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Ostrich Bay Sediment Toxicity Evaluation

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Ostrich Bay Sediment Toxicity Evaluation

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Table of Contents

List of Figures and Tables

Page

Figures

Tables

Abstract

Sediments from 12 sampling stations in Ostrich Bay, near the city of Bremerton, Washington, were evaluated for compliance with the Washington State Sediment Management Standards. A former Naval ammunition depot discharged metals, munitions chemicals, and other organic chemicals into the bay during operations from 1904 to 1959.

Samples were collected in October 2004, and evaluated for toxicity and chemistry. Four bioassay tests – amphipod, juvenile polychaete, larval bivalve, and Microtox® – were conducted on each sample. Chemical analyses included semivolatile organics, metals, explosive compounds (nitroaromatics, nitramines, and perchlorate), and sulfides.

Both biological and chemical concentration-based regulatory criteria were exceeded. Six of the 12 stations did not meet the Sediment Quality Standards (SQS) based on bioassay testing. In addition, the mercury concentration SQS was exceeded at six stations, primarily in the same area where mercury exceedances were found in a 1994 investigation. The chemical concentration SQS for other metals and organic compounds were met, with the exception of benzoic acid at four stations.

The basis for the observed sediment toxicity is unknown. Elevated sulfide levels in Ostrich Bay do not appear to be a contributor. A previous attempt to identify a metal or organic contaminant responsible for the toxicity of Ostrich Bay sediments also was unsuccessful.

Acknowledgements

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Introduction

Background

Ostrich Bay is part of the complex system of Puget Sound embayments and channels near the city of Bremerton (Figure 1). The bay is about 1.2 miles long and 0.5 mile wide, and connects with Dyes Inlet to the north and with Oyster Bay to the south. Depths in Ostrich Bay are generally -20 to -30 ft mean lower low water (MLLW), with a maximum depth of about -45 ft.

A Naval ammunition depot formerly located on the west shore of Ostrich Bay discharged ordnance (munitions) chemicals, metals, and other organic chemicals into the bay during operations from 1904 to 1959 (EPA, 1994).

Sediment contamination in the bay has subsequently been investigated in a number of studies including a Remedial Investigation conducted by the U.S. Navy in 1994-1997 (URS, 1994; EA, 1998a,b). Ostrich Bay sediments tested in 1994 exceeded bioassay toxicity standards at most sampling locations during Phase II of the Navy Remedial Investigation. Sampling in 1997 gave similar results during a Remedial Investigation Treatability Study. Chemical contaminants found in Ostrich Bay sediments have included metals (e.g., cadmium, silver, and mercury), semivolatile organic compounds, and a variety of nitroaromatic and other munitions compounds.

Study Objectives

In response to a request from the Washington State Department of Ecology (Ecology) Sediment Management Unit, the Environment Assessment Program conducted a field study to evaluate current conditions in Ostrich Bay sediments. The primary objective of the study was to establish whether current sediment quality in the bay meets the Washington State regulatory standards for toxicity established in the Sediment Management Standards (Chapter 173-204 WAC). A secondary objective was to evaluate the spatial distribution of chemical contaminants in the sediments. The data collected will be used by Ecology's Toxics Cleanup Program in negotiations at the Jackson Park Housing Complex CERCLA site, which abuts Ostrich Bay.

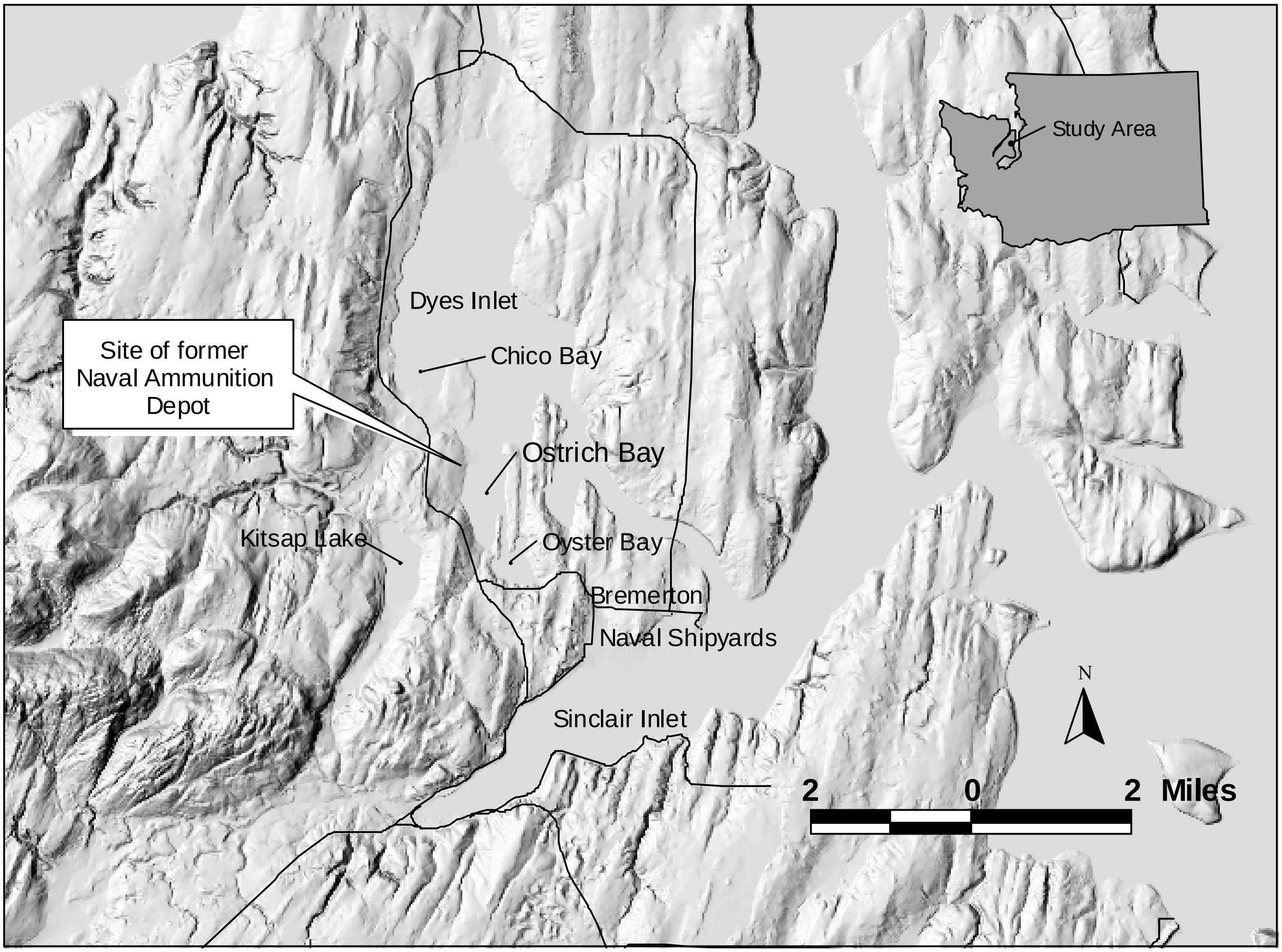

Figure 1. Ostrich Bay Study Area.

Methods

Sampling Design

Sampling locations were selected to meet several objectives:

1. Evaluate previously sampled locations to allow comparisons of results with existing data.
2. Select locations that can be used to characterize the current condition of Ostrich Bay sediments.
3. Include locations that will characterize the northern extent of contamination in Ostrich Bay.

Most of the selected sampling stations (Figure 2) have been sampled previously during the Phase II Remedial Investigation in 1994 and the Treatability Study in 1997. Two additional locations, OB1 and OB2, were added to provide more comprehensive coverage of the bay.

A reference station CR02 in Carr Inlet, about ten miles northwest of Tacoma, was selected based on grain size analysis data for this location from previous sampling. The location is close to the Carr Inlet stations used in the previous Ostrich Bay sediment toxicity studies.

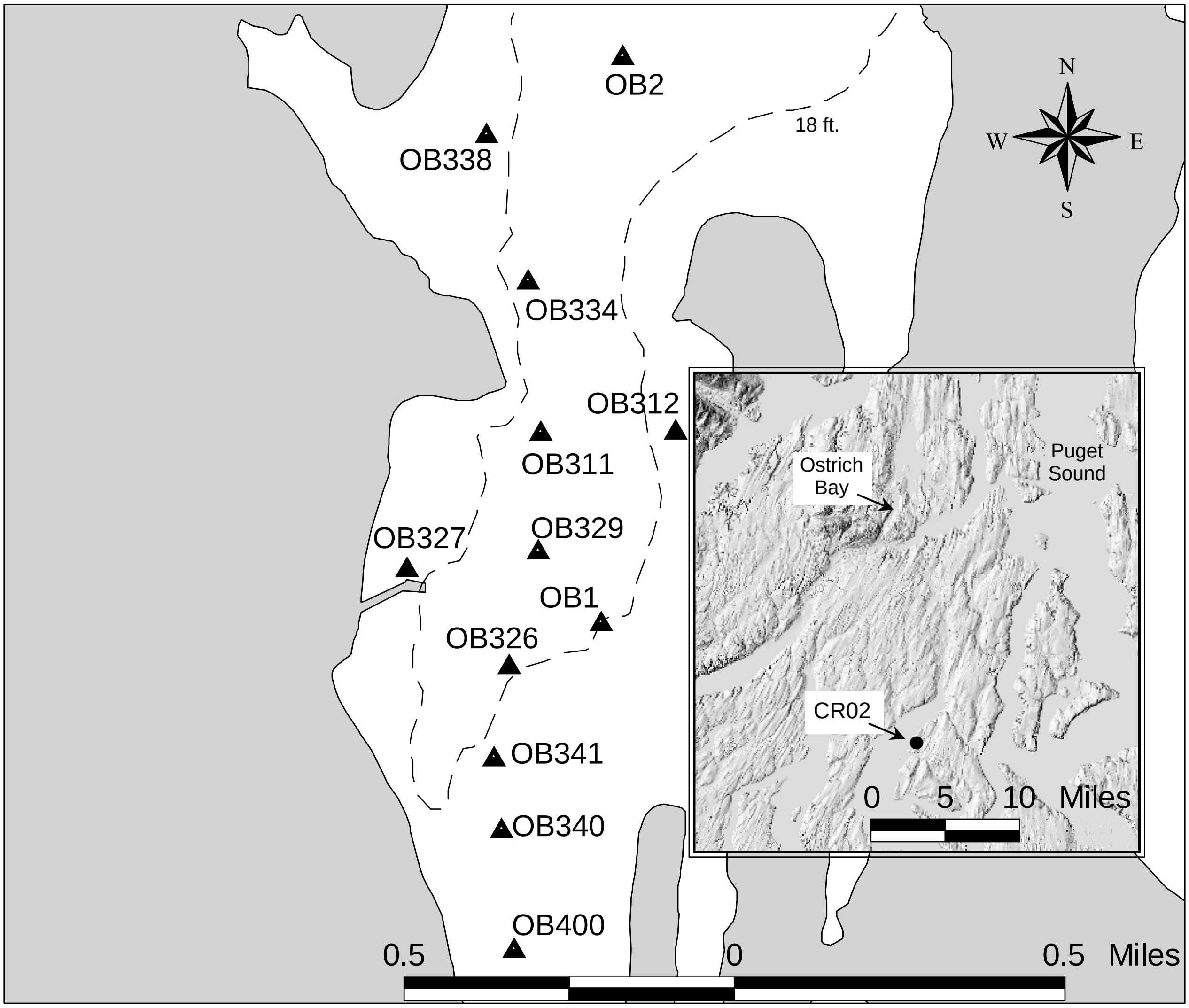

Figure 2. Ostrich Bay Sampling Stations and Carr Inlet Reference Station CR02 (Inset).

Sampling Methods

Where applicable, sampling methods followed Puget Sound Estuary Protocols (PSEP, 1996) and requirements of Ecology's Sediment Management Standards (Chapter 173-204 WAC; Ecology 2003). There were no deviations from sampling methods. Samples were collected from Ecology's 26-foot research vessel R.V. *Skookum* using a 0.1 m^2 stainless steel Van Veen grab sampler. Station positions were located using a Northstar GPS (Global Positioning System) Receiver with differential correction. A field log, with location information and physical descriptions of the samples collected, was maintained during sampling (Appendix A).

Surface Sediments

Three independent grab samples were taken at each station. A grab was considered adequate if it was filled with sediment and both the grab and access doors on top of the grab were closed tightly. For each grab, the overlying water was siphoned off upon retrieval. The top 10-cm layer of sediment, not in contact with the sidewalls of the grab, was then removed with a stainless steel scoop for analysis. An 8-oz subsample from the first grab at each station was carefully removed with minimal disturbance and placed in a container for sulfide analysis. Subsamples for all other analyses were taken from a homogenate derived from the three grab samples. Sediment from each grab was placed in a stainless steel bucket, and homogenized by stirring. Objects that could not be homogenized were removed before stirring (e.g., rocks, shells, algae, macroinvertebrates).

The project Field Safety Officer, with expertise in ordnance recovery and munitions, provided oversight during the handling of sediment samples and, where necessary, removed and identified munition materials. Identifications were noted in the field log (Appendix A).

Sediment subsamples were placed in glass jars (Teflon lid liners) that had been cleaned to EPA QA/QC specifications (EPA, 1990). Separate 2-oz jars were used for total organic carbon (TOC), solids, perchlorate, and sulfides analyses; 8-oz jars for BNA, Priority Pollutant Metals, and explosive compounds (nitroaromatics and nitramines); 8-oz plastic jars for grain size; and ½-gallon jars for bioassays (except Microtox®, where a ½-liter glass jar was used). Sample jars to be analyzed for nitroaromatics and nitramines were wrapped in aluminum foil to exclude light.

All utensils used to manipulate the samples (stainless steel scoops and buckets) were precleaned by washing with Liquinox® detergent, followed by sequential rinses with tap water, dilute (10%) nitric acid, deionized water, pesticide-grade acetone, and pesticide-grade hexane. The grab sampler was thoroughly washed with detergent and rinsed with deionized water. The equipment was then air-dried and wrapped in aluminum foil until used in the field. Between stations, the grab sampler was thoroughly brushed and rinsed with seawater.

All samples were stored in coolers on ice at 4°C and transported to the Ecology Manchester Environmental Laboratory (MEL) or contract laboratories within 24 hours of collection. Chain-of-custody was maintained throughout the study.

Water Column

At each station, vertical profiles of salinity, temperature, dissolved oxygen (DO), and depth were recorded with a Seabird CTD. Water samples were collected at the surface and at one foot above the bottom with a Van Dorn bottle to measure pH, using a portable on-board pH meter. The meter was calibrated at the beginning of each sampling day with pH 7 and 10 buffers.

Analytical Methods

Table 1 summarizes the analytical methods and laboratories used in this study. Samples for this study were analyzed by MEL or by MEL-accredited contract laboratories. The bioassay test methods are shown in Table 2. A more detailed description of the bioassay tests is provided in Appendix B.

Table 1. Analytical Test Methods.

Parameter	Method	Laboratory
Grain Size	Plumb (1981)	ARI
Total Organic Carbon	PSEP-TOCM (reported on a dry weight basis at 70°C)	MEL
Percent Solids	EPA Method 160.3	MEL
Total Sulfides	PSEP (1986) 10-day acute (Accreditation method: PSEP – 1995)	CAS
Perchlorates	EPA Method 314.0 Ion Chromatography	CAS
Priority Pollutant Metals	EPA Method 245.5 (CVAA) for Mercury EPA Method 200.8	MEL
Nitroaromatics and Nitramines	EPA Method 8330 HPLC	CAS
BNA (Semivolatile Organics)	EPA Method 8270 GC/MS	MEL

ARI Analytical Resources, Inc.
CAS Columbia Analytical Services
MEL Manchester Environmental Laboratory

Table 2. Bioassay Test Methods.

Test	Reference	Laboratory
Amphipod – 10-day acute (*Ampelisca abdita*)	PSEP (1996) (Accreditation method: PSEP – 1995)	Nautilus Environmental
Larval Bivalve – 48-hr acute (*Mytilus galloprovincialis*)	PSEP (1996) (Accreditation method: PSEP – 1995)	Nautilus Environmental
Juvenile Polychaete – 20-day chronic (*Neanthes* sp.)	PSEP (1996) (Accreditation method: PSEP – 1995)	Nautilus Environmental
Microtox Bioassay	Ecology (2003)	Nautilus Environmental

Data Quality

Physical/Chemical

Data quality was assessed through analysis of field duplicates, laboratory replicates, laboratory control samples, and matrix spikes. Procedural blanks were analyzed to assess laboratory contamination.

Most data quality objectives established for this project in the sampling plan (Blakley, 2004) were met (Appendix C, Table C-1), with the following exceptions:

- BNA analysis. Phthalates were detected in the method blank. In addition, data from laboratory duplicates indicate that precision objectives were not met for fluoranthene and pyrene.
- Perchlorate analysis. Recovery in spiked samples was low (44-50%) and below the target of 80-120%.

Data quality assessments based on the reporting laboratories' quality assurance procedures and criteria are provided in the Case Narratives (Appendix G). Data quality qualifier flags established from these assessments are included in the report data tables. In addition, data quality problems noted in the Case Narratives are considered in the discussions of results for this investigation.

Field duplicates (and laboratory replicates, in the case of grain size) were evaluated by examining their contribution to analytical variability for TOC, grain size, and metals concentrations (Appendix C, Table C-2). Variability among field duplicates contributed little to total variance (from 0% for cadmium to 3.9% of the variance in nickel concentrations). For grain size, variability among laboratory replicates represented only 0.7% of the variance in percent fines (sum of % silt and % clay size fractions).

Within stations, variability between field duplicates was also consistently at least an order of magnitude less than variability between years (1994 and 2004). Data quality for the analytes included in this analysis therefore appears adequate to detect long-term changes in sediment characteristics (TOC, grain size) and metals concentrations.

Bioassays

The tests met acceptability criteria for control performance, with the exception of the juvenile polychaete test. Mean individual polychaete growth for the control sediment was 0.65 milligrams/individual/day (mg/ind/day) per dry weight basis, and did not meet the performance criterion of $\geq$ 0.72 mg/ind/day. In addition, mean individual polychaete growth rate in the reference sediment was 60% of the value for the control sediment, which is less than the performance criterion of at least 80% (Appendix B).

The salinity of the natural seawater used in the bivalve, amphipod, and juvenile polychaete tests was higher than the recommended range of 28 ± 1 parts per trillion (ppt); measured values were typically in the range of 30 ± 2 ppt in these tests. These values are well within the range of tolerance for the test species and are typical of marine waters. Consequently the salinity of the water was not adjusted, and the salinities observed in the tests would not be expected to have had an adverse impact on the outcome of the tests. There were no deviations to the test protocol in any of the tests, with the exception of the extension of sediment settling time from 4 hours to 24 hours prior to addition of bivalve larvae. The extended settling time was provided to reduce the risk of artifactual toxicity associated with the physical effects of settling suspended particulate interfering with the conclusion of the test.

Results of reference toxicant tests conducted with the test organisms are provided in Appendix C, Table C-3. Results of these tests fell within the acceptable range of mean ± two standard deviations for historical data generated by the testing laboratory. These data indicate that the test organisms were of an appropriate sensitivity.

Results

Physical Characteristics of Sediments

Sediment physical characteristics (Table 3) showed some spatial variation. In general, grain size exhibited a north-south gradient, from predominantly silt at southern stations (OB 400, 340, 341, 326, 1, and 329) to predominantly sand at most northern locations (OB 311, 312, 334, and 338).

Organic content (% TOC) ranged from 1.3 - 3.0% and tended to be higher in samples with high silt content. The reference location (CR02) in Carr Inlet was an exception, with the highest silt content and lowest TOC.

Table 3. Sediment Sample Grain Size, Percent Solids, and TOC Content.

Station ID	Lab ID	% Solids	TOC (%)	Grain Size (%)			
				Gravel	Sand	Silt	Clay
CR02 (reference)	04414092	44.8	1.3	0.0	11.3	73.8	14.9
OB1	04414080	34.9	2.9	1.0	22.9	50.8	25.3
OB2	04414081	37.2	2.7	0.8	30.3	43.6	25.2
OB311	04414082	45.6	1.8	0.0*	54.7*	27.4*	18.0*
OB311D (duplicate)	04414093	--	1.7	0.2	55.3	27.8	16.8
OB312	04414083	44.2	2.0	3.7	44.4	34.0	17.9
OB326	04414084	32.5	3.0	1.3	18.6	52.0	28.1
OB327	04414085	53.9	1.3	1.5	65.5	21.5	11.4
OB329	04414086	32.5	3.0	1.2	20.6	50.6	27.6
OB334	04414087	48.3	1.7	1.9	56.4	26.6	15.0
OB338	04414088	43.2	2.3	2.9	51.3	29.7	16.0
OB340	04414089	36.3	3.0	2.9	16.0	54.9	26.3
OB341	04414090	34.8	3.0	1.0	26.7	48.3	24.0
OB400	04414091	36.2**	2.9*	0.3	15.5	62.8	21.4

* Mean of three laboratory replicates.
** Mean of two laboratory replicates.
-- Not analyzed

Water Column Profiles

Vertical oxygen profiles from the CTD data are of primary interest because of the high sulfide levels associated with Dyes Inlet sediments. The profiles show reductions in oxygen levels with depth at some stations (Appendix D, Figure D-1). However, at all stations the levels were 7 mg/L or higher, with the exception of the Carr Inlet reference station (CR02). There, the levels dropped to nearly 4 mg/L. This station had one of the lowest sediment sulfide concentrations in this study (Table 7), suggesting that sulfide levels are not related to oxygen levels in the water column.

CTD data for three stations (OB340, OB341, and OB400) were rejected. These stations had anomalous values for beam transmission and surface level oxygen. Oxygen levels at depth were not anomalously low, however.

Data for salinity, temperature, and other parameters are provided in Appendix D, Table D-1. Consistent with the oxygen data, the vertical profiles do not show evidence of stratification or a pycnocline, except for temperature and salinity changes near the surface (OB311 and OB338).

Chemical Concentrations

Metals

Metals concentrations were generally low in all samples, with the exception of mercury (Table 4).

Regulatory standards for sediment contamination in Puget Sound have been established in Washington State's Sediment Management Standards (SMS), Chapter 173-204 WAC. The SMS establishes two levels for sediment quality, the *Sediment Quality Standards* (SQS) and the *Cleanup Screening Levels* (CSL).

CSLs are "minor adverse effects" levels, used as an upper regulatory level for source control and as minimum cleanup levels. SMS set criteria for CSLs based on bioassay testing and also set numerical CSLs based on chemical concentrations for some substances. Of the two approaches, biological effects CSLs have precedence over chemistry, and exceedance of a numerical CSL can be overridden by a demonstration that biological effects criteria are not exceeded. Similarly, a finding of no exceedances based on chemical criteria can be overridden by a demonstration of biological effects exceedances.

SQS are "no adverse biological effects" levels and are used as a sediment quality goal for Washington State sediments. Although a single SQS exceedance at a sediment location does not represent a CSL exceedance, SMS imposes a limit by specifying that a location exceeding more than one SQS constitutes a CSL exceedance. A more detailed description of the sediment quality evaluation procedures is provided in Ecology (2003)

Chemical concentration criteria were not exceeded, except for mercury concentration exceedances of the SQS (but not the CSL) at six stations (Table 4). With one exception (OB2), these stations are clustered in the center of Ostrich Bay (Figure 3).

Table 4. Metals Concentrations (mg/Kg dw) in Relation to Sediment Management Standards (SMS).

Metal	SMS		Reference	Ostrich Bay Stations												
	SQS	CSL	CR02	OB1	OB2	OB311	OB311D	OB312	OB326	OB327	OB329	OB334	OB338	OB340	OB341	OB400
Antimony	--	--	0.2 U	0.2 U	0.2 U	0.2 U	0.2 UJ	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Arsenic	57	93	0.5	10.6	10.3	7.8	7.3	7.6	9.6	4.7	10.5	7.7	7.2	9.3	9.2	8.2
Beryllium	--	--	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Cadmium	5.1	6.7	0.6	1.7	1.2	0.9	0.9	1.2	1.5	0.9	1.3	0.9	0.7	2.1	1.8	2.3
Chromium	260	270	36.5	52.0	45.9	35.8	35.3	37.7	48.4	30.0	48.9	34.9	39.3	50.2	48.0	48.0
Copper	390	390	24.5	66.2	69.4	39.6	38.5	42.1	65.2	31.2	67.5	38.2	38.4	65.3	63.0	60.3
Lead	450	530	9.25	48.5	50.0	29.5	29.0	40.8	48.0	19.2	49.3	30.5	33.8	46.1	43.8	44.0
Mercury	0.41	0.59	0.05	0.43*	0.46*	0.27	0.26	0.27	0.47*	0.16	0.48*	0.25	0.24	0.46*	0.45*	0.39
Nickel	--	--	34.4	44.5	40.8	34.4	32.8	34.9	41.0	32.0	42.1	33.7	36.2	42.0	40.0	41.0
Selenium	--	--	0.5 U	1.0	0.9	0.6	0.6	0.6	1.0	0.5	1.0	0.6	0.9	1.0	0.9	0.9
Silver	6.1	6.1	0.17	0.7	0.7	0.4	0.4	0.5	0.7	0.3	0.7	0.4	0.4	0.7	0.7	0.6
Thallium	--	--	0.18	0.3	0.2	0.3	0.3	0.3	0.2	0.5	0.2	0.3	0.2	0.3	0.3	0.3
Zinc	410	960	57	130	130	85	81	91	120	64	120	83	87	128	120	123

SMS Sediment Managements Standards
SQS Sediment Quality Standards
CSL Cleanup Screening Level
* SQS exceedance
U The compound was analyzed for, but was not detected at or above the Method Detection Limit indicated.

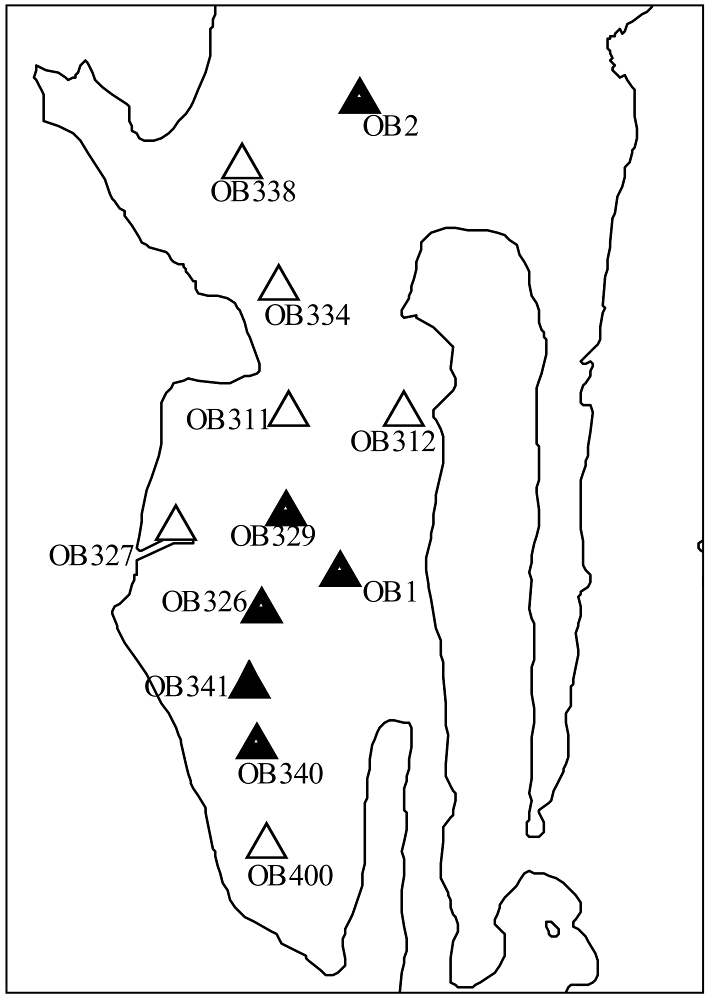

Figure 3. Mercury SQS Exceedances (solid triangles).

Munitions Compounds

EPA Method 8330 (Nitroaromatics and Nitramines) analyzes for a number of munitions compounds including tetryl and trinitrobenzene, which have been reported to be the most toxic of those tested (Nipper et al., 2001). RDX was the only compound detected (Table 5), although with low confidence. RDX concentrations were below the Method Detection Limit at every station where the compound was found, and the identifications are flagged as tentative. These stations included the Carr Inlet reference station, reinforcing the low confidence in the RDX detections.

Perchlorate is also an ingredient in munitions and highly soluble in water. It was detected in only one sample (Table 5), and at a concentration below the Method Reporting Limit. Matrix spike recovery was 44-50%, below the project objective of 80-120%, and confidence in these results is low.

Sediment Management Standards chemical concentration criteria have not been established for any of the compounds listed in Table 5.

Table 5. Munitions Compound Concentrations (mg/Kg dw)

	Reference	Ostrich Bay Stations											
Compound	(CR02)	OB1	OB2	OB311	OB312	OB326	OB327	OB329	OB334	OB338	OB340	OB341	OB400
2,4-dinitrotoluene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
2,6-dinitrotoluene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
2-amino-4,6-dinitrotoluene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	0.2 J	2.1 U	2 U	2 U	2 U	2.1 U	2 U
2-nitrotoluene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
3-nitrotoluene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
4-amino-2,6-dinitrotoluene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
4-nitrotoluene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
1,3-dinitro-benzene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
TNT	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
Trinitrobenzene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
RDX	**0.27** JN	**0.32** JN	**0.36** JN	1.8 U	1.7 U	2 U	**0.29** JN	2.1 U	**0.28** JN	**0.28** JN	**0.35** JN	2.1 U	**0.38** JN
Nitrobenzene	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
Tetryl	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
HMX	1.8 U	2 U	2 U	1.8 U	1.7 U	2 U	1.6 U	2.1 U	2 U	2 U	2 U	2.1 U	2 U
Perchlorate	32 U	**42** J	32 U	32 U	32 U	32 U	32 U	32 U	32 U	32 U	32 U	32 U	32 U

Abbreviations:

TNT 2-Methyl-1,3,5-trinitro-benzene
RDX Hexahydro-1,3,5-trinitro-1,3,5-triazine
Tetryl N-Methyl-N-2,4,6-tetranitrobenzenamine
HMX Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine

Qualifier codes:

U The compound was analyzed for, but was not detected at or above the Method Detection Limit.
J The result is an estimated concentration that is less than the Method Reporting Limit but greater than or equal to the Method Detection Limit.
N The result is presumptive. The analyte was tentatively identified but a confirmation analysis was not performed.

Semivolatile Organic Compounds (BNAs)

Semivolatile organic compounds or BNAs (Base/Neutral/Acids) detected consisted primarily of polycyclic aromatic hydrocarbons, or PAHs (Appendix E, Table E-1). Highest PAH concentrations were from sampling stations away from the shoreline, in a line running from OB2 to OB400, with the exception of OB340.

Numerical Sediment Quality Standard (SQS) concentrations have been developed for some semivolatile compounds, either on a dry weight basis, or organic carbon-normalized. Overall, the sediment samples did not exceed these criteria, with the exception of four stations where the SQS for benzoic acid was exceeded (Table 6).

Table 6. Results for Semivolatile Organic Compounds (SVOCs) with Established Sediment Quality Standards. (See Appendix E for other SVOCs.)

Compound	SQS	CR02	OB1	OB2	OB311	OB312	OB326	OB327	OB329	OB334 *	OB338	OB340	OB341	OB400
TOC normalized (mg/Kg organic carbon normalized)														
2-Methylnaphthalene	38	nd	**0.62**	nd	nd	nd	nd	nd	0.63	nd	nd	nd	nd	nd
Acenaphthene	16	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Acenaphthylene	66	nd	**1.00**	**1.26**	**1.03**	**0.65**	**0.80**	**0.76**	**0.83**	**1.91**	**nd**	**0.63**	**0.80**	**0.69**
Anthracene	220	nd	**1.79**	**1.81**	**2.63**	nd	**1.33**	**1.85**	**1.27**	**5.15**	**0.96**	**1.03**	**1.23**	**1.38**
Benzo(a)anthracene	110	nd	**3.72**	**4.37**	**3.71**	**2.00**	**2.40**	**3.23**	**2.67**	**9.32**	**2.30**	**1.97**	**2.53**	**2.03**
Benzo(a)pyrene	99	nd	**4.62**	**6.48**	**6.46**	**3.05**	**4.00**	**5.85**	**4.47**	**15.65**	**3.83**	**3.47**	**4.47**	**3.52**
Total Benzofluoranthenes	230	nd	**9.31**	**12.30**	**12.86**	**8.25**	**8.88**	**13.31**	**9.21**	**34.53**	**8.43**	**8.57**	**10.57**	**9.10**
Bis(2-Ethylhexyl) Phthalate	47	nd	nd	nd	nd	**5.25**	nd	nd	nd	nd	nd	nd	nd	nd
Chrysene	110	nd	**4.34**	**5.81**	**7.54**	**2.80**	**3.07**	**5.38**	**3.43**	**20.65**	**2.78**	**2.43**	**3.30**	**3.10**
Fluoranthene	160	**1.46**	**8.48**	**7.07**	**5.09**	**3.80**	**4.50**	**6.00**	**4.50**	**19.88**	**3.70**	**3.27**	**4.80**	**4.21**
Fluorene	23	nd	nd	nd	nd	nd	nd	nd	nd	2.09	nd	nd	nd	nd
Hexachlorobenzene	0.38	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hexachlorobutadiene	3.9	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Indeno(1,2,3-cd)pyrene	34	nd	**4.83**	**4.96**	**5.14**	**3.60**	**3.70**	**4.31**	**3.67**	**6.62**	**2.78**	**2.67**	**3.13**	**2.83**
Naphthalene	99	nd	**0.93**	**1.00**	**1.03**	**0.75**	**0.63**	**0.73**	**0.90**	nd	**0.57**	**0.83**	**0.93**	**0.90**
Phenanthrene	100	nd	**6.24**	**2.78**	**2.97**	nd	**2.07**	**2.31**	**1.93**	**3.26**	**1.65**	nd	nd	**1.97**
Pyrene	1000	**1.46**	**9.83**	nd	**5.26**	nd	nd	**6.38**	**5.07**	**14.50**	**4.22**	**3.90**	**5.30**	**4.69**
Non-normalized organics (ug/Kg dw)														
Benzoic Acid	650	nd	**3420**	nd	**2690**	nd	nd	nd	nd	nd	nd	**3530**	nd	**3370**

* Averages of two laboratory duplicates
nd not detected
[shaded box] Value exceeds Sediment Quality Standard (SQS)
Bold Detected values

Sulfides

Sulfide concentrations ranged from 306 to 1,270 mg/Kg dw (Table 7). The stations with the two highest concentrations (OB326 and OB1) are located in the center of Ostrich Bay. Lower concentrations occurred towards the mouth of the bay (OB2 and OB334) although OB338, in the same vicinity, had one of the highest concentrations.

Data quality for the sulfides analysis is good, with one exception. Triplicate analysis for the OB311 sample was performed seven days past the recommended holding time. The value from a single measurement performed within the holding time is markedly higher than the triplicate mean and is considered more reliable.

Table 7. Total Sulfide Concentrations.

Station ID	Sulfides (mg/Kg dw)
CR02	425
OB1	1,270
OB2	502*
OB311	665 **
OB312	691
OB326	1,070
OB327	638
OB329	780
OB334	306
OB338	900
OB340	823
OB341	866
OB400	833

* Mean of two laboratory replicates.
** A triplicate analysis (mean = 346 mg/Kg) was also performed but 7 days past the recommended holding time.

Bioassays

Sediments were toxic to bioassay test organisms at six of the 12 stations (Table 8 and Figure 4). At two stations (OB1 and OB400), the amphipod test gave an SQS exceedance, while the Microtox test indicated an SQS exceedance at four additional stations.

Table 8. Summary of Bioassay Testing Results. (See Appendix F for complete data.)

Station	Amphipod (*Ampelisca*)	Polychaete *(Neanthes)*		Bivalve *(Mytilus)*			Microtox		Overall Station Status
	Mortality	Mortality	Growth (mg/organism)	Survival	% Normal Larvae	% Normal Surviving Larvae	5 min	15 min	SQS or CSL*
OB 1	34%	4.0%	6.8	87.8%	91.1%	80.0%	96.6%	94.5%	SQS
OB 2	15%	20.0%	9.4	86.1%	92.2%	79.5%	99.1%	101.8%	Pass
OB 311	22%	20.0%	9.1	97.7%	90.8%	88.6%	24.9%	22.9%	SQS
OB 312	16%	0.0%	7.6	87.3%	89.0%	77.9%	98.5%	103.6%	Pass
OB 326	18%	0.0%	7.4	88.9%	85.8%	76.2%	100.6%	109.7%	Pass
OB 327	17%	8.0%	8.3	86.2%	92.4%	79.5%	97.2%	103.5%	Pass
OB 329	22%	0.0%	7.4	91.8%	94.9%	87.0%	58.9%	62.5%	SQS
OB 334	15%	4.0%	9.5	92.6%	90.6%	83.9%	27.6%	25.9%	SQS
OB 338	23%	4.0%	8.4	87.2%	87.1%	76.1%	68.2%	73.8%	SQS
OB 340	26%	8.0%	8.4	92.8%	86.9%	80.6%	103.0%	101.8%	Pass
OB 341	26%	4.0%	7.8	87.4%	84.9%	74.3%	99.3%	103.1%	Pass
OB 400	29%	4.0%	7.9	94.7%	89.9%	85.0%	99.5%	99.1%	SQS
CR02 (Reference)	20%	0.0%	7.8	90.4%	92.6%	83.6%	na	na	na

SQS bioassay exceedance

* SQS or CSL station exceedance. A station with two or more SQS exceedances is assigned a CSL exceedance under the Sediment Management Standards (WAC 173-204-520(1)(d) and (3)(d)).

na not applicable

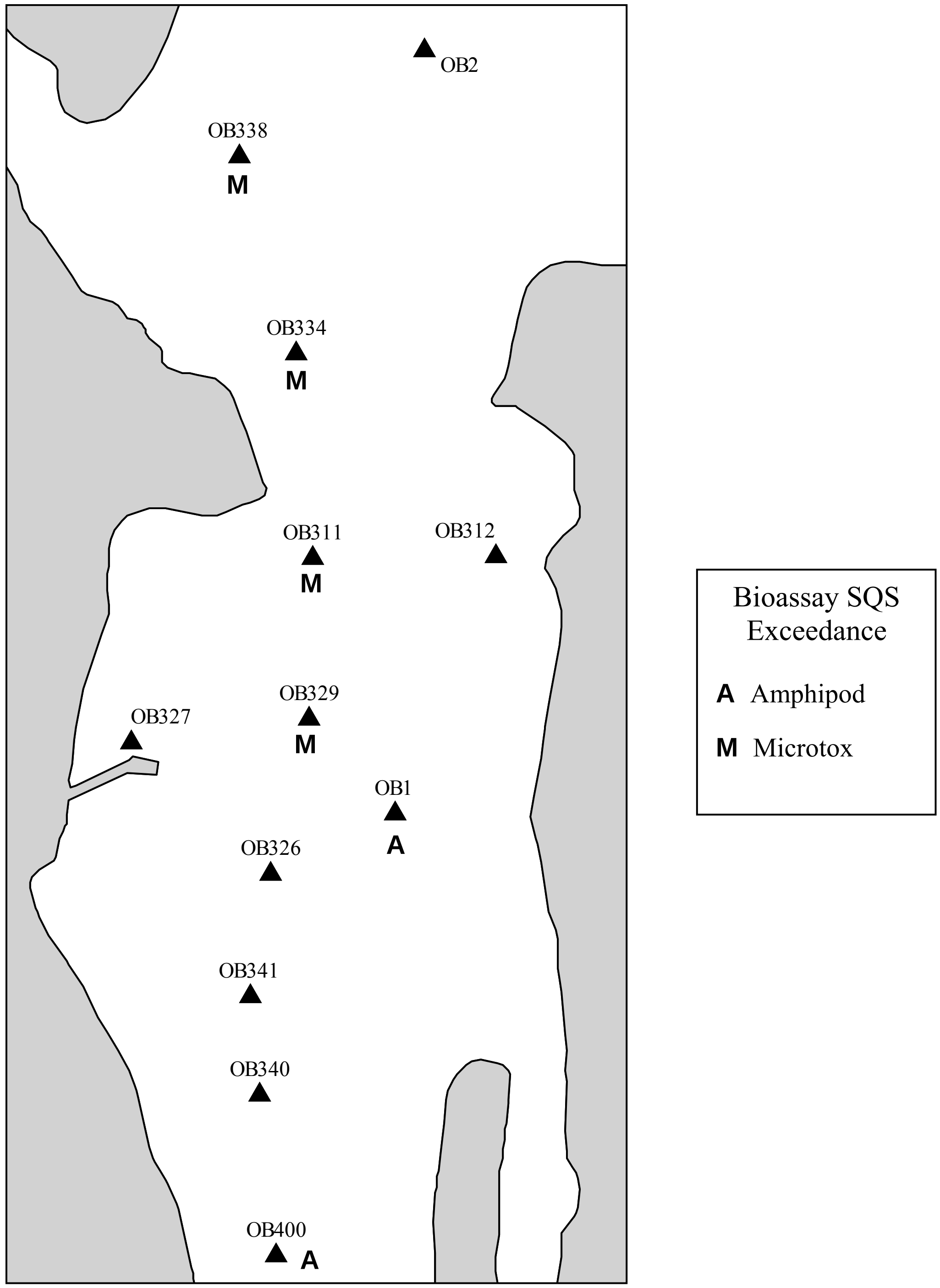

Figure 4. Bioassay SQS Exceedances

Sulfide and Ammonia Contributions to Bioassay Toxicity

Linear regression analyses were conducted to evaluate the contribution of sulfides and un-ionized ammonia to the bioassay test results. Grain size, expressed as percent fines (silt and clay size fractions), was also evaluated as a possible factor.

Several measures of sulfide and ammonia concentrations were included in the regression analyses. Total sulfides values are available from the analysis of sediment subsamples from each station (Table 9). In addition, sulfide and ammonia were measured in conjunction with the bioassay testing, both in porewater from the test sample and in the overlying water on Day 0 of each test.

There is little evidence that sulfides contributed to bioassay toxicity. There was a statistically significant relationship between total sulfide and amphipod survival, as well as polychaete growth (Table 9). However, the effect is minor, as indicated by the small regression slopes (-0.01 and -0.002, respectively). Regressions on the sulfide parameters measured in bioassay testing reached statistical significance for bivalve larval survival and survival of normal bivalve larvae but in both instances the regression slope was positive, indicating enhancement rather than toxicity.

Ammonia levels appear to have contributed to toxicity in the Microtox test, both for the 5 min and 15 min endpoints. However, no statistically significant effects were found for the other tests except the amphipod, where the slope for regression of survival on interstitial ammonia was significantly positive (i.e., not indicating toxicity).

Grain size did not contribute to bioassay toxicity. Regression of percent fines on bioassay endpoint values was not statistically significant in any instance.

Table 9. Linear Regression Analyses of Bioassay Responses on Sediment Parameters

Bioassay	Endpoint	Parameter[b]	R^2	Slope[c]
Amphipod *Ampelisca*	Survival[a]	Total sulfides	0.50	-0.01 **
		Percent fines[a]	0.21	ns
		Bulk porewater: Ammonia	0.17	ns
		Test interstitial: Ammonia	0.32	389.2 *
		Overlying water: Ammonia	0.16	ns
		Bulk porewater: Sulfide	0.19	ns
Juvenile polychaete *Neanthes*	Growth	Total sulfides	0.52	-0.002 **
		Percent fines[a]	0.26	ns
		Bulk porewater: Ammonia	0.16	ns
		Test interstitial: Ammonia	0.17	ns
		Overlying water: Ammonia	0.18	ns
		Test interstitial: Sulfide	0.03	ns
		Overlying water: Sulfide	0.24	ns
	Survival[a]	Total sulfides	0.09	ns
		Percent fines[a]	0.21	ns
		Bulk porewater: Ammonia	<0.01	ns
		Test interstitial: Ammonia	<0.01	ns
		Overlying water: Ammonia	<0.01	ns
		Test interstitial: Sulfide	<0.01	ns
		Overlying water: Sulfide	<0.01	ns
Bivalve larvae *Mytilus*	Survival[a]	Total sulfides	0.03	ns
		Percent fines[a]	0.00	ns
		Bulk porewater: Ammonia	0.23	ns
		Bulk porewater: Sulfide	0.04	ns
		Overlying water: Sulfide	0.50	59.1 **
	Normal (%)[a]	Total sulfides	0.16	ns
		Percent fines[a]	0.00	ns
		Bulk porewater: Ammonia	0.23	ns
		Bulk porewater: Sulfide	0.27	ns
		Overlying water: Sulfide	0.04	ns
	Normal surviving larvae (%)[a]	Total sulfides	0.13	ns
		Percent fines[a]	0.00	ns
		Bulk porewater: Ammonia	0.24	ns
		Bulk porewater: Sulfide	0.03	ns
		Overlying water: Sulfide	0.41	45.0 *
Microtox	5 min.[a]	Total sulfides	0.20	ns
		Percent fines[a]	0.28	ns
		Ammonia	0.36	-340.1 *
	15 min.[a]	Total sulfides	0.20	ns
		Percent fines[a]	0.28	ns
		Ammonia	0.36	-366.3 *

See Appendix B for description of bioassay endpoints.

a All proportions were arcsine-square root transformed. For Microtox, values exceeding 100% were recoded to 100% before transformation.

b With the exception of total sulfides and grain size (% fines), all parameters were measured on bioassay water at the outset of the bioassay test.

c ns Slope not significantly different from zero.
Regression slopes shown are significantly different from zero at: * $p<0.05$ ** $p<0.01$

Discussion

Sediments in Ostrich Bay exhibited limited exceedances of biological criteria in Washington State's Sediment Management Standards (Chapter 173-204 WAC) in comparison with previous studies. Six of the 12 stations tested (50%) exceeded one bioassay test SQS; none exceeded more than one bioassay SQS. In contrast, 24/24 stations (100%) exceeded bioassay SQS in the 1994 Phase II Remedial Investigation (EA, 1998a), and 20/24 stations (83%) exceeded more than one SQS. Three years later, 20/23 stations (87%) exceeded bioassay SQS in the Remedial Investigation Treatability Study (EA, 1998b). Multiple SQS exceedances occurred at 16/23 stations (70%). These comparisons suggest a marked reduction in sediment toxicity over the ten- year span of these investigations.

The basis for the sediment toxicity in Ostrich Bay is unknown. A previous attempt to identify responsible compounds was inconclusive: "The data suggest that some organic or organometallic contaminant(s) that were not included in the comprehensive suite of chemical analyses caused the toxicological responses." (Carr et al., 2001). Sulfide was not investigated in that study as a possible contributor to toxicity, although sulfide levels in Ostrich Bay are relatively high (median = 802 mg/Kg; Figure 5). However, results from the current study do not demonstrate a toxic effect of sulfide levels on bioassay responses. Ammonia levels also do not appear to be a contributor, except for Microtox responses.

Of the metals included in this study, only mercury exceeded the SQS, and there was little overlap between stations exceeding the mercury and biological SQS (Figures 3 and 4). Benzoic acid was the only other analyte to exceed the SQS, and only at four of the stations (Table 6). The sediment toxicity may therefore be due to the combined effects of chemicals that individually did not exceed regulatory standards, or to effects from chemicals not included in the analyses.

The 1997 investigation found more widespread mercury SQS exceedances than in 1994, and mercury levels were higher overall, leading to speculation on possible causes (EA, 1998b). However, comparison of results from the present study with the 1994 and 1997 data (Figure 6) suggests that the 1997 data may be biased high, since 1994 and 2004 results are relatively similar. The spatial pattern of mercury SQS exceedances in this investigation is also consistent with results from the 1994 Phase II Remedial Investigation (EA, 1998a). In both studies, stations OB326, OB329, OB340, and OB341exceeded the SQS.

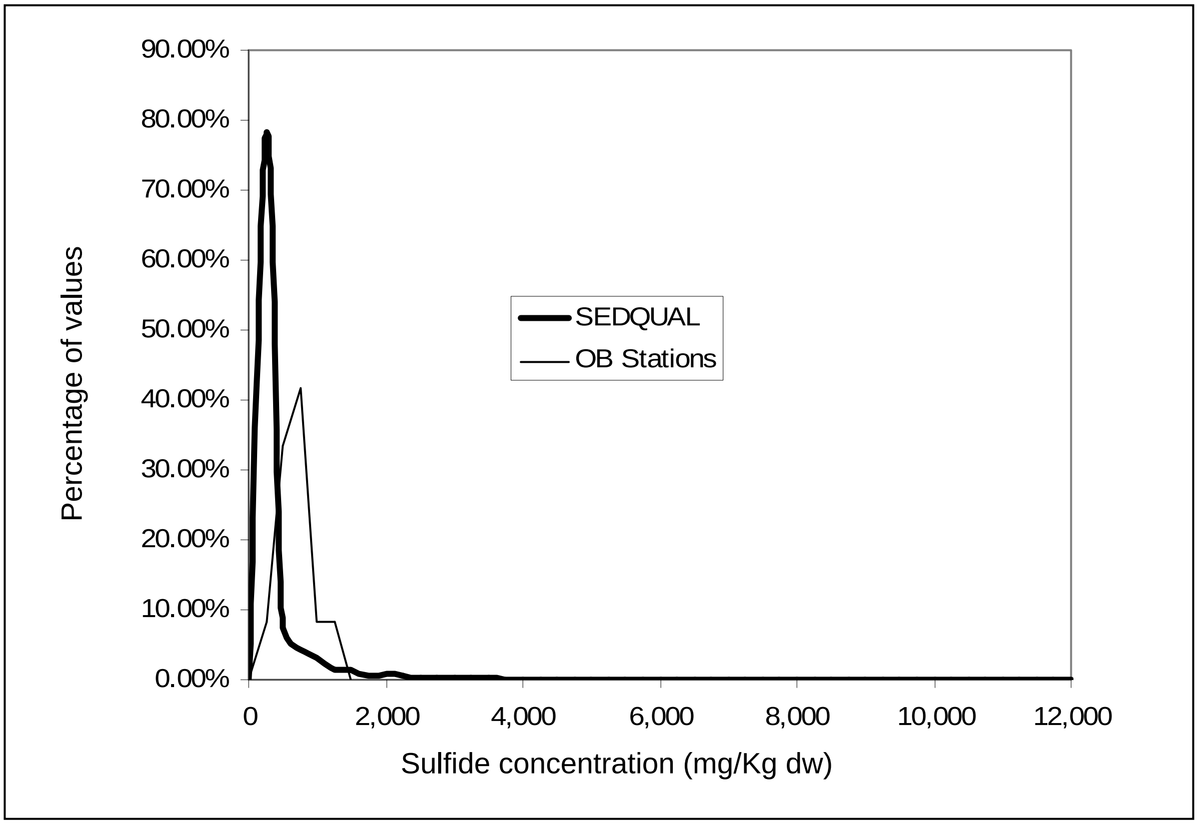

Figure 5. Comparison of Frequency Distribution for Ostrich Bay Station Sulfide Concentrations with SEDQUAL Database Distribution. (Medians: SEDQUAL 15 mg/Kg, Ostrich Bay 802 mg/Kg)

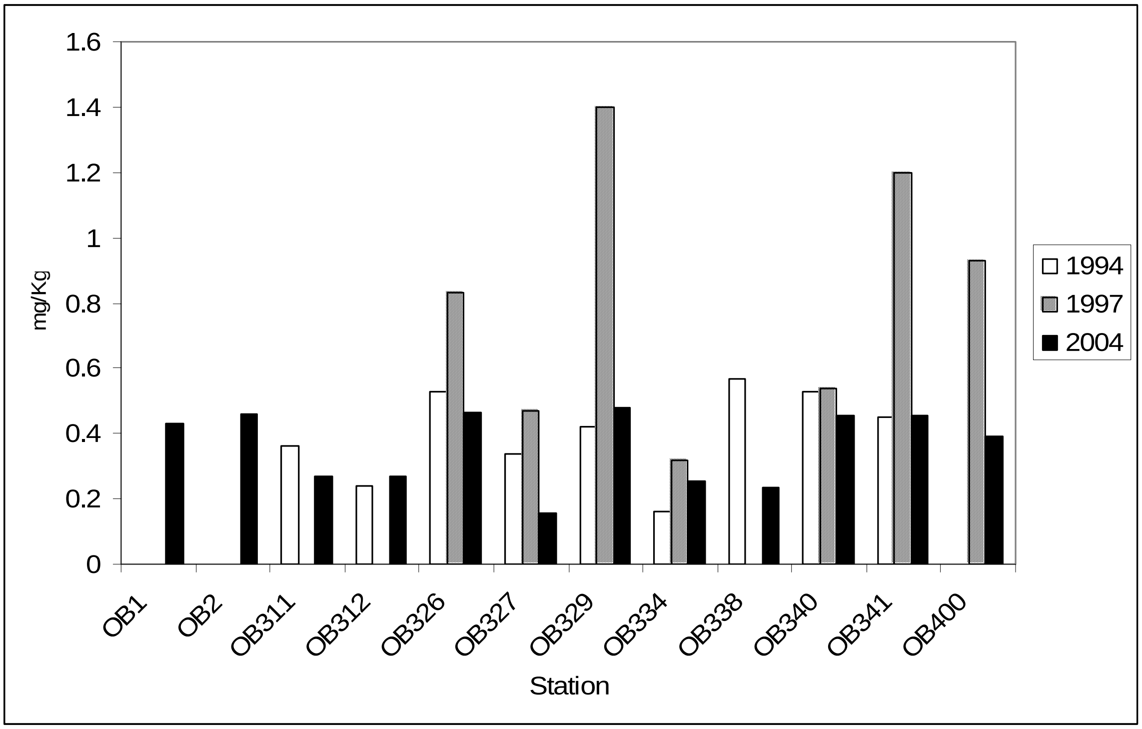

Figure 6. Comparison of Mercury Concentrations from 1994, 1997, and 2004 Investigations in Ostrich Bay. (Zero value denotes no data.)

Conclusions and Recommendations

Sediments in Ostrich Bay exceed the Washington State Sediment Management Standards in parts of this waterbody but appear to be improving in quality, based on results from bioassay testing. A previous attempt to identify the chemical basis for sediment toxicity in Ostrich Bay was unsuccessful, and the previously unexplored possibility that sulfides are responsible is not supported by results from the present study.

The chemically-based mercury Sediment Quality Standard was exceeded at six of the stations in Ostrich Bay. These stations appear to define a similar area of contamination to that observed in the 1994 Phase II Remedial Investigation. The possibility that mercury concentrations are increasing in Ostrich Bay, suggested by data from a 1997 supplemental investigation, is not supported by results from the present investigation which were similar to those obtained in 1994.

While the bioassay test results suggest an improvement in sediment quality, they do not evaluate the effects of bioaccumulative substances such as mercury. Further attention to mercury contamination in the bay is recommended, given the lack of evidence for a decline in mercury concentrations.

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Appendices

A. Sampling Station Location Information

B. Bioassay Test Descriptions

C. Data Quality Assessment

D. CTD Results

E. Semivolatile Organic Compounds

F. Bioassay Test Results

G. Case Narratives

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Appendix A. Sampling Station Location Information

Table A-1. Field Log Notes.

Station	Latitude	Longitude	Grab #	Depth[b]	Date	Time	Penetration	pH		Comments[c]
	Degrees decimal minutes[a]			(m)			(cm)	Surface	Bottom	
OB2	122º 40.783	47º 35.907	1	9.5	10/6/04	10:42	15	9.16	8.06	Silty sand, green. Shell bits. RPD [redox potential discontinuity] @ 1 cm. 5/8" 1 pellet (powder)
			2	9.6	10/6/04	10:55	14			" organic matter (light). String for silk bag.
			3	9.8	10/6/04	11:12	14			Silty sand. Algae (or bryazoans). Large mass. RPD @ 1 cm. Shell bits. 3 grains 5" smokeless powder.
OB338	122º 41.046	47º 35.799	1	6.2	10/6/04	12:07	14	8.20	8.03	Brown algae, Ulva (large quantity), dark silty sand. Slight H_2S odor. Low shell content.
			2	6.3	10/6/04	12:21	15			Brown algae, black silty sand. Low shell content.
			3	6.7	10/6/04	12:29	13.5			Brown algae, Ulva. H_2S odor.
OB334	122º 40.956	47º 35.608	1	10.5	10/6/04	13:53	14	8.83	8.04	Silty sand, shell debris, good amt. algae.
			2	10.3	10/6/04	14:07	15			Sandy silt, bryazoans, shell fragments, hermit crabs.
			3	10.4	10/6/04	14:15	12			Sandy silt with shell fragments, [word?] wood present. No odor.
OB312	122º 40.662	47º 35.416	1	6.4	10/6/04	14:36	15	8.13	7.86	Silty sand, green, no odor.
			2	5.7	10/6/04	14:43	14			Same.
			3	7.0	10/6/04	14:48	15			Green silty sand. H_2S odor.
OB311	122º 40.924	47º 35.409	1	14.5	10/6/04	15:17	16	8.10	7.94	Grayish-green, silty sand
			2	14.1	10/6/04	15:32	16			Silty sand. Crab carapace, sea pens, shell debris.
			3	14.2	10/6/04	15:40	16			Green silty sand, sea pens.
OB329	122º 40.923	47º 35.253	1	10	10/6/04	16:15	16	8.25	7.87	No organic material, gray-green silty, H_2S odor.
			2	10	10/6/04	16:30	16			Lot of algal mats, silty. Worm holes. A fish!
			3	10	10/6/04	16:48	16			Gray-green, brown. Algae. H_2S odor.
OB1	122º 40.796	47º 35.162	1	7	10/7/04	9:48	16	8.29	7.87	Green-gray silty sand. H_2S odor.
			2	7	10/7/04	9:59	16			Green-gray silty sand. Sulfide odor.
			3	7	10/7/04	10:08	17			Green-gray silty sand. Some shells.
OB326	122º 40.972	47º 35.101	1	7.4	10/7/04	10:27	17	8.26	7.74	Green-gray silty sand. Sufide odor. Strong.
			2	7.6	10/7/04	10:39	17.5			Green-gray silty sand. Sulfide odor. Shell fragments.
			3	7.8	10/7/04	10:44	16			Green-gray silty sand. Sufide.
OB341	122º 40.997	47º 34.980	1	7.3	10/7/04	11:01	17.5	8.43	7.76	Same with sulfide. Very silty.
			2	7.3	10/7/04	11:12	17			Same. Some green algae. Ulva?
			3	7.3	10/7/04	11:18	16			Same.
OB340	122º 40.979	47º 34.885	1	7.2	10/7/04	11:35	17	8.35	7.83	Green-gray silty. Brown algal mat. Sulfide.
			2	7.4	10/7/04	11:45	16			Same.
			3	7.4	10/7/04	11:51	16			Same.
OB400	122º 40.948	47º 34.728	1	7.3	10/7/04	12:43	17	8.42	7.65	Green-gray silty. Brown algal mat. Sulfide.
			2	7.3	10/7/04	12:52	17			Same.
			3	7.3	10/7/04	12:58	15.5			Same.
OB327	122º 41.176	47º 35.225	1	8.3	10/7/04	13:27	17	7.97	7.63	Green-gray silty sand.
			2	8.5	10/7/04	13:37	17			Same.
			3	8.3	10/7/04	13:46	12			Gray sandy silt with shells.

a NAD27 b Depths are not tide-adjusted c "Bryazoans" were probably *Phyllochaetopterus* sp.

Appendix B. Bioassay Test Descriptions

Table B-1. Bioassay Descriptions and Test Criteria.

Bioassay test	**Amphipod**: A 10-day acute sediment toxicity test that assesses mortality of the amphipod, *Ampelisca abdita*.
Method	USEPA (1994) and PSEP (1995)
No. replicates/sample	5
Endpoints	Mortality
Performance criteria	The control sediment shall have less than ten percent mortality over the test period. The reference sediment shall have less than twenty-five percent mortality. WAC 173-204-315(2).
Decision criteria	The test sediment has a higher (statistically significant, t test, $p \leq 0.05$) mean mortality than the reference sediment and the test sediment mean mortality exceeds twenty-five percent, on an absolute basis. SQS exceedance. WAC 173-204-320(3). The test sediment has a higher (statistically significant, t test, $p \leq 0.05$) mean mortality than the reference sediment and the test sediment mean mortality is greater than a value represented by the reference sediment mean mortality plus thirty percent. CSL exceedance. WAC 173-204-520(3).
Bioassay test	**Juvenile Polychaete**: A 20-day sublethal sediment toxicity test that assesses decreases in biomass of the juvenile polychaete *Neanthes* sp.
Method	PSEP (1995)
No. replicates/sample	5
Endpoints	Growth and mortality
Performance criteria	The control sediment shall have less than ten percent mortality and mean individual growth of ≥ 0.72 mg/ind/day per dry weight basis. The reference sediment shall have a mean individual growth rate which is at least eighty percent of the mean individual growth rate found in the control sediment. Control sediments exhibiting growth below 0.72 mg/ind/day may be approved by the department on a case-by-case basis. WAC 173-204-315(2).
Decision criteria	The test sediment has a mean individual growth rate of less than seventy percent of the reference sediment mean individual growth rate and the test sediment mean individual growth rate is statistically different (t test, $p \leq 0.05$) from the reference sediment mean individual growth rate. SQS exceedance. WAC 173-204-320(3). The test sediment has a mean individual growth rate of less than fifty percent of the reference sediment mean individual growth rate and the test sediment mean individual growth rate is statistically different (t test, $p \leq 0.05$) from the reference sediment mean individual growth rate. CSL exceedance. WAC 173-204-520(3).

Bioassay test	**Bivalve larval development**: A 48-hr sediment toxicity test that assesses abnormal development and mortality of mussel larvae (*Mytilus galloprovincialis*).
Method	PSEP (1995) and ASTM (1989)
No. replicates/sample	5
Endpoints	Developmental abnormality and mortality
Performance criteria	The seawater control sample shall have less than thirty percent combined abnormality and mortality (i.e., a seventy percent normal survivorship at time-final). WAC 173-204-315(2).
Decision criteria	The test sediment has a mean survivorship of normal larvae that is less (statistically significant, t test, $p \leq 0.05$) than the mean normal survivorship in the reference sediment and the test sediment mean normal survivorship is less than eighty-five percent of the mean normal survivorship in the reference sediment (i.e., the test sediment has a mean combined abnormality and mortality that is greater than fifteen percent relative to time-final in the reference sediment). SQS exceedance. WAC 173-204-320(3). The test sediment has a mean survivorship of normal larvae that is less (statistically significant, t test, $p \leq 0.05$) than the mean normal survivorship in the reference sediment and the test sediment mean normal survivorship is less than seventy percent of the mean normal survivorship in the reference sediment (i.e., the test sediment has a mean combined abnormality and mortality that is greater than thirty percent relative to time-final in the reference sediment). WAC 173-204-520(3).

Bioassay test	**Microtox®** 100 percent sediment porewater extract test: A rapid (15-min) method of assessing toxicity in aqueous media by utilizing the bioluminescent properties of the marine bacteria *Vibrio fischeri*. The test method assumes that light emitted by the bacteria can be used as an accurate assessment of the overall biological condition of the bacteria exposed to chemical compounds and mixtures. Light emitted by the bacteria exposed to potentially toxic samples is compared to light emitted to unexposed bacterial controls. Differences in luminescence are therefore deemed an indication of relative toxicity.
Method	Ecology Protocol
Reference	Ecology, 2003
No. replicates/sample	5
Endpoints	Light output (bioluminescence) after 5 min and 15 min exposure to test sample
Decision criteria	The mean light output of the highest concentration of the test sediment is less than eighty percent of the mean light output of the reference sediment, and the two means are statistically different from each other (t test, $p \leq 0.05$). SQS exceedance. WAC 173-204-320(3).

SQS - Sediment Quality Standard
CSL - Cleanup Screening Level

Appendix C. Data Quality Assessment

Table C-1: Quality Control Samples, Evaluation Criteria, and Assessment.

	Method Blank		Analytical Replicates[1]		Laboratory Control Sample[2]		Matrix Spike and Matrix Spike Duplicate	
Parameter	Number	Evaluation	Number	Evaluation	Number	Evaluation	Number	Evaluation
Grain size	--		1 triplicate analysis[3]	Method Quality Objective: RSD ≤ 20 %[3] *Objective was met for all grain sizes*	--		--	
Total organic Carbon (TOC)	1/batch	Analyte concentration < PQL[4] *Objective was met (concentration < 0.10%)*	1 triplicate analysis[3]	RSD ≤ 20 %[3] *Objective was met (RSD < 1%)*	--		--	
BNAs	1/batch	Analyte concentration < PQL[4] *Phthalates were detected*	1 duplicate analysis per batch[5]	RPD ≤ 35 % applied when the analyte concentration is > PQL[5] *Objective was met except for fluoranthene (RPD = 108%) and pyrene (RPD = 74%)*	--		*Not requested but included by MEL. Results indicated a low bias for some compounds – see Case Narrative.*	
Priority Pollutant metals	1/batch	Analyte concentration < PQL[4] *Objective was met*	1 duplicate analysis per batch[6]	RPD ≤ 20 % applied when the analyte concentration is > PQL[6] *Objective was met (Case Narrative)*	1	80– 20 % recovery, or performance based intralaboratory control limits, whichever is lower[6] *Objective was met*	--	

	Method Blank		Analytical Replicates[1]		Laboratory Control Sample[2]		Matrix Spike and Matrix Spike Duplicate	
Parameter	Number	Evaluation	Number	Evaluation	Number	Evaluation	Number	Evaluation
Nitroaromatics, nitramines[9]	1/batch	Analyte concentration < EQL[8] *Objective was met*			1/batch	120-60% recovery[9] *Objective was met*	1	120-60% recovery and RPD ≤ 30 %[9] *Objective was met*
Perchlorate[12]	1/batch	Analyte concentration < 2.0 μ/L[11] *Not applicable – used modified method and data reported as ug/Kg dry wt.*	1 duplicate analysis per batch[12]	RPD ≤ 15 %[12] *Not applicable – all samples were nondetects except one*	--		1	120-80% recovery and RPD ≤ 15 %[12] *RPD OK but recovery was only 44-50%*
Total Sulfides	1/batch	Analyte concentration < PQL[4] *Objective was met*	1 triplicate analysis[3]	RSD ≤ 20 %[3] *Objective was met*	1/batch	135-65% recovery[11] *Objective was met*	1 (MS only)	135-65% recovery[11] *Objective was met*

RPD Relative percent difference
RSD Relative standard deviation

[1] Synonymous with Laboratory Replicates or, if applicable, Laboratory Duplicates.
[2] A known matrix spiked with analytes representative of the target analytes used to document laboratory performance. A Fortified Blank or a commercially available Certified Reference Material containing the analytes of interest may be used.
[3] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 13.
[4] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 11 (Organics) and Table 12 (Metals). Recommended PQLs for many analytes are provided in Table 5. Alternatively, the Method Detection Limit (MDL) may be used for this evaluation. The PQL is also known as the EQL (Estimated Quantitation Limit).]
[5] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 11.
[6] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 12.
[7] SW-846 Method 8330.
[8] EQLs are listed in Table 1 of SW-846 Method 8330.
[9] Massachusetts Department of Environmental Protection (2004), Table VIII A-1.
[10] EPA Method 314.0.
[11] EPA Method 314.0, Table 6, assuming a laboratory minimum reporting level of 4.0 μ/L.
[12] EPA Method 314.0, Table 6.

Table C-2. Factors contributing to variation in analyte values. For each analyte, the percentage of the variation due to each factor is shown.

Factor[a]	TOC[b]	% Fines[b]	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Station	86.3	87.4	67.5	83.1	70.1	65.2	68.3	46.8	52.5	70.5
Year[c]	12.8	11.9	30.0	16.9	29.7	34.5	31.5	53.0	43.6	28.1
Field duplicates	0.9	0.0	2.5	0.0	0.2	0.2	0.1	0.3	3.9	1.4
Lab replicates	na	0.7	na	na	na	na	na	na	na	na

a Nested ANOVA

b Values were arcsine-square root transformed.

c 1994 data from EA (1998) and 2004 data from this project were included in nested ANOVA. Only stations with data for both years were included (OB311, OB312, OB326, OB327, OB329, OB334, OB338, OB340, OB341).

na not applicable

Reference: EA, 1998a. Final Remedial Investigation. Jackson Park Housing Complex/Naval Hospital Bremerton Operable Unit 2 – Marine Areas. Prepared by EA Engineering, Science, and Technology, Inc. for Engineering Field Activity, Northwest Naval Facilities Engineering Command, Bremerton, WA.

Table C-3. Bioassay reference toxicant test results.

Species	Endpoint	Toxicant	Current result	Acceptable range (Mean ± 2SD)
A. abdita	Survival	Cadmium	1.08 mg/L	0.22 – 1.09 mg/L
N. arenaceodentata	Survival	Cadmium	15.0 mg/L	8.7 – 19.7 mg/L
M. galloprovincialis	Normality	Copper	10.6 µg/L	7.6 – 16.5 µg/L
Microtox	Light reduction	Phenol	30.1 mg/L	5.9 – 42.1 mg/L

Appendix D. CTD Results

Table D-1. Data from the CTD (Conductivity-Temperature-Depth) recorder.

Station	Pressure, Strain Gauge [db]	Temperature [ITS-90, deg C]	Conductivity [S/m]	Oxygen Current, Beckman/YSI [uA]	Oxygen Temperature, Beckman/YSI [deg C]	Beam Transmission, Chelsea/Seatech/ Wetlab CStar [%]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Density [sigma-t, Kg/m^3]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
OB2	0.504	14.7005	3.701597	21.9696	15.26025	53.2697	257	0.5	29.9058	22.1105	8.42432	0.052	17
	1.008	14.6868	3.703789	21.54852	15.30039	61.9724	271	1	29.9378	22.1386	8.49629	0.335	3
	1.513	14.6567	3.701748	21.55306	15.28998	57.0333	272	1.5	29.9419	22.1479	8.3674	0.353	4
	2.017	14.5909	3.700034	21.39129	15.28663	51.2559	275	2	29.9771	22.1886	8.37156	0.283	4
	2.521	14.4715	3.69645	21.43996	15.2814	56.2878	279	2.5	30.0369	22.2593	8.53394	0.324	3
	3.025	14.4071	3.693768	21.66627	15.2704	63.9251	281	3	30.0624	22.2922	8.723	0.375	2
	3.53	14.3777	3.692397	22.06341	15.25945	68.4319	285	3.5	30.0725	22.3059	8.91399	0.283	4
	4.034	14.3516	3.689899	22.44634	15.24468	70.9398	288	4	30.0701	22.3094	8.98467	0.347	3
	4.538	14.3267	3.688093	22.52936	15.22913	71.9807	290	4.5	30.0728	22.3166	8.95219	0.564	2
	5.042	14.3185	3.686975	22.55654	15.21261	71.6288	292	5	30.0689	22.3153	8.91461	0.637	1
	5.547	14.315	3.68612	22.48503	15.20428	72.3319	294	5.5	30.0637	22.312	8.83698	0.516	2
	6.051	14.3119	3.684929	22.26484	15.16137	72.749	298	6	30.0551	22.306	8.77763	0.178	7
	6.555	14.2992	3.683374	22.03444	15.07028	74.2299	305	6.5	30.0507	22.3052	8.72257	0.126	7
	7.059	14.2818	3.681565	21.77864	15.00391	73.2323	312	7	30.0477	22.3064	8.6331	0.197	5
	7.563	14.2772	3.68051	21.41552	14.79082	71.3164	365	7.5	30.0415	22.3026	8.59161	0.015	110
OB338	0.504	14.6589	3.344465	22.32736	15.41376	38.1805	189	0.5	26.7927	19.7265	9.03476	0.054	11
	1.008	14.6471	3.720068	23.41504	15.45006	56.6161	199	1	30.108	22.2774	9.28581	0.33	3
	1.513	14.6548	3.703198	23.49827	15.46183	55.0885	202	1.5	29.9565	22.1595	9.21811	0.309	4
	2.017	14.6622	3.704001	23.54929	15.46555	54.9942	205	2	29.9579	22.159	9.17882	0.287	3
	2.521	14.6262	3.703548	23.35983	15.47187	56.5835	208	2.5	29.9813	22.1845	9.01179	0.255	4
	3.025	14.5818	3.701526	23.25591	15.46579	58.9746	214	3	29.9972	22.2059	9.14347	0.178	6
	3.53	14.5692	3.700662	23.63713	15.44293	60.076	220	3.5	29.9989	22.2099	9.37332	0.15	7
	4.034	14.5503	3.699119	24.36034	15.38605	61.4207	226	4	29.9995	22.2142	9.73305	0.168	5
	4.539	14.5496	3.698513	24.62553	15.34295	61.9193	231	4.5	29.9944	22.2104	9.48394	0.093	1

Station	Pressure, Strain Gauge [db]	Temperature [ITS-90, deg C]	Conductivity [S/m]	Oxygen Current, Beckman/YSI [uA]	Oxygen Temperature, Beckman/YSI [deg C]	Beam Transmission, Chelsea/Seatech/ Wetlab CStar [%]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Density [sigma-t, Kg/m^3]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
OB334	0.505	14.8276	3.717599	29.34727	15.35878	4.1754	216	0.5	29.9489	22.1165	11.46478	-0.006	14
	1.008	14.818	3.717049	29.05699	15.32597	1.5043	229	1	29.9561	22.1254	11.1957	0.243	5
	1.512	14.7899	3.715464	28.69452	15.31762	55.2306	231	1.5	29.9627	22.1362	11.00841	0.494	2
	2.017	14.7383	3.712536	28.46237	15.30631	52.1266	233	2	29.9759	22.1572	10.94027	0.488	2
	2.521	14.713	3.709315	28.14351	15.28762	54.2092	235	2.5	29.9663	22.155	10.84156	0.336	3
	3.025	14.692	3.707476	27.81228	15.2723	55.3157	238	3	29.9658	22.1589	10.74096	0.385	3
	3.53	14.6732	3.706	27.50895	15.25523	55.9472	241	3.5	29.9668	22.1636	10.58283	0.331	3
	4.034	14.6549	3.704487	26.94105	15.22819	58.1024	244	4	29.9671	22.1676	10.21342	0.525	2
	4.538	14.6454	3.703831	26.59965	15.20877	58.9376	245	4.5	29.9683	22.1706	10.02394	0.807	1
	5.043	14.6369	3.703119	26.225	15.20032	59.9007	246	5	29.9682	22.1722	9.86235	0.845	1
	5.546	14.6188	3.702211	25.89661	15.19106	62.6574	248	5.5	29.9739	22.1803	9.75453	0.633	2
	6.051	14.5148	3.696744	25.11389	15.15865	68.0671	251	6	30.0048	22.2256	9.59999	0.281	5
	6.555	14.4061	3.690084	24.5198	15.11092	71.1129	255	6.5	30.0286	22.2663	9.54652	0.314	3
	7.059	14.3768	3.687479	24.21907	15.07175	72.6136	258	7	30.0275	22.2714	9.47776	0.381	2
	7.564	14.3724	3.686721	23.92161	15.03596	73.5785	260	7.5	30.0238	22.2695	9.29582	0.449	3
	8.068	14.3694	3.686308	23.60236	15.01474	74.8382	262	8	30.0223	22.269	9.14353	0.481	1
	8.572	14.3617	3.68569	23.25071	14.99418	75.009	264	8.5	30.0225	22.2707	9.04211	0.439	3
	9.077	14.3271	3.683687	22.95269	14.96285	75.2411	267	9	30.0309	22.2843	9.01255	0.361	3
	9.581	14.3095	3.681752	22.36211	14.82776	75.3776	302	9.5	30.0269	22.2848	8.9475	0.029	73
OB312	0.504	15.1884	3.737902	28.27137	16.2961	54.6673	203	0.5	29.8584	21.9721	10.67119	0.067	16
	1.008	15.069	3.730484	28.61121	16.12152	56.3825	213	1	29.8833	22.0165	10.80045	0.26	4
	1.513	14.8629	3.71712	28.47305	16.04733	51.4738	216	1.5	29.9215	22.0892	10.84653	0.333	4
	2.017	14.7899	3.713478	28.06637	15.95766	53.0424	219	2	29.9447	22.1223	10.4082	0.253	4
	2.521	14.7365	3.709875	26.62283	15.84932	56.8857	223	2.5	29.9532	22.14	9.64869	0.272	4
	3.025	14.5936	3.70103	25.28135	15.76218	60.8608	227	3	29.9836	22.193	9.2173	0.284	3
	3.53	14.5045	3.694999	23.88342	15.66327	62.4508	231	3.5	29.9979	22.2224	8.80572	0.249	4
	4.034	14.4688	3.692378	22.88174	15.58456	61.7991	234	4	30.0017	22.2327	8.63548	0.288	4
	4.538	14.4463	3.69106	22.38977	15.54006	60.7652	237	4.5	30.0069	22.2413	8.5447	0.495	2
	5.042	14.445	3.690851	22.1471	15.51226	60.2812	239	5	30.0059	22.2408	8.4397	0.523	2
	5.547	14.4417	3.690678	21.75922	15.47358	59.965	242	5.5	30.0067	22.2422	8.24583	0.406	1
	6.051	14.3851	3.68609	20.66661	15.24206	58.0758	269	6	30.0089	22.2554	8.09563	0.087	69

Station	Pressure, Strain Gauge [db]	Temperature [ITS-90, deg C]	Conductivity [S/m]	Oxygen Current, Beckman/YSI [uA]	Oxygen Temperature, Beckman/YSI [deg C]	Beam Transmission, Chelsea/Seatech/ Wetlab CStar [%]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Density [sigma-t, Kg/m^3]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
OB311	0.504	15.4055	3.754806	26.23905	15.74705	9.7733	450	0.5	29.8376	21.9082	9.89912	0.081	19
	1.008	15.214	3.746227	26.16433	15.78287	5.888	460	1	29.9131	22.0089	9.9972	0.224	5
	1.512	14.8445	3.725432	25.92815	15.78507	19.3278	463	1.5	30.01	22.1612	9.66227	0.33	3
	2.017	14.4816	3.701327	24.80412	15.75779	18.1705	467	2	30.0732	22.2851	9.14595	0.246	5
	2.521	14.3998	3.691976	23.61601	15.6742	27.8719	471	2.5	30.052	22.2856	8.86135	0.271	4
	3.025	14.3662	3.689207	22.99396	15.58146	30.086	474	3	30.0528	22.2931	8.79745	0.283	3
	3.53	14.3479	3.687371	22.62504	15.4784	28.519	478	3.5	30.0502	22.2949	8.79368	0.251	4
	4.034	14.3335	3.686082	22.41052	15.37336	30.4612	482	4	30.0495	22.2973	8.76566	0.29	3
	4.538	14.3238	3.685054	22.26876	15.305	32.7089	485	4.5	30.0476	22.2977	8.72375	0.441	3
	5.042	14.3182	3.684588	22.18319	15.27804	24.1097	487	5	30.0475	22.2988	8.7061	0.616	1
	5.546	14.3165	3.68416	22.11769	15.2458	42.5098	489	5.5	30.0449	22.2971	8.69263	0.494	2
	6.051	14.3108	3.683252	21.92524	15.16973	60.6674	493	6	30.0408	22.2952	8.64785	0.157	8
	6.555	14.303	3.682173	21.72768	15.08906	68.1529	500	6.5	30.0369	22.2937	8.60427	0.242	4
	7.059	14.2972	3.681503	21.61513	15.04696	70.9727	504	7	30.0351	22.2936	8.58516	0.226	5
	7.564	14.2951	3.681189	21.57971	15.01844	70.0464	508	7.5	30.0337	22.293	8.6007	0.306	3
	8.068	14.298	3.681101	21.55321	14.99129	70.6155	511	8	30.0305	22.2899	8.5911	0.357	2
	8.572	14.2925	3.680816	21.52942	14.98065	70.8988	514	8.5	30.032	22.2921	8.58984	0.261	4
	9.076	14.2915	3.680659	21.51053	14.95036	70.7943	518	9	30.0311	22.2917	8.58939	0.312	4
	9.581	14.291	3.680537	21.4806	14.93347	71.2099	521	9.5	30.0303	22.2911	8.58055	0.336	3
	10.09	14.2909	3.680467	21.46377	14.91582	70.4688	525	10	30.0295	22.2906	8.59284	0.251	4
	10.59	14.2912	3.680404	21.46516	14.90597	69.7743	528	11	30.0286	22.2898	8.59414	0.341	3
	11.09	14.2902	3.680342	21.46119	14.89696	69.0669	531	11	30.0286	22.29	8.59601	0.339	3
	11.6	14.2909	3.680266	21.46098	14.88866	68.9873	534	12	30.0271	22.2887	8.60321	0.294	3
	12.1	14.2904	3.680194	21.47	14.87981	69.1208	537	12	30.0267	22.2885	8.59759	0.32	3
	12.61	14.2901	3.680151	21.42033	14.86674	69.7148	541	13	30.0264	22.2883	8.56913	0.288	4
	13.11	14.2902	3.680126	21.38983	14.86406	69.6322	544	13	30.0259	22.2879	8.56978	0.298	3
	13.62	14.2945	3.680483	21.35322	14.79587	67.5628	600	14	30.0256	22.2868	8.58341	-0.078	85

Station	Pressure, Strain Gauge [db]	Temperature [ITS-90, deg C]	Conductivity [S/m]	Oxygen Current, Beckman/YSI [uA]	Oxygen Temperature, Beckman/YSI [deg C]	Beam Transmission, Chelsea/Seatech/ Wetlab CStar [%]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Density [sigma-t, Kg/m^3]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
OB329	0.504	15.277	3.696231	32.55758	15.6194	41.3373	439	0.5	29.4115	21.6065	12.42059	0.082	14
	1.008	15.2397	3.741265	32.18672	15.67688	45.3323	448	1	29.8515	21.9567	11.79847	0.269	4
	1.513	15.0508	3.73269	30.59927	15.65759	44.7878	451	1.5	29.9165	22.0459	11.05251	0.422	3
	2.017	14.8552	3.718009	29.64835	15.63979	48.6802	453	2	29.9351	22.1013	10.62569	0.42	3
	2.521	14.7508	3.709025	28.18258	15.61014	51.1434	455	2.5	29.9346	22.1228	9.90907	0.469	2
	3.025	14.6982	3.704299	26.74501	15.5772	56.2181	457	3	29.9324	22.132	9.38666	0.461	2
	3.53	14.6302	3.699783	25.26214	15.54581	61.0939	460	3.5	29.944	22.155	9.07383	0.426	2
	4.034	14.4714	3.693016	24.44316	15.50382	63.4937	462	4	30.0055	22.2351	9.03483	0.535	2
	4.538	14.396	3.688182	23.92465	15.47046	66.5804	463	4.5	30.0199	22.2617	8.99164	0.753	2
	-1E-28	-1E-28	-9.99E-29	-9.99E-29	-9.99E-29	-9.99E-29	-0	5	-9.99E-29	-9.99E-29	-9.99E-29	-1E-28	0
	5.492	14.3798	3.686415	23.46539	15.425	67.2347	466	5.5	30.0161	22.2621	8.88822	0.726	2
	6.051	14.3755	3.686091	22.86171	15.36568	67.603	468	6	30.0163	22.2632	8.6913	0.33	4
	6.555	14.3617	3.685278	22.24351	15.2957	66.9709	472	6.5	30.0195	22.2684	8.55972	0.381	2
	7.059	14.3116	3.682802	21.94405	15.24829	65.2417	474	7	30.0357	22.2912	8.52876	0.413	3
	7.564	14.2862	3.680649	21.74545	15.20195	67.4439	476	7.5	30.0358	22.2963	8.51261	0.524	2
	8.068	14.2815	3.679945	21.61917	15.16923	67.1461	478	8	30.0329	22.295	8.50036	0.561	1
	8.572	14.282	3.679757	21.52325	15.13036	66.9905	480	8.5	30.0306	22.2932	8.50111	0.363	3
	9.076	14.2837	3.679432	21.1857	14.84814	68.4934	542	9	30.0261	22.2894	8.49464	-0.011	117
OB1	0.505	14.6672	3.685823	27.8536	14.79447	41.4573	436	0.5	29.7911	22.0296	11.06853	0.011	20
	1.008	14.6673	3.686963	28.31793	14.8258	43.6951	469	1	29.8013	22.0375	11.45342	0.094	14
	1.513	14.6885	3.690154	29.12708	14.8227	49.5536	465	1.5	29.8135	22.0424	11.74534	0.36	4
	2.017	14.708	3.695232	29.17446	14.82771	49.8529	468	2	29.8439	22.0618	11.5492	0.317	3
	2.521	14.7301	3.700613	28.95979	14.83351	49.8395	471	2.5	29.875	22.0812	11.32055	0.343	3
	3.025	14.7236	3.702776	28.41314	14.84355	46.3223	474	3	29.8993	22.1012	10.72347	0.351	3
	3.53	14.7086	3.702371	26.80122	14.84481	45.5123	477	3.5	29.9069	22.1102	9.56366	0.322	3
	4.034	14.6921	3.701474	24.498	14.83988	46.2211	480	4	29.9114	22.1171	8.53745	0.396	3
	4.538	14.6171	3.699817	22.85246	14.82865	47.2141	482	4.5	29.9541	22.1655	8.06957	0.613	1
	5.043	14.5274	3.695561	22.04408	14.80994	48.3069	483	5	29.9848	22.2076	7.93753	0.626	2
	5.547	14.4439	3.690742	21.22141	14.79111	50.5569	485	5.5	30.0056	22.2408	7.83384	0.478	2
	6.051	14.3676	3.686034	20.12558	14.75019	56.4348	489	6	30.0219	22.269	7.73537	0.187	6
	6.555	14.3321	3.683041	18.32323	14.5267	67.0294	547	6.5	30.0222	22.2765	7.4867	-0.057	79

Station	Pressure, Strain Gauge [db]	Temperature [ITS-90, deg C]	Conductivity [S/m]	Oxygen Current, Beckman/YSI [uA]	Oxygen Temperature, Beckman/YSI [deg C]	Beam Transmission, Chelsea/Seatech/ Wetlab CStar [%]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Density [sigma-t, Kg/m^3]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
OB326	1.008	14.6312	3.694776	31.88265	14.88055	36.1821	395	1	29.8993	22.1204	11.76074	0.373	3
	1.513	14.6247	3.694797	30.66116	14.8817	50.997	401	1.5	29.9041	22.1254	11.08217	0.634	2
	2.017	14.6297	3.695353	29.3796	14.87455	50.9893	402	2	29.9051	22.1251	10.31522	0.547	2
	2.521	14.638	3.696731	27.41804	14.87341	52.3197	404	2.5	29.9109	22.1279	9.4227	0.556	2
	3.026	14.6405	3.697572	25.97072	14.86954	51.7221	406	3	29.9164	22.1316	8.86597	0.595	1
	3.53	14.6047	3.697797	24.1755	14.8641	48.9446	408	3.5	29.9458	22.1616	8.2348	0.477	3
	4.034	14.5083	3.695032	22.0723	14.85066	51.1386	410	4	29.9951	22.2195	7.66676	0.575	1
	4.538	14.4786	3.692483	21.37314	14.83979	54.918	412	4.5	29.9949	22.2254	7.60742	0.793	2
	5.042	14.4595	3.690858	20.88252	14.82578	58.9179	413	5	29.9947	22.2293	7.55854	0.776	1
	5.547	14.4176	3.6884	20.26696	14.81195	60.1944	414	5.5	30.0048	22.2456	7.50775	0.675	1
	6.051	14.3551	3.684483	19.35746	14.78336	62.7027	417	6	30.0176	22.2682	7.37831	0.218	6
	6.555	14.3407	3.683364	18.07832	14.67318	63.6507	451	6.5	30.0184	22.2718	7.16843	0.045	81
OB327	0.504	14.6999	3.698877	26.95872	15.47598	46.7671	386	0.5	29.8828	22.0933	10.36163	0.109	15
	1.008	14.6694	3.697071	26.06719	15.42451	50.0936	394	1	29.8905	22.1057	9.76592	0.382	2
	1.513	14.6556	3.696105	25.31527	15.3888	52.5896	396	1.5	29.8921	22.1098	9.42696	0.39	3
	2.017	14.634	3.69546	24.45142	15.36372	54.515	399	2	29.9028	22.1225	9.06271	0.343	3
	2.521	14.6104	3.694584	23.34298	15.33091	56.2857	402	2.5	29.9128	22.1351	8.63809	0.323	3
	3.025	14.5908	3.693961	22.5626	15.31173	57.5272	405	3	29.9222	22.1463	8.35579	0.401	3
	3.53	14.5623	3.692822	21.66136	15.28369	58.2026	408	3.5	29.9337	22.161	8.04594	0.321	3
	4.034	14.5361	3.691616	20.71342	15.25712	58.2712	411	4	29.9429	22.1736	7.79067	0.418	2
	4.538	14.5256	3.691293	20.34777	15.23737	58.3064	413	4.5	29.9478	22.1795	7.71763	0.599	2
	5.043	14.5203	3.691062	20.1032	15.22232	58.1779	414	5	29.9497	22.182	7.65099	0.65	2
	5.546	14.5142	3.690799	19.85674	15.21395	58.3269	416	5.5	29.9518	22.185	7.56443	0.541	1
	6.051	14.5035	3.690318	19.21209	15.17888	57.8615	419	6	29.9556	22.19	7.3116	0.213	6
	6.555	14.4859	3.689657	18.37177	15.13446	57.4697	425	6.5	29.963	22.1994	7.07732	0.294	3
	7.059	14.4947	3.689793	18.23998	15.02257	57.4708	470	7	29.9572	22.1931	7.28439	-0.07	71

Station	Pressure, Strain Gauge [db]	Temperature [ITS-90, deg C]	Conductivity [S/m]	Oxygen Current, Beckman/YSI [uA]	Oxygen Temperature, Beckman/YSI [deg C]	Beam Transmission, Chelsea/Seatech/ Wetlab CStar [%]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Density [sigma-t, Kg/m^3]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
CR2	1.008	14.5586	3.696503	23.46913	14.88644	0.3444	338	1	29.97	22.1896	9.08602	0.219	4
	1.513	14.5067	3.693766	22.90482	14.88268	0.3922	345	1.5	29.986	22.2129	8.75444	0.338	4
	2.017	14.4702	3.691359	22.0284	14.85574	0.4164	347	2	29.992	22.225	8.32317	0.289	4
	2.521	14.4037	3.687083	20.72236	14.82497	0.4318	351	2.5	30.0048	22.2484	7.65423	0.25	4
	3.025	14.3422	3.68287	18.96347	14.78452	0.4563	355	3	30.0141	22.2682	6.85345	0.303	3
	3.53	14.2459	3.67739	17.7242	14.74878	0.4936	359	3.5	30.0389	22.307	6.70086	0.257	4
	4.034	14.1755	3.671956	16.92897	14.69664	0.5218	363	4	30.0442	22.3253	6.45402	0.299	4
	4.538	14.1542	3.670025	16.14984	14.65749	0.5431	365	4.5	30.043	22.3287	5.99819	0.515	2
	5.042	14.1193	3.667952	15.61101	14.64058	0.5434	367	5	30.0511	22.342	5.72083	0.577	1
	5.547	14.0725	3.665238	14.77562	14.6051	0.5756	369	5.5	30.0626	22.3604	5.33483	0.39	3
	6.051	13.9416	3.658323	13.25177	14.52719	0.5892	374	6	30.1016	22.4168	5.00029	0.17	7
	6.555	13.8383	3.65041	12.29803	14.42307	0.6122	380	6.5	30.1098	22.4439	4.89713	0.236	4
	7.059	13.8021	3.649207	12.06479	14.37372	0.6347	384	7	30.1271	22.4644	4.83754	0.251	4
	7.564	13.7609	3.646493	11.61472	14.32053	0.6561	388	7.5	30.1343	22.4782	4.51161	0.323	4
	8.068	13.7505	3.645769	11.18811	14.2927	0.6614	390	8	30.1356	22.4812	4.31497	0.354	2
	8.572	13.7341	3.644374	10.54863	14.25734	0.6704	394	8.5	30.1355	22.4844	4.09234	0.276	4
	9.076	13.7108	3.643021	10.18562	14.22252	0.713	397	9	30.1412	22.4934	4.14431	0.334	3
	9.581	13.696	3.641865	10.33868	14.20769	0.7213	400	9.5	30.142	22.497	4.4535	0.331	3
	10.09	13.6857	3.641129	10.84726	14.16958	0.7291	404	10	30.1432	22.5	4.71229	0.247	4
	10.59	13.669	3.640428	11.28452	14.14275	0.7636	407	11	30.1497	22.5083	4.82758	0.324	3
	11.09	13.6499	3.639403	11.48554	14.12403	0.7826	410	11	30.1552	22.5163	4.84145	0.369	3
	11.6	13.6457	3.638904	11.5496	14.1082	0.7809	413	12	30.1537	22.5159	4.81717	0.347	3
	12.1	13.6413	3.638343	11.52991	14.09227	0.8122	416	12	30.1518	22.5153	4.73627	0.297	3
	12.61	13.6382	3.638021	11.3467	14.07677	0.818	419	13	30.1511	22.5154	4.60763	0.309	4
	13.11	13.6309	3.637664	11.14052	14.06216	0.8377	423	13	30.1533	22.5186	4.5094	0.306	3
	13.62	13.6267	3.637441	10.82497	14.04919	0.8705	426	14	30.1544	22.5203	4.32219	0.285	3
	14.12	13.6259	3.637359	10.46784	14.04293	0.8817	430	14	30.1541	22.5202	4.2273	0.357	3
	14.62	13.6245	3.637237	10.34454	14.03595	0.8992	432	15	30.1539	22.5203	4.21665	0.332	3
	15.13	13.621	3.636973	10.1964	14.0293	0.9154	436	15	30.154	22.521	4.20625	0.244	4
	15.63	13.6217	3.636818	10.14146	14.01874	0.9409	441	16	30.1519	22.5193	4.25515	-0.159	2

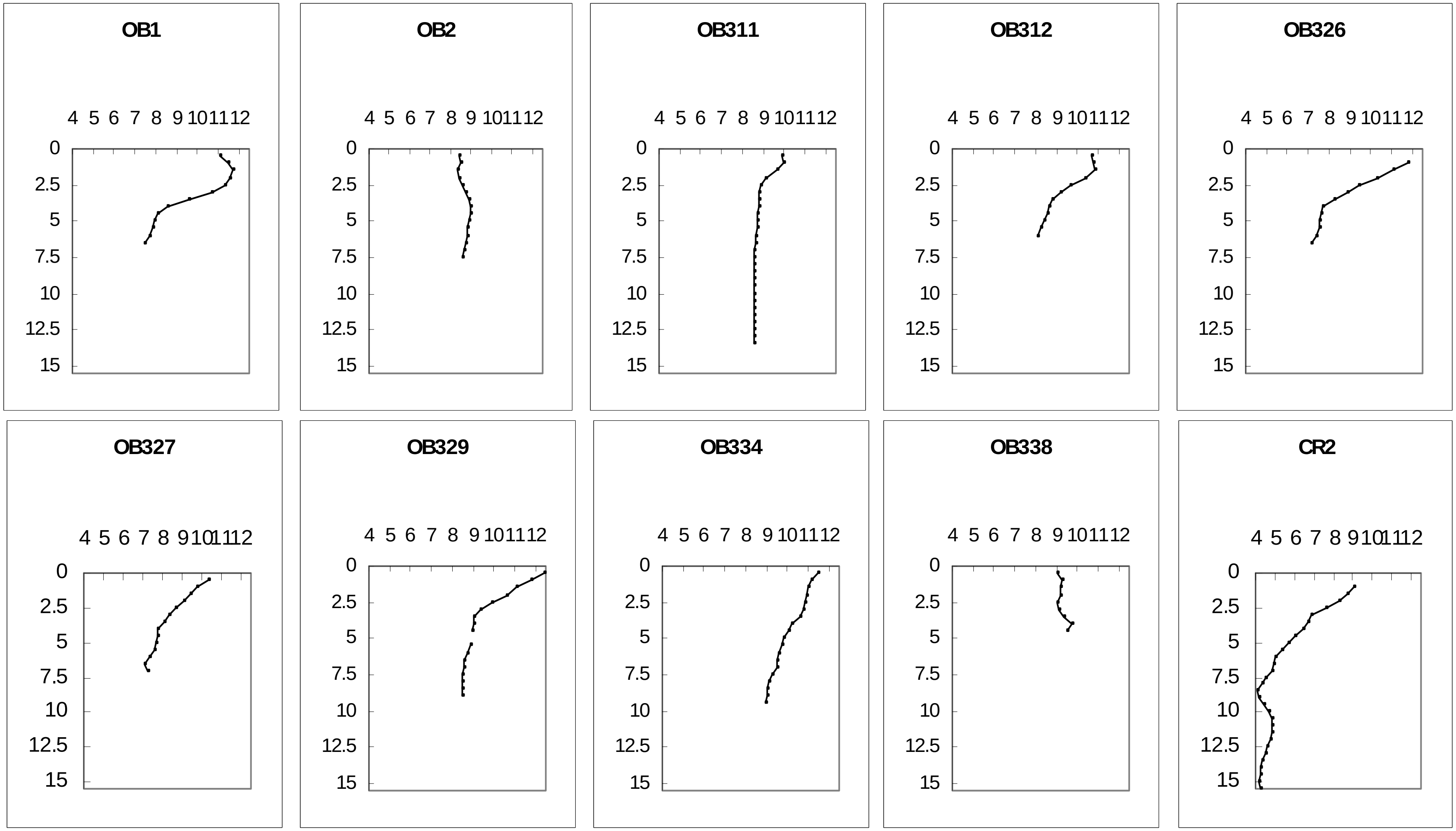

Figure D-1. Vertical Profiles of Oxygen.

Ordinate: depth below surface (m). Abscissa: O_2 (mg/L)

Appendix E. Semivolatile Organic Compounds

Table E-1. Semivolatile organic compound concentrations (ug/Kg dw).

	Station											
	CR02		OB1		OB2		OB311		OB312		OB326	
Nitrophenols												
2,4-Dinitrophenol	1800	REJ	2250	REJ	2120	REJ	1800	REJ	1840	REJ	2420	REJ
2,4-Dinitrotoluene	45	UJ	56	U	53	U	45	U	46	U	61	U
2-Nitrophenol	90	UJ	113	U	106	U	90	U	92	U	121	U
4-Nitrophenol	225	UJ	282	UJ	266	UJ	225	UJ	230	UJ	303	UJ
Chlorophenols												
2,4,5-Trichlorophenol	45	UJ	56	U	53	U	45	U	46	U	61	U
2,4,6-Trichlorophenol	45	UJ	56	U	53	U	45	U	46	U	61	U
2,4-Dichlorophenol	45	UJ	56	U	53	U	45	U	46	U	61	U
2,4-Dimethylphenol	45	UJ	56	U	53	U	45	U	46	U	61	U
2-Chlorophenol	22	UJ	28	U	27	U	22	U	23	U	30	U
Chlorinated benzenes												
1,2,4-Trichlorobenzene	22	UJ	28	U	27	U	22	U	23	U	30	U
1,2-Dichlorobenzene	22	UJ	28	U	27	U	22	U	23	U	30	U
1,3-Dichlorobenzene	22	UJ	28	U	27	U	22	U	23	U	30	U
1,4-Dichlorobenzene	22	UJ	28	U	27	U	22	U	23	U	30	U
Hexachlorobenzene	22	UJ	28	U	27	U	22	U	23	U	30	U
Phthalates												
Bis(2-Ethylhexyl) Phthalate	42	UJ	104	U	152	U	22	U	**105**		115	U
Butylbenzylphthalate	22	UJ	28	U	27	U	22	U	23	U	30	U
Diethylphthalate	45	UJ	69	U	53	U	45	U	46	U	61	U
Dimethylphthalate	45	UJ	56	U	53	U	45	U	46	U	61	U
Di-N-Butylphthalate	29	UJ	73	U	19	U	47	U	134	U	31	U
Di-N-Octyl Phthalate	45	UJ	56	U	53	U	45	U	46	U	61	U
PAHs												
1-Methylnaphthalene	22	UJ	28	U	27	U	22	U	23	U	30	U
2-Chloronaphthalene	22	UJ	28	U	27	U	22	U	23	U	30	U
2-Methylnaphthalene	22	UJ	**18**	J	27	U	22	U	23	U	30	U
Acenaphthene	22	UJ	28	U	27	U	22	U	23	U	30	U
Acenaphthylene	22	UJ	**29**		**34**		**18**	J	**13**	J	**24**	J
Anthracene	22	UJ	**52**		**49**		**46**		23	U	**40**	
Benzo(a)anthracene	22	UJ	**108**		**118**		**65**		**40**		**72**	
Benzo(a)pyrene	22	UJ	**134**		**175**		**113**		**61**		**120**	
Benzo(b)fluoranthene	45	UJ	**238**		**244**		**212**		**165**		**259**	
Benzo(ghi)perylene	45	UJ	**131**		**135**		**80**		**58**		**98**	
Benzo(k)fluoranthene	45	UJ	**32**	J	**88**	J	**13**	J	46	U	**7.3**	J
Chrysene	22	UJ	**126**		**157**		**132**		**56**		**92**	
Dibenzo(a,h)anthracene	45	UJ	56	U	53	U	45	U	46	U	61	U
Fluoranthene	**19**	J	**246**		**191**		**89**		**76**		**135**	
Fluorene	22	UJ	28	U	27	U	22	U	23	U	30	U
Indeno(1,2,3-cd)pyrene	41	UJ	**140**		**134**		**90**		**72**		**111**	
Naphthalene	22	UJ	**27**	J	**27**		**18**	J	**15**	J	**19**	J
Phenanthrene	22	UJ	**181**		**75**		**52**		23	U	**62**	
Pyrene	**19**	J	**285**		209	U	**92**		77	U	146	U

	Station											
	CR02		**OB1**		**OB2**		**OB311**		**OB312**		**OB326**	
Other Semivolatile Organic Compounds												
1,2-Diphenylhydrazine	45	UJ	56	U	53	U	45	U	46	U	61	U
2,2'-Oxybis[1-chloropropane]	22	UJ	28	U	27	U	22	U	23	U	30	U
2,6-Dinitrotoluene	45	UJ	56	U	53	U	45	U	46	U	61	U
2-Methylphenol	22	UJ	28	U	27	U	22	U	23	UJ	30	U
2-Nitroaniline	45	UJ	56	U	53	U	45	U	46	U	61	U
3,3'-Dichlorobenzidine	225	UJ	282	UJ	266	UJ	225	UJ	230	UJ	303	UJ
3B-Coprostanol	450	UJ	563	REJ	531	REJ	450	REJ	460	REJ	606	REJ
3-Nitroaniline	45	UJ	56	U	53	U	45	U	46	U	61	U
4,6-Dinitro-2-Methylphenol	901	UJ	1130	UJ	1060	UJ	900	UJ	919	UJ	1210	UJ
4-Bromophenyl-Phenylether	22	UJ	28	U	27	U	22	U	23	U	30	U
4-Chloro-3-Methylphenol	45	UJ	56	U	53	U	45	U	46	U	61	U
4-Chloroaniline	45	UJ	56	U	53	U	45	U	46	U	61	U
4-Chlorophenyl-Phenylether	22	UJ	28	U	27	U	22	U	23	U	30	U
4-Methylphenol	22	UJ	28	U	27	U	22	U	23	U	30	U
4-Nitroaniline	225	UJ	282	U	266	U	225	U	230	U	303	U
Aniline	45	UJ	56	UJ	53	UJ	45	UJ	46	UJ	61	UJ
Benzidine	450	UJ	563	UJ	531	UJ	450	UJ	460	UJ	606	UJ
Benzoic Acid	1800	UJ	**3420**	J	2120	UJ	**2690**	J	1840	UJ	2420	UJ
Benzyl Alcohol	45	UJ	56	UJ	53	UJ	45	UJ	46	U	61	UJ
Bis(2-Chloroethoxy)Methane	22	UJ	28	U	27	U	22	U	23	U	30	U
Bis(2-Chloroethyl)Ether	22	UJ	28	U	27	U	22	U	23	U	30	U
Caffeine	45	UJ	56	U	53	U	45	U	46	U	61	U
Carbazole	22	UJ	28	U	27	U	22	U	23	U	30	U
Dibenzofuran	22	UJ	28	U	27	U	22	U	23	U	30	U
Hexachlorobutadiene	22	UJ	28	U	27	U	22	U	23	U	30	U
Hexachlorocyclopentadiene	225	UJ	282	UJ	266	UJ	225	UJ	230	UJ	303	UJ
Hexachloroethane	45	UJ	56	U	53	U	45	U	46	U	61	U
Isophorone	22	UJ	28	U	27	U	22	U	23	U	**47**	
Nitrobenzene	22	UJ	28	U	27	U	22	U	23	U	30	U
N-Nitrosodimethylamine	45	UJ	56	U	53	U	45	U	46	U	61	U
N-Nitroso-Di-N-Propylamine	22	UJ	28	U	27	U	22	U	23	U	30	U
N-Nitrosodiphenylamine	45	UJ	56	U	53	U	45	U	46	U	61	U
Pentachlorophenol	225	UJ	282	UJ	266	UJ	225	UJ	230	UJ	303	UJ
Phenol	22	UJ	28	U	27	U	22	U	23	U	30	U
Pyridine	90	UJ	113	U	106	U	90	U	92	U	121	U

	Station											
	OB327		OB329		OB334*		OB338		OB340		OB341	
Nitrophenols												
2,4-Dinitrophenol	1340	REJ	2540	REJ	1625	REJ	1860	REJ	2300	REJ	2280	REJ
2,4-Dinitrotoluene	34	U	64	U	40.5	U	46	U	57	U	57	U
2-Nitrophenol	67	U	127	U	81.5	U	93	U	115	U	114	U
4-Nitrophenol	168	UJ	318	UJ	203.5	UJ	232	UJ	287	UJ	285	UJ
Chlorophenols												
2,4,5-Trichlorophenol	34	U	64	U	40.5	U	46	U	57	U	57	U
2,4,6-Trichlorophenol	34	U	64	U	40.5	U	46	U	57	U	57	U
2,4-Dichlorophenol	34	U	64	U	40.5	U	46	U	57	U	57	U
2,4-Dimethylphenol	34	U	64	U	40.5	U	46	U	57	U	57	U
2-Chlorophenol	17	U	32	U	20	U	23	U	29	U	28	U
Chlorinated benzenes												
1,2,4-Trichlorobenzene	17	U	32	U	20	U	23	U	29	U	28	U
1,2-Dichlorobenzene	17	U	32	U	20	U	23	U	29	U	28	U
1,3-Dichlorobenzene	17	U	32	U	20	U	23	U	29	U	28	U
1,4-Dichlorobenzene	17	U	32	U	20	U	23	U	29	U	28	U
Hexachlorobenzene	17	U	32	U	20	U	23	U	29	U	28	U
Phthalates												
Bis(2-Ethylhexyl) Phthalate	94	U	158	U	77	U	168	U	314	U	212	U
Butylbenzylphthalate	17	U	32	U	20	U	23	U	29	U	28	U
Diethylphthalate	34	U	64	U	40.5	U	46	U	57	U	57	U
Dimethylphthalate	34	U	64	U	40.5	U	46	U	57	U	57	U
Di-N-Butylphthalate	37	U	32	U	27	U	46	U	29	U	28	U
Di-N-Octyl Phthalate	34	U	64	U	40.5	U	46	U	57	U	57	U
PAHs												
1-Methylnaphthalene	17	U	32	U	20	U	23	U	29	U	28	U
2-Chloronaphthalene	17	U	32	U	20	U	23	U	29	U	28	U
2-Methylnaphthalene	17	U	**19**	J	15	U	23	U	29	U	28	U
Acenaphthene	17	U	32	U	20	U	23	U	29	U	28	U
Acenaphthylene	**9.9**	J	**25**	J	**32.5**		23	U	19	J	24	J
Anthracene	**24**		**38**		**87.5**		**22**	J	**31**		**37**	
Benzo(a)anthracene	**42**		**80**		**158.5**		**53**		**59**		**76**	
Benzo(a)pyrene	**76**		**134**		**266**		**88**		**104**		**134**	
Benzo(b)fluoranthene	**151**		**269**		**356.5**		**194**		**257**		**259**	
Benzo(ghi)perylene	**46**		**92**		**112.5**		**49**		**62**		**77**	
Benzo(k)fluoranthene	**22**	J	**7.3**	J	**230.5**	J	46	U	57	U	**58**	J
Chrysene	**70**		**103**		**351**		**64**		**73**		**99**	
Dibenzo(a,h)anthracene	34	U	64	U	40.5	U	46	U	57	U	57	U
Fluoranthene	**78**		**135**		**338**		**85**		**98**		**144**	
Fluorene	17	U	32	U	**35.5**		23	U	29	U	28	U
Indeno(1,2,3-cd)pyrene	**56**		**110**		**112.5**		**64**		**80**		**94**	
Naphthalene	**9.5**	J	**27**	J	15	U	**13**	J	**25**	J	**28**	J
Phenanthrene	**30**		**58**		**55.5**		**38**		29	U	28	U
Pyrene	**83**		**152**		**246.5**		**97**		**117**		**159**	

	Station											
	OB327		**OB329**		**OB334***		**OB338**		**OB340**		**OB341**	
Other Semivolatile Organic Compounds												
1,2-Diphenylhydrazine	34	U	64	U	40.5	U	46	U	57	U	57	U
2,2'-Oxybis[1-chloropropane]	17	U	32	U	20	U	23	U	29	U	28	U
2,6-Dinitrotoluene	34	U	64	U	40.5	U	46	U	57	U	57	U
2-Methylphenol	17	U	32	U	20	U	23	UJ	29	U	28	U
2-Nitroaniline	34	U	64	U	40.5	U	46	U	57	U	57	U
3,3'-Dichlorobenzidine	168	UJ	318	UJ	203.5	UJ	232	UJ	287	UJ	285	UJ
3B-Coprostanol	336	REJ	636	REJ	406.5	REJ	464	REJ	574	REJ	570	REJ
3-Nitroaniline	34	U	32	U	40.5	U	46	U	57	U	57	U
4,6-Dinitro-2-Methylphenol	672	UJ	1270	UJ	813	UJ	928	UJ	1150	UJ	1140	UJ
4-Bromophenyl-Phenylether	17	U	32	U	20	U	23	U	29	U	28	U
4-Chloro-3-Methylphenol	34	U	64	U	40.5	U	46	U	57	U	57	U
4-Chloroaniline	34	U	64	U	40.5	U	46	U	57	U	57	U
4-Chlorophenyl-Phenylether	17	U	32	U	20	U	23	U	29	U	28	U
4-Methylphenol	17	U	32	U	20	U	23	U	29	U	28	U
4-Nitroaniline	168	U	318	U	203.5	U	232	UJ	287	U	285	U
Aniline	34	UJ	64	UJ	40.5	UJ	46	UJ	57	UJ	57	UJ
Benzidine	336	UJ	636	UJ	406.5	UJ	464	UJ	574	UJ	570	UJ
Benzoic Acid	1340	UJ	2540	UJ	1625	UJ	1860	UJ	**3530**	J	2280	UJ
Benzyl Alcohol	34	UJ	64	UJ	40.5	UJ	46	U	57	UJ	57	UJ
Bis(2-Chloroethoxy)Methane	17	U	32	U	20	U	23	U	29	U	28	U
Bis(2-Chloroethyl)Ether	17	U	32	U	20	U	23	U	29	U	28	U
Caffeine	34	U	64	U	40.5	U	46	U	57	U	57	U
Carbazole	17	U	32	U	20.5	U	23	U	29	U	28	U
Dibenzofuran	17	U	32	U	20	U	23	U	29	U	28	U
Hexachlorobutadiene	17	U	32	U	20	U	23	U	29	U	28	U
Hexachlorocyclopentadiene	168	UJ	318	UJ	203.5	UJ	232	UJ	287	UJ	285	UJ
Hexachloroethane	34	U	64	U	40.5	U	46	U	57	U	57	U
Isophorone	17	U	32	U	20	U	23	U	29	U	28	U
Nitrobenzene	17	U	32	U	20	U	23	U	29	U	28	U
N-Nitrosodimethylamine	34	U	64	U	40.5	U	46	U	57	U	57	U
N-Nitroso-Di-N-Propylamine	17	U	32	U	20	U	23	U	29	U	28	U
N-Nitrosodiphenylamine	34	U	64	U	40.5	U	46	U	57	U	57	U
Pentachlorophenol	168	UJ	318	UJ	203.5	UJ	232	UJ	287	UJ	285	UJ
Phenol	17	U	32	U	20	U	23	U	29	U	28	U
Pyridine	67	U	127	U	81.5	U	93	U	115	U	114	U

	Station	
	OB400	
Nitrophenols		
2,4-Dinitrophenol	2210	REJ
2,4-Dinitrotoluene	55	U
2-Nitrophenol	110	U
4-Nitrophenol	276	U
Chlorophenols		
2,4,5-Trichlorophenol	55	U
2,4,6-Trichlorophenol	55	U
2,4-Dichlorophenol	55	U
2,4-Dimethylphenol	55	U
2-Chlorophenol	28	U
Chlorinated benzenes		
1,2,4-Trichlorobenzene	28	U
1,2-Dichlorobenzene	28	U
1,3-Dichlorobenzene	28	U
1,4-Dichlorobenzene	28	U
Hexachlorobenzene	28	U
Phthalates		
Bis(2-Ethylhexyl) Phthalate	201	UJ
Butylbenzylphthalate	28	U
Diethylphthalate	55	U
Dimethylphthalate	55	U
Di-N-Butylphthalate	76	U
Di-N-Octyl Phthalate	55	U
PAHs		
1-Methylnaphthalene	28	U
2-Chloronaphthalene	28	U
2-Methylnaphthalene	28	U
Acenaphthene	28	U
Acenaphthylene	20	J
Anthracene	**40**	
Benzo(a)anthracene	**59**	
Benzo(a)pyrene	**102**	
Benzo(b)fluoranthene	**226**	
Benzo(ghi)perylene	**64**	J
Benzo(k)fluoranthene	**38**	J
Chrysene	**90**	
Dibenzo(a,h)anthracene	55	UJ
Fluoranthene	**122**	
Fluorene	28	U
Indeno(1,2,3-cd)pyrene	**82**	J
Naphthalene	**26**	J
Phenanthrene	**57**	
Pyrene	**136**	

	Station	
	OB400	
Other Semivolatile Organic Compounds		
1,2-Diphenylhydrazine	55	U
2,2'-Oxybis[1-chloropropane]	28	U
2,6-Dinitrotoluene	55	U
2-Methylphenol	28	U
2-Nitroaniline	55	U
3,3'-Dichlorobenzidine	276	UJ
3B-Coprostanol	553	UJ
3-Nitroaniline	55	U
4,6-Dinitro-2-Methylphenol	1100	UJ
4-Bromophenyl-Phenylether	28	U
4-Chloro-3-Methylphenol	55	U
4-Chloroaniline	55	U
4-Chlorophenyl-Phenylether	28	U
4-Methylphenol	28	U
4-Nitroaniline	276	U
Aniline	55	U
Benzidine	553	UJ
Benzoic Acid	**3370**	J
Benzyl Alcohol	55	U
Bis(2-Chloroethoxy)Methane	28	U
Bis(2-Chloroethyl)Ether	28	U
Caffeine	55	U
Carbazole	28	U
Dibenzofuran	28	U
Hexachlorobutadiene	28	U
Hexachlorocyclopentadiene	276	UJ
Hexachloroethane	55	UJ
Isophorone	28	U
Nitrobenzene	28	U
N-Nitrosodimethylamine	55	U
N-Nitroso-Di-N-Propylamine	28	U
N-Nitrosodiphenylamine	55	U
Pentachlorophenol	276	U
Phenol	28	U
Pyridine	110	U
Retene		

* Averages of two laboratory duplicates

Bold Detected values

Qualifier codes

U The compound was analyzed for, but was not detected at or above the Method Detection Limit.

J The result is an estimated concentration that is less than the Method Reporting Limit but greater than or equal to the Method Detection Limit.

N The result is presumptive. The analyte was tentatively identified but a confirmation analysis was not performed.

Appendix F. Bioassay Test Results

Table F-1. 10-day Amphipod Survival (*Ampelisca abdita*). Test Initiated October 29, 2004.

Lab ID	Replicate	Number Survived	% Survival	Mean % Survival	Standard Deviation
	1	20	100		
	2	15	75		
Control	3	19	95	**91.0**	9.6
	4	18	90		
	5	19	95		
	1	15	75		
	2	18	90		
04414092 (Ref)	3	15	75	**80.0**	6.1
	4	16	80		
	5	16	80		
	1	12	60		
	2	11	55		
4414080	3	13	65	**66.0**	9.6
	4	16	80		
	5	14	70		
	1	14	70		
	2	19	95		
4414081	3	17	85	**85.0**	10.6
	4	19	95		
	5	16	80		
	1	15	75		
	2	17	85		
4414082	3	17	85	**78.0**	8.4
	4	16	80		
	5	13	65		
	1	17	85		
	2	14	70		
4414083	3	18	90	**84.0**	8.2
	4	17	85		
	5	18	90		
	1	15	75		
	2	16	80		
4414084	3	18	90	**82.0**	5.7
	4	17	85		
	5	16	80		
	1	16	80		
	2	17	85		
4414085	3	20	100	**83.0**	10.4
	4	15	75		
	5	15	75		
	1	16	80		
	2	16	80		
4414086	3	16	80	**78.0**	4.5
	4	14	70		
	5	16	80		
	1	17	85		
	2	16	80		
4414087	3	17	85	**85.0**	6.1
	4	19	95		
	5	16	80		
	1	15	75		
	2	15	75		
4414088	3	14	70	**77.0**	5.7
	4	17	85		
	5	16	80		
	1	17	85		
	2	12	60		
4414089	3	15	75	**74.0**	9.6
	4	14	70		
	5	16	80		
	1	16	80		
	2	13	65		
4414090	3	15	75	**74.0**	5.5
	4	15	75		
	5	15	75		
	1	14	70		
	2	15	75		
4414091	3	15	75	**71.0**	4.2
	4	13	65		
	5	14	70		

Table F-2. 20-Day Polychaete Survival & Growth (*Neanthes arenaceodentata*). Test Initiated October 19, 2004.

Site	Replicate	Survival: Number Survived	% Survival	Mean % Survival	Standard Deviation	Total Wgt.per Org (mg)	Growth Wgt per Org (mg)	Mean Wgt per Org (mg)	Standard Deviation
	1	5	100			14.65	13.00		
	2	5	100			19.24	17.59		
Control	3	5	100	**96.0**	8.9	18.70	17.05	**13.07**	4.4
	4	4	80			12.18	10.53		
	5	5	100			8.85	7.20		
	1	5	100			10.04	8.39		
	2	5	100			8.28	6.63		
04414092 (Ref)	3	5	100	**100.0**	0.0	9.75	8.10	**7.81**	2.3
	4	5	100			6.58	4.93		
	5	5	100			12.68	11.03		
	1	4	80			8.78	7.12		
	2	5	100			8.39	6.74		
4414080	3	5	100	**96.0**	8.9	10.48	8.83	**6.79**	1.8
	4	5	100			9.04	7.39		
	5	5	100			5.53	3.88		
	1	3	60			11.52	9.87		
	2	5	100			11.70	10.05		
4414081	3	3	60	**80.0**	20.0	11.43	9.78	**9.43**	1.3
	4	5	100			11.98	10.33		
	5	4	80			8.76	7.11		
	1	5	100			9.68	8.03		
	2	4	80			9.63	7.98		
4414082	3	2	40	**80.0**	24.5	13.62	11.96	**9.08**	1.7
	4	5	100			9.55	7.90		
	5	4	80			11.19	9.54		
	1	5	100			12.76	11.11		
	2	5	100			9.01	7.36		
4414083	3	5	100	**100.0**	0.0	6.51	4.86	**7.56**	2.5
	4	5	100			10.34	8.69		
	5	5	100			7.45	5.80		
	1	5	100			10.38	8.73		
	2	5	100			9.67	8.02		
4414084	3	5	100	**100.0**	0.0	9.24	7.59	**7.44**	1.2
	4	5	100			8.98	7.33		
	5	5	100			7.20	5.55		
	1	5	100			7.09	5.44		
	2	5	100			10.82	9.17		
4414085	3	5	100	**92.0**	11.0	9.56	7.91	**8.33**	1.8
	4	4	80			10.62	8.97		
	5	4	80			11.83	10.17		
	1	5	100			6.45	4.80		
	2	5	100			10.04	8.39		
4414086	3	5	100	**100.0**	0.0	9.03	7.38	**7.40**	1.5
	4	5	100			9.76	8.11		
	5	5	100			9.96	8.31		
	1	5	100			14.50	12.85		
	2	5	100			15.78	14.13		
4414087	3	4	80	**96.0**	8.9	12.00	10.35	**9.52**	4.2
	4	5	100			6.43	4.78		
	5	5	100			7.14	5.49		
	1	5	100			8.98	7.33		
	2	5	100			6.90	5.25		
4414088	3	4	80	**96.0**	8.9	12.44	10.78	**8.38**	2.2
	4	5	100			10.20	8.55		
	5	5	100			11.64	9.99		
	1	5	100			10.23	8.58		
	2	5	100			6.39	4.74		
4414089	3	4	80	**92.0**	11.0	13.60	11.95	**8.38**	2.7
	4	4	80			11.39	9.73		
	5	5	100			8.57	6.92		
	1	5	100			7.69	6.04		
	2	5	100			8.45	6.80		
4414090	3	5	100	**96.0**	8.9	12.15	10.50	**7.83**	1.9
	4	5	100			10.77	9.12		
	5	4	80			8.37	6.71		
	1	5	100			6.69	5.04		
	2	5	100			15.31	13.66		
4414091	3	5	100	**96.0**	8.9	8.59	6.94	**7.92**	3.4
	4	5	100			7.95	6.30		
	5	4	80			9.32	7.67		

Initial Weights

Tare Wgt. (mg)	Total Wgt. (mg)	# org.	Weight per org (mg)	Mean Wgt. per Org. (mg)	St. Dev.
578.06	586.60	5	1.71		
592.36	598.78	5	1.28		
609.75	613.85	5	0.82		
590.59	595.79	5	1.04		
617.91	634.92	5	3.40	1.65	1.03

Table F-3. Microtox 100 Percent Sediment Porewater Test. Test Date: October 26, 2004.

Site	Light Reading							92 (Ref)	Control	Change in light readings compared to initial control	Change in light readings compared to final control	Evaluation of initial light output
	Replicate											
	Reading	1	2	3	4	5	Mean	$T_{(mean)}/R_{(mean)}$	$T_{(mean)}/C_{(mean)}$	$I_{(t)(mean)}/I_{(0)C(mean)}$	$I_{(t)(mean)}/I_{(t)C(mean)}$	$I_{(0)(mean)}/I_{(0)C(mean)}$
Control	$I_{(0)}$	93	85	98	84	74	87					
	$I_{(5)}$	88	81	95	84	71	84			0.97		
	$I_{(15)}$	80	85	87	74	63	78			0.90		
	$C_{(5)}$	0.95	0.95	0.97	1.00	0.96	0.97					
	$C_{(15)}$	0.86	1.00	0.89	0.88	0.85	0.90					
04414092 (Ref)	$I_{(0)}$	82	87	86	85	77	83					0.96
	$I_{(5)}$	84	88	88	89	79	86				1.02	
	$I_{(15)}$	85	86	84	83	74	82				1.06	
	$R_{(5)}$	1.02	1.01	1.02	1.05	1.03	1.03					
	$R_{(15)}$	1.04	0.99	0.98	0.98	0.96	0.99					
4414080	$I_{(0)}$	82	93	70	104	77	85					0.98
	$I_{(5)}$	82	92	68	105	76	85					
	$I_{(15)}$	76	84	65	100	73	80					
	$T_{(5)}$	1.00	0.99	0.97	1.01	0.99	0.99	0.97	1.03			
	$T_{(15)}$	0.93	0.90	0.93	0.96	0.95	0.93	0.95	1.04			
4414081	$I_{(0)}$	86	77	90	83	82	84					0.96
	$I_{(5)}$	81	79	95	87	83	85					
	$I_{(15)}$	79	79	93	84	85	84					
	$T_{(5)}$	0.94	1.03	1.06	1.05	1.01	1.02	0.99	1.05			
	$T_{(15)}$	0.92	1.03	1.03	1.01	1.04	1.01	1.02	1.12			
4414082	$I_{(0)}$	30	29	27	36	32	31					0.35
	$I_{(5)}$	21	21	19	27	23	22					
	$I_{(15)}$	18	20	17	24	19	20					
	$T_{(5)}$	0.24	0.24	0.22	0.31	0.26	0.26	0.25	0.26			
	$T_{(15)}$	0.21	0.23	0.20	0.28	0.22	0.23	0.23	0.25			
4414083	$I_{(0)}$	84	89	90	87	73	85					0.97
	$I_{(5)}$	85	90	91	89	73	86					
	$I_{(15)}$	84	93	91	90	75	87					
	$T_{(5)}$	1.01	1.01	1.01	1.02	1.00	1.01	0.99	1.05			
	$T_{(15)}$	1.00	1.04	1.01	1.03	1.03	1.02	1.04	1.14			

$I_{(0)}$ is the light reading after the initial five minute incubation period
$I_{(5)}$ is the light reading five minutes after $I_{(0)}$
$I_{(15)}$ is the light reading fifteen minutes after $I_{(0)}$
$C_{(t)}$, $R_{(t)}$, and $T_{(t)}$ are the changes in light readings from the initial reading in each sample container for the control, reference sediment and test sites. I

Quality Control Steps:

1. Is control final mean output greater than 80% control initial mean output?
   $I_{(5)}$: $F_{c(mean)}/I_{c(mean)}$=97%
   $I_{(15)}$: $F_{c(mean)}/I_{c(mean)}$=90%

Control results are acceptable

2. Does the reference final mean exceed 80% of control final mean?
   $I_{(5)}$: $F_{R(mean)}/F_{C(mean)}$=102%
   $I_{(15)}$: $F_{R(mean)}/F_{C(mean)}$=106%

The reference site (92) is acceptable to use in statistical analyses.

3. Is the reference initial mean > 80% of control initial mean?
   $I_{R(mean)}/I_{C(mean)}$=96%

Use reference initial readings to calculate change in light readings at $I_{(5)}$ and $I_{(15)}$ for reference site.

4. Are test initial mean values > 80% of control initial mean values?
   80: $I_{T(mean)}/I_{C(mean)}$=98%, use site initial readings to calculate change in light readings.
   81: $I_{T(mean)}/I_{C(mean)}$=96%, use site initial readings to calculate change in light readings.
   82: $I_{T(mean)}/I_{C(mean)}$=35%, use control initial mean to calculate change in light readings.
   83: $I_{T(mean)}/I_{C(mean)}$=97%, use site initial readings to calculate change in light readings.

Table F-3 (cont.). Test Date: October 27, 2004.

Site	Light Reading Replicate Reading	1	2	3	4	5	Mean	92 (Ref) $T_{(mean)}/R_{(mean)}$	Control $T_{(mean)}/C_{(mean)}$	Change in light readings compared to initial control $I_{(t)(mean)}/I_{(0)C(mean)}$	Change in light readings compared to final control $I_{(t)(mean)}/I_{(t)C(mean)}$	Evaluation of initial light output $I_{(0)(mean)}/I_{(0)C(mean)}$
Control	$I_{(0)}$	106	91	97	97	112	101					
	$I_{(5)}$	93	90	96	94	108	96			0.96		
	$I_{(15)}$	83	88	93	85	97	89			0.89		
	$C_{(5)}$	0.88	0.99	0.99	0.97	0.96	0.96					
	$C_{(15)}$	0.78	0.97	0.96	0.88	0.87	0.89					
04414092 (Ref)	$I_{(0)}$	101	107	113	101	91	103					1.02
	$I_{(5)}$	104	110	111	102	94	104				1.08	
	$I_{(15)}$	96	100	105	103	81	97				1.09	
	$R_{(5)}$	1.03	1.03	0.98	1.01	1.03	1.02					
	$R_{(15)}$	0.95	0.93	0.93	1.02	0.89	0.94					
4414084	$I_{(0)}$	59	102	113	116	101	98					0.98
	$I_{(5)}$	59	104	115	120	105	101					
	$I_{(15)}$	60	105	118	120	107	102					
	$T_{(5)}$	1.00	1.02	1.02	1.03	1.04	1.02	1.01	1.07			
	$T_{(15)}$	1.02	1.03	1.04	1.03	1.06	1.04	1.10	1.16			
4414085	$I_{(0)}$	95	99	115	75	99	97					0.96
	$I_{(5)}$	93	98	115	73	99	96					
	$I_{(15)}$	92	97	115	72	97	95					
	$T_{(5)}$	0.98	0.99	1.00	0.97	1.00	0.99	0.97	1.03			
	$T_{(15)}$	0.97	0.98	1.00	0.96	0.98	0.98	1.03	1.10			
4414086	$I_{(0)}$	58	66	71	58	84	67					0.67
	$I_{(5)}$	50	60	63	51	77	60					
	$I_{(15)}$	50	58	63	49	77	59					
	$T_{(5)}$	0.50	0.60	0.63	0.51	0.77	0.60	0.59	0.62			
	$T_{(15)}$	0.50	0.58	0.63	0.49	0.77	0.59	0.62	0.66			
4414087	$I_{(0)}$	40	35	32	34	37	36					0.35
	$I_{(5)}$	32	28	25	27	29	28					
	$I_{(15)}$	27	25	22	24	25	25					
	$T_{(5)}$	0.32	0.28	0.25	0.27	0.29	0.28	0.28	0.29			
	$T_{(15)}$	0.27	0.25	0.22	0.24	0.25	0.24	0.26	0.27			

$I_{(0)}$ is the light reading after the initial five minute incubation period
$I_{(5)}$ is the light reading five minutes after $I_{(0)}$
$I_{(15)}$ is the light reading fifteen minutes after $I_{(0)}$
$C_{(t)}$, $R_{(t)}$, and $T_{(t)}$ are the changes in light readings from the initial reading in each sample container for the control, reference sediment and test sites.

Quality Control Steps:

1. Is control final mean output greater than 80% control initial mean output?
   $I_{(5)}$: $F_{c(mean)}/I_{c(mean)}$=96%
   $I_{(15)}$: $F_{c(mean)}/I_{c(mean)}$=89%

Control results are acceptable

2. Does the reference final mean exceed 80% of control final mean?
   $I_{(5)}$: $F_{R(mean)}/F_{C(mean)}$=108%
   $I_{(15)}$: $F_{R(mean)}/F_{C(mean)}$=109%

The reference site (92) is acceptable to use in statistical analyses

3. Is the reference initial mean > 80% of control initial mean?
   $I_{R(mean)}/I_{C(mean)}$=102%

Use reference initial readings to calculate change in light readings at $I_{(5)}$ and $I_{(15)}$ for reference site.

4. Are test initial mean values > 80% of control initial mean values?
   84: $I_{T(mean)}/I_{C(mean)}$=98%, use site initial readings to calculate change in light readings.
   85: $I_{T(mean)}/I_{C(mean)}$)=96%, use site initial readings to calculate change in light readings.
   86: $I_{T(mean)}/I_{C(mean)}$=67%, use control initial mean to calculate change in light readings.
   87: $I_{T(mean)}/I_{C(mean)}$)=35%, use control initial mean to calculate change in light readings.

Table F-3 (cont.). Test Date: October 28, 2004.

Site	Light Reading	Replicate						92 (Ref)	Control	Change in light readings compared to initial control	Change in light readings compared to final control	Evaluation of initial light output
	Reading	**1**	**2**	**3**	**4**	**5**	**Mean**	$T_{(mean)}/R_{(mean)}$	$T_{(mean)}/C_{(mean)}$	$I_{(t)(mean)}/I_{(0)C(mean)}$	$I_{(t)(mean)}/I_{(t)C(mean)}$	$I_{(0)(mean)}/I_{(0)C(mean)}$
Control	$I_{(0)}$	96	88	85	92	97	92					
	$I_{(5)}$	101	85	89	89	93	91			1.00		
	$I_{(15)}$	88	86	81	88	94	87			0.95		
	$C_{(5)}$	1.05	0.97	1.05	0.97	0.96	1.00					
	$C_{(15)}$	0.92	0.98	0.95	0.96	0.97	0.95					
04414092 (Ref)	$I_{(0)}$	98	89	94	108	98	97					1.06
	$I_{(5)}$	97	87	101	105	107	99				1.09	
	$I_{(15)}$	90	83	97	100	102	94				1.08	
	$R_{(5)}$	0.99	0.98	1.07	0.97	1.09	1.02					
	$R_{(15)}$	0.92	0.93	1.03	0.93	1.04	0.97					
4414088	$I_{(0)}$	74	68	58	61	65	65					0.71
	$I_{(5)}$	72	67	56	59	65	64					
	$I_{(15)}$	74	70	57	60	67	66					
	$T_{(5)}$	0.79	0.73	0.61	0.64	0.71	0.70	0.68	0.70			
	$T_{(15)}$	0.81	0.76	0.62	0.66	0.73	0.72	0.74	0.75			
4414089	$I_{(0)}$	82	88	97	96	105	94					1.02
	$I_{(5)}$	87	93	101	101	110	98					
	$I_{(15)}$	80	88	96	94	104	92					
	$T_{(5)}$	1.06	1.06	1.04	1.05	1.05	1.05	1.03	1.05			
	$T_{(15)}$	0.98	1.00	0.99	0.98	0.99	0.99	1.02	1.03			
4414090	$I_{(0)}$	100	102	103	97	100	100					1.10
	$I_{(5)}$	102	105	107	96	99	102					
	$I_{(15)}$	97	109	103	94	99	100					
	$T_{(5)}$	1.02	1.03	1.04	0.99	0.99	1.01	0.99	1.02			
	$T_{(15)}$	0.97	1.07	1.00	0.97	0.99	1.00	1.03	1.05			
4414091	$I_{(0)}$	103	98	87	98	103	98					1.07
	$I_{(5)}$	105	99	89	99	105	99					
	$I_{(15)}$	98	93	84	94	101	94					
	$T_{(5)}$	1.02	1.01	1.02	1.01	1.02	1.02	1.00	1.02			
	$T_{(15)}$	0.95	0.95	0.97	0.96	0.98	0.96	0.99	1.01			

$I_{(0)}$ is the light reading after the initial five minute incubation period
$I_{(5)}$ is the light reading five minutes after $I_{(0)}$
$I_{(15)}$ is the light reading fifteen minutes after $I_{(0)}$
$C_{(t)}$, $R_{(t)}$, and $T_{(t)}$ are the changes in light readings from the initial reading in each sample container for the control, reference sediment and test sites.

Quality Control Steps:

1. Is control final mean output greater than 80% control initial mean output?
   $I_{(5)}$: $F_{c(mean)}/I_{c(mean)}$=100%
   $I_{(15)}$: $F_{c(mean)}/I_{c(mean)}$=95%

Control results are acceptable

2. Does the reference final mean exceed 80% of control final mean?
   $I_{(5)}$: $F_{R(mean)}/F_{C(mean)}$=109%
   $I_{(15)}$: $F_{R(mean)}/F_{C(mean)}$=108%

The reference site (92) is acceptable to use in statistical analyses

3. Is the reference initial mean > 80% of control initial mean?
   $I_{R(mean)}/I_{C(mean)}$=106%

Use reference initial readings to calculate change in light readings at $I_{(5)}$ and $I_{(15)}$ for reference site.

4. Are test initial mean values > 80% of control initial mean values?
   88: $I_{T(mean)}/I_{C(mean)}$=71%, use control initial mean to calculate change in light readings.
   89: $I_{T(mean)}/I_{C(mean)}$=102%, use site initial readings to calculate change in light readings.
   90: $I_{T(mean)}/I_{C(mean)}$=110%, use site initial readings to calculate change in light readings.
   91: $I_{T(mean)}/I_{C(mean)}$=107%, use site initial readings to calculate change in light readings.

Table F-4. 48-Hr Bivalve Larval Development Test (*Mytilus galloprovincialis*). Test Initiated October 19, 2004.

Site	Rep	Initial Density	Number Survived	Proportion Survived	Mean Prop. Survived	Standard Deviation	Number Normal	Prop. Normal	Mean Prop. Normal	Standard Deviation	Combined Prop. Surv./Normal	Mean Combined Prop. Surv./Normal	Standard Deviation
	1	188	176	0.936			169	0.960			0.899		
	2		179	0.952			165	0.922			0.878		
Control	3		150	0.798	**0.83**	**0.11**	139	0.927	**0.93**	**0.02**	0.739	**0.78**	**0.11**
	4		132	0.702			120	0.909			0.638		
	5		143	0.761			136	0.951			0.723		
	1		125	0.665			118	0.944			0.628		
	2		163	0.867			152	0.933			0.809		
04414092 (Ref)	3		173	0.920	**0.90**	**0.15**	157	0.908	**0.93**	**0.03**	0.835	**0.84**	**0.14**
	4		197	1.048			173	0.878			0.920		
	5		192	1.021			186	0.969			0.989		
	1		182	0.968			168	0.923			0.894		
	2		164	0.872			152	0.927			0.809		
4414080	3		158	0.840	**0.88**	**0.05**	145	0.918	**0.91**	**0.04**	0.771	**0.80**	**0.06**
	4		162	0.862			137	0.846			0.729		
	5		159	0.846			150	0.943			0.798		
	1		176	0.936			162	0.920			0.862		
	2		157	0.835			142	0.904			0.755		
4414081	3		183	0.973	**0.86**	**0.11**	171	0.934	**0.92**	**0.02**	0.910	**0.79**	**0.11**
	4		131	0.697			118	0.901			0.628		
	5		162	0.862			154	0.951			0.819		
	1		185	0.984			164	0.886			0.872		
	2		184	0.979			172	0.935			0.915		
4414082	3		184	0.979	**0.98**	**0.09**	166	0.902	**0.91**	**0.02**	0.883	**0.89**	**0.08**
	4		206	1.096			186	0.903			0.989		
	5		159	0.846			145	0.912			0.771		
	1		152	0.809			129	0.849			0.686		
	2		170	0.904			149	0.876			0.793		
4414083	3		157	0.835	**0.87**	**0.06**	141	0.898	**0.89**	**0.03**	0.750	**0.78**	**0.08**
	4		160	0.851			144	0.900			0.766		
	5		182	0.968			169	0.929			0.899		
	1		144	0.766			131	0.910			0.697		
	2		176	0.936			148	0.841			0.787		
4414084	3		163	0.867	**0.89**	**0.08**	140	0.859	**0.86**	**0.03**	0.745	**0.76**	**0.04**
	4		179	0.952			151	0.844			0.803		
	5		174	0.926			146	0.839			0.777		
	1		157	0.835			144	0.917			0.766		
	2		177	0.941			162	0.915			0.862		
4414085	3		161	0.856	**0.86**	**0.09**	151	0.938	**0.92**	**0.03**	0.803	**0.79**	**0.07**
	4		179	0.952			159	0.888			0.846		
	5		136	0.723			131	0.963			0.697		
	1		200	1.064			190	0.950			1.011		
	2		168	0.894			164	0.976			0.872		
4414086	3		174	0.926	**0.92**	**0.10**	162	0.931	**0.95**	**0.03**	0.862	**0.87**	**0.09**
	4		171	0.910			156	0.912			0.830		
	5		150	0.798			146	0.973			0.777		
	1		177	0.941			167	0.944			0.888		
	2		169	0.899			147	0.870			0.782		
4414087	3		180	0.957	**0.93**	**0.04**	165	0.917	**0.91**	**0.04**	0.878	**0.84**	**0.07**
	4		163	0.867			141	0.865			0.750		
	5		181	0.963			169	0.934			0.899		
	1		170	0.904			143	0.841			0.761		
	2		182	0.968			164	0.901			0.872		
4414088	3		167	0.888	**0.87**	**0.07**	150	0.898	**0.87**	**0.03**	0.798	**0.76**	**0.08**
	4		145	0.771			127	0.876			0.676		
	5		156	0.830			131	0.840			0.697		
	1		180	0.957			165	0.917			0.878		
	2		157	0.835			131	0.834			0.697		
4414089	3		168	0.894	**0.93**	**0.09**	145	0.863	**0.87**	**0.03**	0.771	**0.81**	**0.08**
	4		167	0.888			147	0.880			0.782		
	5		200	1.064			170	0.850			0.904		
	1		163	0.867			135	0.828			0.718		
	2		170	0.904			143	0.841			0.761		
4414090	3		171	0.910	**0.87**	**0.03**	151	0.883	**0.85**	**0.04**	0.803	**0.74**	**0.06**
	4		161	0.856			145	0.901			0.771		
	5		157	0.835			124	0.790			0.660		
	1		204	1.085			176	0.863			0.936		
	2		169	0.899			159	0.941			0.846		
4414091	3		177	0.941	**0.95**	**0.08**	160	0.904	**0.90**	**0.03**	0.851	**0.85**	**0.06**
	4		166	0.883			144	0.867			0.766		
	5		174	0.926			160	0.920			0.851		

Initial Density

Rep	Number Counted
1	187
2	197
3	183
4	179
5	201
6	182
Mean	**188**
St.Dev.	8.9
CV (%)	4.7

Table F-5. Summary of Amphipod t-test p values.

Test Site	Survival[1]	
	Compared to Control	Compared to Ref Sed
04414092 (Ref)	**0.03**	
04414080	**0.003**	**0.03**
04414081	0.16	NA
04414082	**0.02**	0.34
04414083	0.09	NA
04414084	0.05	NA
04414085	0.18	NA
04414086	**0.030**	0.280
04414087	0.110	NA
04414088	**0.010**	0.220
04414089	**0.010**	0.140
04414090	**0.010**	0.070
04414091	**0.010**	**0.020**

[1] - One-tailed t-test following arcsine square-root transformation.
NA-not applicable. Results are greater than or equal to control or reference sediment values.
Bold indicates a statistically significant decrease relative to the control or reference sediment ($p<0.05$)

Table F-6. Summary of Neanthes t-test p values.

Test Site	Survival[1]		Growth	
	Compared to Control	Compared to Ref Sed (92)	Compared to Control	Compared to Ref Sed (92)
04414092 (Ref)	NA		**0.022**	
04414080	NA	0.200	**0.009**	0.230
04414081	0.080	0.050	0.080	NA
04414082	0.100	0.070	0.050	NA
04414083	NA	NA	**0.030**	0.410
04414084	NA	NA	**0.030**	0.380
04414085	0.270	0.090	**0.030**	NA
04414086	NA	NA	**0.030**	0.370
04414087	NA	0.240	0.110	NA
04414088	NA	0.240	**0.030**	NA
04414089	0.270	0.220	**0.040**	NA
04414090	NA	0.240	**0.020**	NA
04414091	NA	0.240	**0.040**	NA

[1] - One-tailed t-test following arcsine square-root transformation.
NA-not applicable. Results are greater than or equal to control or reference sediment values.
Bold indicates a statistically significant decrease relative to the control or reference sediment ($p<0.05$)

Table F-7. Summary of Microtox t-test Statistical Results.

Test Site	p-value[1]	Sample Mean relative to Reference Mean $T_{(mean)}/R_{(mean)}$ (%)	p-value[1]	Sample Mean relative To Reference Mean $T_{(mean)}/R_{(mean)}$ (%)
		$I_{(5)}$		**$I_{(15)}$**
04414080	0.004	97.000	0.005	95.000
04414081	0.370	99.000	NA	102.000
04414082	**<.001**	**25.000**	**<.001**	**23.000**
04414083	0.030	99.000	NA	104.000
04414084	NA	101.000	NA	110.000
04414085	0.020	97.000	NA	103.000
04414086	**<.001**	**59.000**	**<.001**	**62.000**
04414087	**<.001**	**28.000**	**<.001**	**26.000**
04414088	**<.001**	**68.000**	**<.001**	**74.000**
04414089	NA	103.000	NA	102.000
04414090	0.410	99.000	NA	103.000
04414091	NA	100.000	0.390	99.000

[1] - One-tailed t-test.
Bold indicates a CSL Failure according to the SMS rule where the test mean output is less than 80% of reference mean output and statistically significantly different ($p<.05$).

Table F-8. Summary of Amphipod t-test p values.

Test Site	Survival[1]	
	Compared to Control	Compared to Ref Sed
04414092 (Ref)	**0.03**	
04414080	**0.003**	**0.03**
04414081	0.16	NA
04414082	**0.02**	0.34
04414083	0.09	NA
04414084	0.05	NA
04414085	0.18	NA
04414086	**0.030**	0.280
04414087	0.110	NA
04414088	**0.010**	0.220
04414089	**0.010**	0.140
04414090	**0.010**	0.070
04414091	**0.010**	**0.020**

[1] - One-tailed t-test following arcsine square-root transformation.
NA-not applicable. Results are greater than or equal to control or reference sediment values.
Bold indicates a statistically significant decrease relative to the control or reference sediment ($p<0.05$)

Table F-9. Summary of Bivalve t-test p values.

Test Site	Normal Survival[1]	
	Compared to Control	Compared to Ref Sed
04414092 (Ref)	NA	
04414080	NA	0.17
04414081	NA	0.26
04414082	NA	NA
04414083	NA	0.19
04414084	0.37	0.13
04414085	NA	0.45
04414086	NA	NA
04414087	NA	NA
04414088	0.39	0.140
04414089	NA	0.290
04414090	0.26	0.100
04414091	NA	NA

[1] - One-tailed t-test following arcsine square-root transformation.
NA-not applicable. Results are greater than or equal to control or reference sediment values.
Bold indicates a statistically significant decrease relative to the control ($p<0.05$)

Appendix G. Case Narratives

Manchester Environmental Laboratory

7411 Beach Dr E, Port Orchard, Washington 98366

Case Summary

November 22, 2004

Project: Ostrich Bay

Samples: 412-4080-93

Laboratory: Analytical Resources, Inc.

By: Pam Covey

These fourteen (14) sediment samples required Grain Size analyses using Puget Sound Estuary Protocol (PSEP) method. The samples were received at the Manchester Environmental Laboratory and taken to the contract lab on October 15, 2004 for Grain Size analyses.

The analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness. One sample (41-4082) was analyzed in triplicate and was within QA requirements. See the QA memo from ARI regarding an anomaly on sample 41-4089.

The results are acceptable for use as reported.

Manchester Environmental Laboratory

7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

October 26, 2004

Subject: General Chemistry Ostrich Bay

Project No: 181204

Officer: Nigel Blakely

By: Dean Momohara

Summary

The samples were analyzed by the following method: PSEP-TOC for total organic carbon (TOC).

The analysis requested was evaluated by established regulatory quality assurance guidelines.

Sample Information

Samples were received by Manchester Environmental Laboratory on 10/08/04 and 10/11/04. All samples were received in good condition. Fourteen (14) samples were received and assigned laboratory identification numbers 414080 – 414093.

Holding Times

The analysis was performed within established EPA holding times.

Calibration

Instrument calibrations and calibration checks were performed in accordance with the appropriate method. All initial and continuing calibration checks were within control limits. The calibration correlation coefficient were within the acceptance range of 1.000 - 0.995.

Method Blanks

No analytically significant levels of analyte were detected in the method blanks associated with these samples.

Matrix Spikes

NA

Replicates

All duplicate relative percent differences of samples with concentrations greater than 5 times the reporting limit were within the acceptance range of 0% - 20%.

Laboratory Control Samples

All laboratory control sample recoveries were within the acceptance limits of 80% - 120%.

Other Quality Assurance Measures and Issues

U - The analyte was not detected at or above the reported result.

bold - The analyte was present in the sample. (Visual Aid to locate detected compounds on report sheet.)

Please call Dean Momohara at (360) 871-8808 to further discuss this project.

cc: Project File

Manchester Environmental Laboratory

7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

November 1, 2004

Subject: Metals Ostrich Bay

Project No: 181204

Officer: Nigel Blakley

By: Dean Momohara

Summary

The samples were analyzed and/or digested using the following methods: EPA method 245.5 (CVAA) for the digestion and analysis of mercury (Hg) and EPA method 3050B and 6020 for the digestion and analysis of trace metals, respectively.

All analyses requested were evaluated by established regulatory quality assurance guidelines.

Sample Information

Samples were received by Manchester Environmental Laboratory on 10/08/04 and 10/11/04. All coolers were received within the proper temperature range of 0°C - 6°C. The samples were received in good condition. Fourteen (14) samples were received and assigned laboratory identification numbers 414080 – 414093.

Holding Times

All analyses were performed within established EPA holding times.

Calibration

Instrument calibrations and calibration checks were performed in accordance with the appropriate method. All initial and continuing calibration checks were within control limits. All calibration correlation coefficients were within the acceptance range of 1.000 - 0.995. The instruments were calibrated with NIST traceable standards and verified to be in calibration with a second source NIST traceable standard.

Balances are professionally calibrated yearly and calibrated in-house daily. Soil drying oven temperatures were recorded before and after each analysis batch and were within acceptable limits.

Method Blanks

No analytically significant levels of analyte were detected in the method blanks associated with these samples.

Matrix Spikes

The standard spiking levels for nickel, zinc and lead were insufficient for the elevated concentration of analyte in the source sample and no action was taken. All other matrix spike recoveries were within the acceptance limits of 75% - 125%.

Replicates

All duplicate relative percent differences were within the acceptance range of 0% - 20%.

Laboratory Control Samples

All laboratory control sample recoveries were within the acceptance limits of 85% - 115% for metals and 80% - 120% for Hg.

Other Quality Assurance Measures and Issues

All internal standard recoveries were within acceptance limits.

U - The analyte was not detected at or above the reported result.

bold - The analyte was present in the sample. (Visual Aid to locate detected compounds on report sheet.)

Please call Dean Momohara at (360) 871-8808 to further discuss this project.

cc: Project File

COLUMBIA ANALYTICAL SERVICES, INC.

Client:	Washington Department of Ecology	**Service Request No.:**	K2407982
Project:	Ostrich Bay/D3400	**Date Received:**	10/09/04
Sample Matrix:	Sediment		

CASE NARRATIVE

All analyses were performed consistent with the quality assurance program of Columbia Analytical Services, Inc. (CAS). This report contains analytical results for samples designated for Tier III validation deliverables including summary forms and all of the associated raw data for each of the analyses. When appropriate to the method, method blank results have been reported with each analytical test.

Sample Receipt

Thirteen sediment samples were received for analysis at Columbia Analytical Services on 10/09/04. The samples were received in good condition and consistent with the accompanying chain of custody form. The samples were stored in a refrigerator at 4°C upon receipt at the laboratory.

General Chemistry Parameters

Perchlorate by EPA Method 314.0M:
The matrix spike recovery of Perchlorate for sample 414081 was outside control criteria because of suspected matrix interference. A Matrix Spike Duplicate (MSD) was also analyzed, but produced similar results. The results of the original analysis are reported. No further corrective action was appropriate.

Total Sulfide by PSEP Method:
The analysis of sample 414082 for Sulfide was initially performed within the recommended holding time. Due to a laboratory error, the requested triplicate analysis was performed 7 days past the recommended holding time. The report includes results from both analyses.

No other anomalies associated with the analysis of these samples were observed.

Explosives by EPA Method 8330

Sample Confirmation Notes:
The confirmation comparison criteria for RDX in samples 414080, 414081, 414085, 414087, 414088, 414089, 414091 and 414092 are not applicable because at least one of the values is below the Method Reporting Limit (MRL). Confirmation analysis is not required for results less than the MRL.

The confirmation comparison criteria for 2-Amino-4,6-dinitrotoluene in samples 414085 is not applicable because at least one of the values is below the Method Reporting Limit (MRL). Confirmation analysis is not required for results less than the MRL.

No other anomalies associated with the analysis of these samples were observed.

Approved by [signature] **Date** 11/9/04

Manchester Environmental Laboratory

7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

December 6, 2004

Subject: Ostrich Bay

Project No: 181204

Sample No: 04414080 - 04414092

Officer: Nigel Blakley

By: Dolores Montgomery

Summary

The samples were analyzed using the following method: EPA method 8270 for semi-volatile organic analysis. An attempt was made to concentrate the sample extracts to a final volume of 0.50mL for analysis in order to attain the lowest quantitation limits possible. This turned out not to be possible due to high levels of hydrocarbons present in the samples and the extracts were analyzed at a final volume of 1.0mL.

All analyses requested were evaluated by established regulatory quality assurance guidelines.

Holding Times

All samples were analyzed within the method holding times with the following exception. Sample 04414092 was initially analyzed without the addition of internal standard. When the error was discovered, the sample extract had exceeded the method shooting holding time. All results for this sample were qualified J for detected results and UJ for non-detects.

Tuning

Calibration against DFTPP is acceptable for the initial calibration, continuing calibration and all associated sample analyses.

Initial Calibration

A nine point initial calibration was performed. All compounds had average response factors with %RSD < 15%, linear correlation coefficients of greater than 0.995, or a coefficient of determination greater than 0.99 with the following exceptions. Response for benzoic acid was extremely low, resulting in a two point calibration using the two highest standards. All detected results were qualified J and all non-detects were qualified UJ. A four point linear curve was used for 4,6-Dinitro-2-methylphenol. All detected results were qualified J and all non-detects qualified UJ. Linear curves should contain at least five points to be considered valid.

Continuing Calibration

Four continuing calibration checks were analyzed with the sample batch. In continuing calibration check bna4312 all compounds were within established QC limits with the following noted exceptions. The following compounds displayed a high response indicating a high bias: 4-nitroaniline, benzo(k)anthracene and benzoic acid. 4-nitroaniline was not detected in any samples and therefore no qualification was necessary. Detected results for benzo(k)anthracene and benzoic acid were qualified J and non-detects UJ. The responses for the following compounds were low indicating a low bias: aniline, benzyl alcohol, hexachlorocyclopentadiene, 4-nitrophenol, 4-6,-Dinitro-2-methylphenol, pentachlorophenol, benzidine, and 3,3'-dichlorobenzidine. None of the compounds were detected in samples and the non-detects were qualified UJ. Response factors for 2,4-dintrophenol and 3B-coprostranol fell below 0.01. Results for these compounds were qualified REJ. This calibration applies to QC samples obs4285a1, obs4285a1, ocs4285a1 and samples 04414080 – 04414090.

In continuing calibration check bna4312b all compounds were within established QC limits with the following noted exceptions. The following compounds displayed a high response indicating a high bias: benzoic acid, 4-nitroaniline, bis(2-Ethylhexyl)phthalate, and benzo(k)anthracene. Detected results were qualified J. The following compounds displayed a decrease in response indicating a low bias: hexachloroethane, hexachlorocyclopentadiene, 4,6-Dinitro-2-methylphenol, benzidine, 3-B coprostanol, Indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. Detected results were qualified J and non detects UJ. The response factor for 2,4-dinitrophenol fell below 0.01. Results for this compound were qualified REJ. This calibration applies to sample 04414091.

In continuing calibration check bna4313 all compounds were within established QC limits with the following noted exceptions. The following compounds displayed a high response indicating a high bias: Di-n-octylphthalate and benzo(k)fluoranthene. Positive detects were qualified J. The following compounds displayed a low response indicating a low bias: hexachloroethane, hexachlorocyclopentadiene, 4,6-Dinitro-2-methylphenol, benzidine, 3B-Coprostanol, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. Detected results were qualified J and non-detected results were qualified UJ. The response factor for 2,4-dinitrophenol fell below 0.01. Results for this compound were qualified REJ. This calibration applies to QC samples 04414082Y and 04414082Z.

In continuing calibration check bna4335 all compounds were within established QC limits with the following noted exceptions. The following compounds displayed a high response indicating a high bias: N-nitrosodimethylamine, pyridine, nitrobenzene, benzoic acid, 4-Nitroaniline, pyrene, retene, butylbenzylphthalate, 3,3'-Dichlorobenzidine, bis(2-ethylhexyl)phthalate, and di-n-octylphthalate. Detected results for these compounds were qualified J. The following compounds displayed a low response indicating a low bias: hexachlorocyclopentadiene, carbazole, benzo(k)fluoranthene, indeno(1,23-cd)pyrene, and 3B-Coprostanol. Detected results were qualified J and non-detected results were qualified UJ. The response factor for 2,4-dinitrophenol fell below 0.01. Results for this compound were qualified REJ. This calibration applies to sample 04414092.

Method Blanks

The following phthalates were detected in the extraction blank: diethylphthalate, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate. The amounts of these compounds detected in the samples were below the reporting limit and less than ten times the amount found in the blank. The results for these compounds were raised to the lower reporting limit and reported as non-detected.

Matrix Spikes

Sample 04414082 was utilized for the matrix spike/matrix spike duplicate (MS/MSD). The percent recoveries and relative percent differences were within established QC limits with the following exceptions. The following compounds fell below the established QC limits for recovery in the matrix spike indicating a low bias: 1,3-dichlorobenzene (49%), hexachloroethane (7%), indeno(1,2,3-cd)pyrene (31%) and benzo(g,h,i)perylene (39%). The following compounds fell below the established QC limits for recovery in the matrix spike duplicate indicating a low bias: N-nitrosodimethylamine (35%), aniline (38%), Bis(2-chloroethyl)Ether (38%), 1,3-dichlorobenzene (31%), 1,4-dichlorobenzene (32%), 1,2-dichlorobenzene (34%), 2,2'-Oxybis[1-chloropropane] (44%), hexachloroethane (5%), hexachlorobutadiene (46%), 4-nitoraniline (25%), indeno(1,2,3-cd)pyrene (30%), and benzo(g,h,i)perylene (38%). No recoveries were obtained for 2,4-dinitrophenol. No additional qualifiers were applied to the native sample based on recovery data alone. Results for 2,4-dintrophenol were already rejected based on low continuing calibration response factors.

Laboratory Control Samples

The percent recoveries were within established QC limits with the following exceptions: benzoic acid (178%) and benzo(k)fluoranthene (199%). No recovery was detected for 2,4-dinitrophenol. No qualifiers were applied based on the LCS recovery data.

Surrogates

All surrogates fell within established QC limits with the following exception. In sample 04414084, recoveries for surrogates D4-1,2-dichlorobenzene (8%) and D5-nitrobenzene (16%)

were low. Recovery for two other base fraction surrogates met QC limits, therefore, no qualifiers were assigned based on surrogate recovery to the sample.

Internal Standards

All internal standards fell within established QC limits.

Comments

The data are useable as qualified.

Please call Dolores Montgomery at (360) 871-8818 to further discuss this project.

cc: Project File