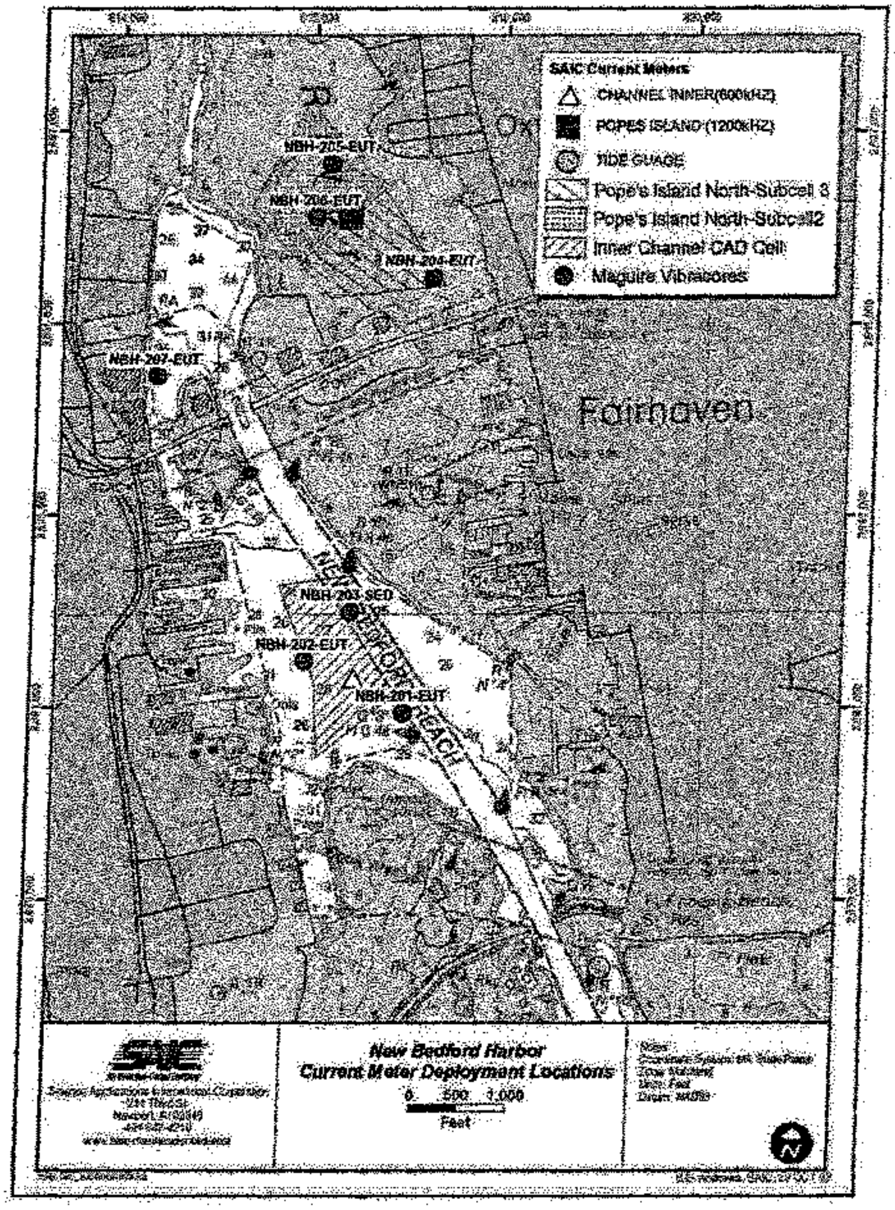


Figure 1. New Bedford Harbor stations selected for the Site Specific Water Quality Criteria Assessment Study (denoted as stations sampled synoptically for sediment core characterization- 'Maguire Vibracores').

Table 1. Results and Test Parameters for 96 hr Acute Suspended Particulate Phase Test using the mysid *Americamysis bahia*, exposed to New Bedford Harbor water and Suspended Particulate Phase samples.

Sample	% Survival[a] (Water only)	% Survival[b] (100% SPP)	% Survival[b] (50% SPP)	Total Ammonia (NH_4, mg/L)	Unionized Ammonia (NH_3, mg/L)
NBH-201	97	96	100	11.3	0.5
NBH-202	100	2	96	37.9	1.6
NBH-204	100	100	100	1.3	0.0
NBH-205	100	98	100	9.1	0.4
NBH-206	100	98	100	6.2	0.3
NBH-207	100	100	100	13.8	0.5
Control [c]	96				
Control [d]		100		1.38	ND

Temperature = 24-25°C ; Salinity = 31-34 mg/Kg; pH = 8.0-8.4; D.O. = 7.8-8.4 mg/L

a = 3 replicates of 10 mysids each per sample

b = 5 replicates of 10 mysids each per sample

c- Control water = Forty Fathoms mix.

d = Control sediment collected from Central Long Island Sound in 2000

Table 2. Hazard Quotients.[1] for CoCs in sediment elutriates
for the NBH Water Quality Study
Benchmark = Chronic WQC [2]

Class	Analyte	WQSV Source[2]	NBH-201-ELUT	NBH-202-ELUT	NBH-204-ELUT	NBH-205-ELUT	NBH-206-ELUT	NBH-207-ELUT
MET	Aluminum	87.0	1.85	27	6.63	3.98	2.48	9.80
MET	Antimony							
MET	Arsenic	36.0	0.14	0.50	0.11	0.65	0.37	0.14
MET	Cadmium	9.3	0.03	0.05	0.03	0.03	0.03	0.03
MET	Chromium	50.0	0.09	0.71	0.09	0.09	0.09	0.21
MET	Copper	3.1	2.29	32	1.29	3.48	2.29	13
MET	Iron							
MET	Lead	8.1	0.14	1.65	0.14	0.14	0.14	0.14
MET	Manganese							
MET	Nickel	8.2	1.65	1.65	1.65	1.65	1.65	1.65
MET	Silver	0.1	12	12	12	12	12	12
MET	Zinc	81.0	0.09	0.50	0.09	0.09	0.09	0.20
PAH	1-Methylnaphthalene							
PAH	1-Methylphenanthrene							
PAH	2,3,5-Trimethylnaphthalene							
PAH	2,6- Dimethylnaphthalene							
PAH	2-Methylnaphthalene (L)							
PAH	Acenaphthene (L)	97.00	2.8E-4	1.9E-3	2.2E-4	2.1E-4	2.1E-4	3.6E-4
PAH	Acenaphthylene (L)	49.00	5.5E-4	4.3E-4	4.3E-4	4.1E-4	4.1E-4	4.3E-4
PAH	Anthracene (L)	18.00	1.5E-3	1.8E-3	1.2E-3	1.4E-3	1.3E-3	1.8E-3
PAH	Benzo(a)anthracene (H)	0.66	0.03	0.23	0.02	0.05	0.04	0.14
PAH	Benzo(a)pyrene (H)	0.19	0.11	0.63	0.07	0.22	0.18	0.35
PAH	Benzo(b)fluoranthene	0.04	0.50	3.68	0.42	0.82	0.95	2.89
PAH	Benzo(e)pyrene							
PAH	Benzo(g,h,i)perylene							
PAH	Benzo(k)fluoranthene	0.02	1.24	8.24	0.65	1.76	1.47	4.18
PAH	Biphenyl							
PAH	Chrysene (H)	0.66	0.04	0.27	0.03	0.07	0.06	0.15
PAH	Dibenz(a,h)anthracene (H)							
PAH	Fluoranthene (H)	2.90	0.02	0.04	4.5E-3	0.02	0.02	0.07
PAH	Fluorene (L)	27.00	1.0E-3	1.6E-3	7.8E-4	4.4E-4	4.8E-4	8.9E-4
PAH	Indeno(1,2,3-cd)pyrene							
PAH	Naphthalene (L)	350.00	4.6E-5	9.1E-5	6.0E-5	5.7E-5	5.7E-5	6.3E-5
PAH	Perylene							
PAH	Phenanthrene (L)	24.00	1.0E-3	1.5E-3	8.8E-4	2.0E-3	1.8E-3	2.2E-3
PAH	Pyrene (H)	1.40	0.07	0.16	0.03	0.15	0.12	0.22
PAH	Sum PAH LD_{50}-based TUs[3]		2.01	13	1.22	3.09	2.84	8.01
PCB	Total PCBs	0.03	57	770	11	29	41	190

1 - Hazard Quotient = concentration(Appendix C)/Chronic Water Quality Criteria Value; Benchmark is for Chromium (6). Measured concentration is for total Chromium.

2 - Chronic Water Quality Criteria or Screening Values

3 - Sum PAH-HQ represents the additive toxic effects of PAHs, and equals sum of Toxic Units (PAH conc./LD50) of 13 PAHs (WQSV="F"); Swartz et.al., 1995.

Table 3. Acute Hazard[1] Quotients for CoCs in sediment elutriates for the NBH Water Quality Study.[1]

Benchmark = Acute WQC [2]

Class	Analyte	WQSV Source[2]	NBH-201-ELUT	NBH-202-ELUT	NBH-204-ELUT	NBH-205-ELUT	NBH-206-ELUT	NBH-207-ELUT
MET	Aluminum	750.0	0.21	3.09	0.77	0.46	0.29	1.14
MET	Antimony							
MET	Arsenic	69.0	0.08	0.26	0.06	0.34	0.19	0.07
MET	Cadmium	43.0	7.0E-3	0.01	7.0E-3	7.0E-3	7.0E-3	7.0E-3
MET	Chromium	1100.0	4.2E-3	0.03	4.2E-3	4.2E-3	4.2E-3	9.4E-3
MET	Copper	4.8	1.48	20	0.83	2.25	1.48	8.13
MET	Iron							
MET	Lead	220.0	5.0E-3	0.06	5.0E-3	5.0E-3	5.0E-3	5.0E-3
MET	Manganese							
MET	Nickel	75.0	0.18	0.18	0.18	0.18	0.18	0.18
MET	Silver	1.9	0.74	0.74	0.74	0.74	0.74	0.74
MET	Zinc	90.0	0.08	0.45	0.08	0.08	0.08	0.18
SEM	SEM-AVS	#REF!						
PAH	1-Methylnaphthalene							
PAH	1-Methylphenanthrene							
PAH	2,3,5-Trimethylnaphthalene							
PAH	2,6- Dimethylnaphthalene							
PAH	2-Methylnaphthalene (L)							
PAH	Acenaphthene (L)	970.000	2.8E-5	1.9E-4	2.2E-5	2.1E-5	2.1E-5	3.6E-5
PAH	Acenaphthylene (L)	490.000	5.5E-5	4.3E-5	4.3E-5	4.1E-5	4.1E-5	4.3E-5
PAH	Anthracene (L)	180.000	1.5E-4	1.8E-4	1.2E-4	1.4E-4	1.3E-4	1.8E-4
PAH	Benzo(a)anthracene (H)	6.600	2.7E-3	0.02	2.0E-3	5.0E-3	3.9E-3	0.01
PAH	Benzo(a)pyrene (H)	1.900	0.01	0.06	7.4E-3	0.02	0.02	0.03
PAH	Benzo(b)fluoranthene	0.380	0.05	0.37	0.04	0.08	0.09	0.29
PAH	Benzo(e)pyrene							
PAH	Benzo(g,h,i)perylene							
PAH	Benzo(k)fluoranthene	0.170	0.12	0.82	0.06	0.18	0.15	0.42
PAH	Biphenyl							
PAH	Chrysene (H)	6.600	4.4E-3	0.03	2.6E-3	6.5E-3	5.8E-3	0.02
PAH	Dibenz(a,h)anthracene (H)							
PAH	Fluoranthene (H)	29.000	1.7E-3	4.5E-3	4.5E-4	2.0E-3	1.7E-3	6.6E-3
PAH	Fluorene (L)	270.000	1.0E-4	1.6E-4	7.8E-5	4.4E-5	4.8E-5	8.9E-5
PAH	Indeno(1,2,3-cd)pyrene							
PAH	Naphthalene (L)	3500.000	4.6E-6	9.1E-6	6.0E-6	5.7E-6	5.7E-6	6.3E-6
PAH	Perylene							
PAH	Phenanthrene (L)	240.000	1.0E-4	1.5E-4	8.8E-5	2.0E-4	1.8E-4	2.2E-4
PAH	Pyrene (H)	14.000	7.1E-3	0.02	2.9E-3	0.02	0.01	0.02
PAH	*Sum PAH LD_{50}-based TUs*[3]		0.20	1.33	0.12	0.31	0.28	0.80
PCB	Total PCBs	10.00	0.17	2.31	0.03	0.09	0.12	0.57

1 - Hazard Quotient = concentration(Appendix C)/Acute Water Quality Criteria Value; Benchmark is for Chromium (6). Measured concentration is for total Chromium.

2 - Acute Water Quality Criteria or Screening Values

3 - Sum PAH-HQ represents the additive toxic effects of PAHs, and equals sum of Toxic Units (PAH conc./LD50) of 13 PAHs (WQSV="F"); Swartz et.al., 1995.

Table 4. Species-specific elutriate Hazard Quotients for chemical exposures to *Americamysis bahia* exposed to New Bedford Harbor Suspended Particulate Phase samples.

		Americamysis bahia[1]					
Analyte	Acute LC_{50}[2]	NBH-201-Elutriate	NBH-202-Elutriate	NBH-204-Elutriate	NBH-205-Elutriate	NBH-206-Elutriate	NBH-207-Elutriate
Cadmium	63	0.00	0.01	0.00	0.00	0.00	0.00
Chromium	2030	0.00	0.02	0.00	0.00	0.00	0.01
Copper	153	0.05	0.64	0.03	0.07	0.05	0.25
Lead	3000	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	498	0.01	0.08	0.01	0.01	0.01	0.03
PCB	17	0.10	1.36	0.02	0.05	0.07	0.33
NH_3	1.94	0.25	0.82	0.02	0.20	0.14	0.00
sum HQs		0.17	2.93	0.07	0.14	0.14	0.63

1 - Hazard Quotient = elutriate concentration (Appendix A-3)/species LC_{50}.

2 - LC_{50} values from Schubauer-Berigan et al (1993) except chromium (U.S. EPA, 1984b) and

3- Spike exposures not performed for mysids.

Table 5. Comparison of measured vs. predicted elutriate concentrations for New Bedford Harbor CAD and navigation channel locations.

	Fish Island (FI-A)		
Analyte[1]	NBH-207-Elutriate[2]	Predicted interstitial FIA-CAD[3]	Predicted Elutriate F1A-CAD[4]
Arsenic	5.1	6.7	1.34
Cadmium	0.3	5.5	1.1
Chromium	10.3	335	67
Copper	39	**866**	**173.2**
Lead	1.1	162	32.4
Zinc	15.8	**444**	88.8 0
Total PCBs	*5.69*	0.0276	0.00552
Sum PAH or TPH	0.979	3795	759

1- units: ug/L.

2- Elutriate represents supernatant from centrifuged Suspended Particulate Phase.

2- interstitial water concentrations reported as 'elutriate' in ASA 2002

3- Predicted elutriate concentration estimated to approximate toxicity test elutriate (sediment to water mixture = 1:4). 20% factor applied is slight over-estimate of dilution.

Italicized value indicates that measured concentrations were greater than predicted

Bold values indicate concentrations higher than Acute Water Quality Criteria.

Appendix A
Reference Toxicant (potassium chloride) Test Results

Appendix B
Summary Report for SPP Tests

Appendix B. Acute Mysid Test-96 Hr: ToxCalc Results

Start Date:	10/17/02	Test ID:	MYS_101702	Sample ID:	NBH
End Date:	10/21/02	Lab ID:		Sample Type:	AMB1-Ambient water
Sample Date:		Protocol:	EPAA 91-EPA Acute	Test Species:	MY-Mysidopsis bahia

Comments: S-Control = Forty Fathoms Lab Water, I-Control = REF (CLIS) 100% SPP

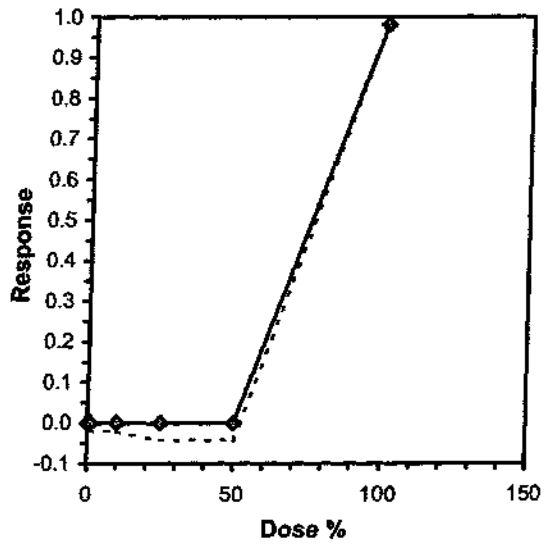
Conc-%	1	2	3	4	5
S-Control	10.000	10.000	9.000	9.000	10.000
I-Control	10.000	10.000	10.000	10.000	10.000
1	9.000	10.000	10.000	10.000	10.000
10	10.000	10.000	10.000	10.000	9.000
25	10.000	10.000	10.000	10.000	10.000
50	10.000	10.000	10.000	10.000	10.000
100	0.000	0.000	1.000	0.000	0.000

			Transform: Untransformed					Isot
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Mean
S-Control	9.600	0.9600	9.600	9.000	10.000	5.705	5	9.600
I-Control	10.000	1.0000	10.000	10.000	10.000	0.000	5	9.840
1	9.800	0.9800	9.800	9.000	10.000	4.563	5	9.840
10	9.800	0.9800	9.800	9.000	10.000	4.563	5	9.840
25	10.000	1.0000	10.000	10.000	10.000	0.000	5	9.840
50	10.000	1.0000	10.000	10.000	10.000	0.000	5	9.840
100	0.200	0.0200	0.200	0.000	1.000	223.607	5	0.200

Auxiliary Tests	Statistic	Critical	Skew
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.881041	0.91	-0.65189
Equality of variance cannot be confirmed			
The control means are not significantly different (p = 0.14)	1.632993	2.306006	

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC01	50.510	22.216	0.000	50.510	-0.8463
IC05	52.552	0.284	51.224	52.552	-0.3090
IC10	55.104	0.279	53.775	55.105	-0.2784
IC15	57.656	0.284	56.326	57.785	-0.1967
IC20	60.207	0.299	58.877	60.479	-0.0699
IC25	62.759	0.321	61.427	63.119	0.0757
IC40	70.415	0.422	69.080	71.268	0.4239
IC50	75.519	0.505	74.181	76.702	0.5483
IC60	80.622	0.595	79.283	82.135	0.6184
IC75	88.278	0.738	86.935	90.284	0.6713
IC80	90.830	0.787	89.486	93.001	0.6813
IC85	93.382	0.836	92.036	95.718	0.6891
IC90	95.934	0.886	94.587	98.434	0.6950
IC95	98.485				
IC99	>100				

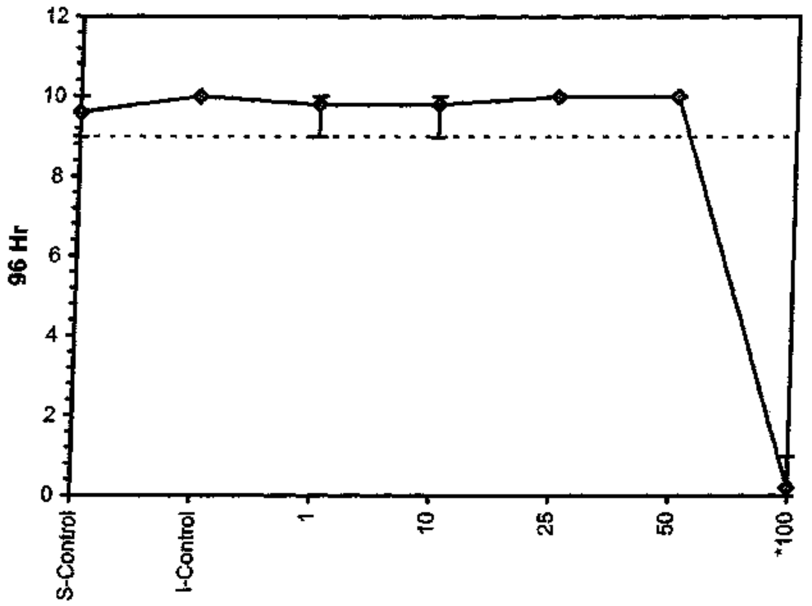


 ToxCalc v5.0.23 Reviewed by:_____

Appendix B. Acute Mysid Test-96 Hr: ToxCalc Results

Start Date:	10/17/02	Test ID:	MYS_101702	Sample ID:	NBH
End Date:	10/21/02	Lab ID:		Sample Type:	AMB1-Ambient water
Sample Date:		Protocol:	EPAA 91-EPA Acute	Test Species:	MY-Mysidopsis bahia
Comments:	S-Control = Forty Fathoms Lab Water, I-Control = REF (CLIS) 100% SPP				

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Appendix C
Chemistry Data

Appendix C-1. Results of elutriate chemical analyses for the NBH Water Quality Study: Metals and PAHs.

Class	Analyte	NBH-201-ELUT	NBH-202-ELUT	NBH-204-ELUT	NBH-205-ELUT	NBH-206-ELUT	NBH-207-ELUT
MET	Aluminum	161 B	2320	577	346	216	853
MET	Antimony	3.50 U	3.50 U	3.50 U	3.50 U	3.50 U	5.80 B
MET	Arsenic	5.20 B	18	3.80 B	24	13	5.10 B
MET	Cadmium	0.30 U	0.45 B	0.30 U	0.30 U	0.30 U	0.30 U
MET	Chromium	4.60 U	35	4.60 U	4.60 U	4.60 U	10
MET	Copper	7.10 B	98	4.00 B	11 B	7.10 B	39
MET	Iron	214	2630	587	218	212	995
MET	Lead	1.10 U	13	1.10 U	1.10 U	1.10 U	1.10 U
MET	Manganese	2.50 U	2.50 U	27	2.50 U	2.50 U	2.50 U
MET	Mercury						
MET	Nickel	14 U	14 U	14 U	14 U	14 U	14 U
MET	Silver	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U	1.40 U
MET	Zinc	6.90 U	40	6.90 U	6.90 U	6.90 U	16 B
PAH	1-Methylnaphthalene	0.03 U	0.01 J	0.02 U	0.02 U	0.02 U	0.01 J
PAH	1-Methylphenanthrene	0.03 U	0.05	0.02 U	0.01 J	0.01 J	0.02
PAH	2,3,5-Trimethylnaphthalene	0.03 U	0.07	0.02 U	0.02 U	0.02 U	0.02 J
PAH	2,6- Dimethylnaphthalene	0.03 U	0.01 J	0.02 U	0.02 J	0.02 J	0.02
PAH	2-Methylnaphthalene (L)	0.03 U	0.02 J	0.02 U	0.02 J	0.01 J	0.02 J
PAH	Acenaphthene (L)	0.03 U	0.18	0.02 U	0.02 U	0.02 U	0.04
PAH	Acenaphthylene (L)	0.03 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
PAH	Anthracene (L)	0.03 U	0.03	0.02 U	0.03	0.02	0.03
PAH	Benzo(a)anthracene (H)	0.02 J	0.15	0.01 J	0.03	0.03	0.10
PAH	Benzo(a)pyrene (H)	0.02 J	0.12	0.01 J	0.04	0.04	0.07
PAH	Benzo(b)fluoranthene	0.02 J	0.14	0.02 J	0.03	0.04	0.11
PAH	Benzo(e)pyrene	0.02 J	0.08	0.02 U	0.04	0.03	0.07
PAH	Benzo(g,h,i)perylene	0.02 J	0.09	0.01 J	0.04	0.03	0.06
PAH	Benzo(k)fluoranthene	0.02 J	0.14	0.01 J	0.03	0.03	0.07
PAH	Biphenyl	0.03 U	0.01 J	0.02 U	0.01 J	0.01 J	0.02 J
PAH	Chrysene (H)	0.03	0.18	0.02 J	0.04	0.04	0.10
PAH	Dibenz(a,h)anthracene (H)	0.03 U	0.03	0.02 U	0.02 U	0.02 U	0.01 J
PAH	Fluoranthene (H)	0.05	0.13	0.01 J	0.06	0.05	0.19
PAH	Fluorene (L)	0.03 U	0.04	0.02 U	0.01 J	0.01 J	0.02
PAH	Indeno(1,2,3-cd)pyrene	0.02 J	0.07	0.02 U	0.03	0.02 J	0.05
PAH	Naphthalene (L)	0.02 J	0.03	0.02 U	0.02 U	0.02 J	0.02
PAH	Perylene	0.03 U	0.02	0.02 U	0.02 U	0.02 U	0.02 J
PAH	Phenanthrene (L)	0.02 J	0.04	0.02 U	0.05	0.04	0.05
PAH	Pyrene (H)	0.10	0.22	0.04	0.21	0.17	0.31
PAH	Total LMW (L) PAHs	0.18	0.36	0.15	0.16	0.15	0.21
PAH	Total HMW (H) PAHs	0.24	0.83	0.12	0.41	0.34	0.77
PAH	Total LMW+HMW PAHs	0.42	1.19	0.27	0.57	0.49	0.98

Units: µg/L.
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene)
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene)
Total PAHs - *sum of LMW & HMW PAHs;*
Data Qualifiers: "B" (metals)=< Contract Detection Limit but >Instrument Detection Limit;
"J"=estimated (result between 1/2 reporting limit (RL) and RL); "U"=not detected above reporting limit.

Appendix C-2. Results of elutriate chemical analyses for the NBH Water Quality Study: PCBs, TOC and Total Suspended Solids.

Class	Analyte	NBH-201-ELUT	NBH-202-ELUT	NBH-204-ELUT	NBH-205-ELUT	NBH-206-ELUT	NBH-207-ELUT
PCB	PCB 101	0.12	0.90	0.01	0.05	0.08	0.40
PCB	PCB 105	0.04	0.04 U	5.9E-3	0.01	0.02	0.10
PCB	PCB 118	0.09	0.54	0.01	0.04	0.07	0.34
PCB	PCB 126	4.4E-3 U	0.04 U	4.1E-3 U	4.0E-3 U	4.1E-3 U	8.1E-3 U
PCB	PCB 128	0.03	0.23	4.1E-3 U	6.7E-3	0.01	0.05
PCB	PCB 138	0.10	0.92	7.6E-3	0.03 P	0.04 P	0.24
PCB	PCB 153	0.08 P	0.93 P	8.5E-3 P	0.03 P	0.05 P	0.27 P
PCB	PCB 156	0.01	0.11	4.1E-3 U	5.5E-3	7.5E-3	0.03 P
PCB	PCB 169	4.4E-3 U	0.04 U	4.1E-3 U	4.0E-3 U	4.1E-3 U	8.1E-3 U
PCB	PCB 170	0.01	0.15	4.1E-3 U	4.2E-3	6.5E-3	0.04
PCB	PCB 18	0.04	0.96	0.02	0.03	0.04	0.14
PCB	PCB 180	0.01	0.21	4.1E-3 U	5.9E-3	8.4E-3	0.05
PCB	PCB 183	4.9E-3	0.07	4.1E-3 U	4.0E-3 U	4.1E-3 U	0.01
PCB	PCB 184	4.4E-3 U	0.04 U	4.1E-3 U	4.0E-3 U	4.1E-3 U	8.1E-3 U
PCB	PCB 187	8.7E-3 P	0.15 P	4.1E-3 U	4.0E-3 U	4.9E-3 P	0.03 P
PCB	PCB 195	4.4E-3 U	0.04 U	4.1E-3 U	4.0E-3 U	4.1E-3 U	8.1E-3 U
PCB	PCB 206	4.4E-3 U	0.04 U	4.1E-3 U	4.0E-3 U	4.1E-3 U	8.1E-3 U
PCB	PCB 209	4.4E-3 U	0.04 U	4.1E-3 U	4.0E-3 U	4.1E-3 U	8.1E-3 U
PCB	PCB 28	0.05	1.52	0.02	0.06	0.07	0.31
PCB	PCB 44	0.05	1.06	0.01	0.03	0.04	0.17
PCB	PCB 49	0.07	1.92	0.02	0.05	0.06	0.31
PCB	PCB 52	0.10	2.41 E	0.02	0.06	0.07	0.30
PCB	PCB 66	0.09	1.13	0.02	0.05	0.08	0.35
PCB	PCB 77	4.4E-3 U	0.04 EU	4.1E-3 U	4.0E-3 U	4.1E-3 U	8.1E-3 EU
PCB	PCB 8	0.01	0.28	4.1E-3 U	8.0E-3	8.2E-3	0.04
PCB	PCB 87	0.08	0.68	7.9E-3	0.02	0.03	0.13
PCB	PCB 114	5.8E-3 P	0.06 P	4.1E-3 U	4.0E-3 U	4.7E-3 P	0.02 P
PCB	PCB 123	0.07	0.93	9.1E-3	0.03	0.04	0.20
PCB	PCB 157	4.5E-3	0.04 U	4.1E-3 U	4.0E-3 U	4.1E-3 U	0.01
PCB	PCB 167	6.7E-3	0.07	4.1E-3 U	4.0E-3 U	4.5E-3	0.02
PCB	PCB 189	4.4E-3 U	0.04 U	4.1E-3 U	4.0E-3 U	4.1E-3 U	8.1E-3 U
PCB	PCB 81	0.08	0.68	7.9E-3	0.02	0.03	0.13
PCB	Total PCBs	1.72	23	0.34	0.88	1.22	5.69
TOC	TOC - Elutriate, mg/L	4.6	12	2.3	7.3	5.4	6.8
TOC	TOC - SPP, mg/L	6.0	8.8	2.6	6.1	4.8	6.8
TSS	Total Susp. Solids, mg/L	525	1020	384	240	610	506

Units: µg/L (except where noted).

Total PCBs - Sum PCB congeners (8, 18, 28, 44, 52, 66, 101, 105, 118, 128, 138, 153, 170, 180, 187, 195, 206, 209) x 2 list of congeners analyzed by NOAA Status and Trends Program (listed in NOAA, 1993; revised NOAA, 1998).

~~Data Qualifiers: "E" = exceeds calibration range;~~

"P"=>25% difference between 2 analytical columns (lower value reported); "U"=not detected above reporting limit.

TOC - Elutriate: TOC of supernatant measured after centrifugation;

TOC - SPP (Suspended Particulate Phase): TOC of sediment/water mixture measured prior to centrifugation.

Appendix C-3. Results of elutriate particulate metals analysis for the NBH Water Quality Study.[1]

Class	Analyte	NBH-201-ELUT	NBH-202-ELUT	NBH-204-ELUT	NBH-205-ELUT	NBH-206-ELUT	NBH-207-ELUT
MET	Aluminum	6530	12400	3630	10900	11600	8400
MET	Antimony	0.56 B	1.1 B	0.31 B	0.57 B	0.61 B	1.1 B
MET	Arsenic	4.7	9.8	2.8	5.7	6	7.3
MET	Cadmium	1	3.7	0.16	0.29	0.23	2.6
MET	Chromium	85.2	276	31.5	55.6	54.8	236
MET	Copper	198	621	74.3	138	117	623
MET	Iron	11600	21300	6300	16800	18200	15100
MET	Lead	64.1	155	21.9	55.4	40.3	159
MET	Manganese	142	194	71.9	154	163	129
MET	Nickel	11.4	25.6	5.2	13	13.6	25
MET	Silver	1.6	4.3	0.19 B	0.25 B	0.25 B	2.3
MET	Zinc	129	289	44.3	92.7	72.4	409

1 - Elutriate particulate sample consisted of sediment pellet remaining after elutriate centrifugation.
Units: µg/g.
Data Qualifiers (assigned by laboratory): "B" = < Contract Detection Limit but >Instrument Detection Limit.