FINAL REPORT
Shipyard Creek, Charleston, South Carolina
MPRSA Section 103 Sediment Testing and Analysis

Submitted to:

U.S. Army Corps of Engineers
Charleston District
69A Hagood Avenue
Charleston, South Carolina 29403

U.S. Environmental Protection Agency
Region 4
61 Forsyth Street, SW
Atlanta, Georgia 30303

On Behalf of:

Shipyard Creek, LLC
3340 Peachtree Road NE, Suite 840
Atlanta, GA 30326

Submitted by:

ANAMAR Environmental Consulting, Inc.
2106 NW 67th Place, Suite 5
Gainesville, FL 32653
www.anamarinc.com

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ACRONYMS, ABBREVIATIONS, AND INITIALISMS

ADDAMS	Automated Dredging and Disposal Alternatives Management System
AET	apparent effects threshold
CCV	continuing calibration verification
CFR	Code of Federal Regulations
CMC	criteria maximum concentration
CQAR	Chemical Quality Assurance Report
cy	cubic yard(s)
DU	dredging unit
EPA, USEPA	U.S. Environmental Protection Agency
ERDC	(USACE) Engineer Research and Development Center
ERL	effects range-low
ERM	effects range median
FDA	U.S. Food and Drug Administration
FDEP	Florida Department of Environmental Protection
HMW	high molecular weight
ICP/MS	inductively coupled plasma/mass spectrometry
ITM	Inland Testing Manual
LCS	laboratory control sample
LMW	low molecular weight
LPC	limiting permissible concentration
MD/MSD	matrix spike/matrix spike duplicate
MDL	method detection limit
MLLW	mean lower low water
MPRSA	Marine Protection, Research, and Sanctuaries Act
MRL	method reporting limit
NELAC	National Environmental Laboratory Accreditation Conference
NOAA	National Oceanic and Atmospheric Administration
NOEC	no observed effect concentration
OCDD	octachlorodibenzo-p-dioxin
ODMDS	ocean dredged material disposal site
PAHs	polynuclear aromatic hydrocarbons
PBDE	polybrominated diphenyl ether
PCBs	polychlorinated biphenyls
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SDS	sodium dodecyl sulfate
SERIM	Southeastern Regional Implementation Manual (EPA and USACE 2008)
SOP	standard operating procedure
SRM	standard reference material
STFATE	Short-Term Fate of Dredged Material Disposal in Open-Water Models
SYC	Shipyard Creek
TEL	threshold effects level
TEQ	toxicity equivalency
TOC	total organic carbon
TPH	total petroleum hydrocarbons
U.S.C.	U.S. Code
UIA	un-ionized ammonia
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USCS	U.S. Soil Classification Systems

EXECUTIVE SUMMARY

This report details the field sampling, analysis, and results of an MPRSA Section 103 sediment testing and analysis contract in support of the Shipyard Creek project. Field sampling took place from June 2 through 4, 2014, and consisted of sediment/soil and site water sample collection for physical, chemical, toxicological, and bioaccumulation analyses.

Sampling Approach

The overall project area was divided into two dredging units. Due to prior use in the area, (including a superfund site) and recent chemical analysis, the turning basin dredging unit was further divided into two sub-units for physical properties, elutriate chemistry, water column toxicology, and benthic toxicology. A more thorough discussion of the site's history may be found in Section 5 of the Quality Assurance Project Plan. Each dredging unit was expected to have consistent characteristics relative to the project area as a whole. All sampling stations were located to represent material that may be disposed of at the Charleston Harbor ODMDS. Samples were analyzed using Tier II and Tier III protocols.

Sediment Physical Results

Sediment samples from Shipyard Creek and the offshore reference site were tested for grain size, specific gravity, and Atterberg limits. For all project samples, the USCS classification is CH, indicating clay of high plasticity, or fat clay. The reference site had a USCS classification of SM, indicating silty sand. The access channel had approximately 76% fines, and the two turning basin samples had 99% fines. The reference site was determined to have approximately 80% sand. The summary tables below show the grain sizes and other physical properties for each sample.

Sediment Chemistry Results

Sediment samples from Shipyard Creek and the reference site were tested for PAHs, organotins, dioxins, polybrominated diphenyl ethers, oil and grease, ammonia, and total organic carbon. While analyses for metals, pesticides, and PCBs are typically performed, analyses for these compounds were done by GEL in 2013, and therefore were not required as part of the QAPP. Sediment analysis for a Section 103 evaluation is typically used to determine the tissue chemistry requirements stated in Section 6 of the SERIM. Discussions for each analyte group are shown below.

Polynuclear Aromatic Hydrocarbons

Eighteen PAHs were tested as specified in Section 5 of the SERIM. Of these, 16 were detected above the method reporting limits in sample SYC14-AC, and 13 were detected above the method reporting limits in sample SYC14-TB. All PAHs met the SERIM's target detection limits. Sample SYC14-AC had concentrations of eight PAHs that exceeded either the threshold effects level or effects range low. Six PAHs in sample SYC14-TB exceeded either the threshold effects level or effects range low. No concentration exceeded the effects range median in either sample.

Organotins

Organotin analyses were performed for the n-butyltin, di-n-butyltin, and tri-n-butyltin. No concentration of any butyltin congener in sample SYC14-AC was found at or above the laboratory reporting limit. The concentration of each congener was greater than the laboratory reporting limit in sample SYC14-TB. All organotin congeners met the SERIM's target detection limits. These analytes do not have threshold effects level, effects range low, or effects range low screening criteria associated with them.

Dioxins

Dioxin and furan analyses were performed for the 17 congeners specified in Appendix M of the SERIM. The concentration for each congener was then normalized to 2,3,7,8-TCDD using the toxicity equivalency factors from the World Health Organization (2005). The sum of each normalized value was calculated to yield a single toxicity equivalence for each sample. The laboratory method detection limit met the target detection limit for all congeners specified in the SERIM, while the laboratory reporting limit slightly exceeded the target detection limit for all congeners. Individual congeners do not have any corresponding screening criteria. Total TEQs have corresponding threshold effects level and apparent effects threshold screening criteria. The total toxicity equivalence exceeded both the corresponding screening criteria.

Polybrominated Diphenyl Ether

Seventeen polybrominated diphenyl ether congeners were tested. Polybrominated diphenyl ether concentrations were below the method detection limits for all congeners for both samples.

Total Organic Carbon, Total Petroleum Hydrocarbons, and Total Ammonia

The sediment samples were analyzed for total organic carbon, total petroleum hydrocarbons, and total ammonia to provide supplemental information about the sediment. These analytes do not have threshold effects level, effects range low, or effects range median screening criteria associated with them.

Elutriate and Water Chemistry

Elutriate samples were prepared from the composited sediment samples SYC14-AC, SYC14-TB1, and SYC14-TB2. Chemistry analysis was then performed on the three elutriates and two background water samples, SYC14-SW and SYC14-ODMDS-SW. Analytical results were compared to the published water quality criteria criterion maximum concentration defined in Section 2.5.2. Analytical testing of the sediment samples was conducted in accordance with Tables 6-5, 10-3, and 13-2 of the QAPP.

Ammonia

Ammonia concentrations range from 28.6 to 44.8 mg/L in the elutriates, and exceed the calculated criterion maximum concentration. The criterion maximum concentration is calculated using pH, temperature, and salinity values from Table 2 from Ambient Water Quality Criteria for Ammonia (Saltwater)-1989 (USEPA 1989) found at http://water.epa.gov/scitech/swguidance/standards/upload/2001_10_12_criteria_ambientwqc_ammoniasalt1989.pdf.

Metals

Trace metals analyses were performed for the list of analytes shown in Table 13-3 of the quality assurance project plan. No metals concentrations for elutriate or site water samples were greater than the criterion maximum concentration. Beryllium, cadmium, mercury, selenium,

silver, and thallium were not detected in concentrations greater than the method reporting limit in any sample. All other metals analyzed were detected in concentrations greater than the method reporting limit in at least one of the elutriate samples or the site water sample. All metals met the target detection limits specified in the SERIM, and no concentration for any metal exceeded its corresponding criterion maximum concentration, where applicable.

Pesticides

Chlorinated pesticides analyses were performed for the list shown in Table 13-3 of the QAPP. No pesticide concentration for elutriate or site water samples was greater than the criterion maximum concentration, and no pesticide concentration was greater than the method reporting limit in any sample. With the exception of technical chlordane and toxaphene, all method reporting limits met the target detection limits specified in the SERIM. For technical chlordane and toxaphene, the MDL is used for comparison to the criterion maximum concentration stated in Table 13-3.

Toxicology

Suspended Particulate Phase Bioassay Data

Suspended particulate phase bioassays were performed on project samples SYC14-TB1, SYC14-TB2, and SYC14-AC. Three species were used for this phase of testing: *Americamysis bahia*, *Menidia beryllina*, and *Mytilus edulis*. Ammonia levels in all test samples required ammonia-reduction procedures to demonstrate that the mortality and abnormal development were caused exclusively by ammonia. Upon completion of the ammonia-reduction procedures, the tests were set up with both ammonia-reduced and unreduced replicates.

Results for the three species found LC50 and EC50 values ranging from 14% to 62%, depending on the sample and test species, and the 100% concentration was statistically different from the control water in all tests. Results also showed that all mortality and abnormal development was due to ammonia, allowing for a higher application factor of 0.05 for the ADDAMS modeling required for offshore disposal.

Solid Phase Bioassay Data

Solid phase bioassays were performed on project samples SYC14-TB1, SYC14-TB2, and SYC14-AC and on the project reference sample SYC14-REF. The three species used for this testing phase were *Leptocheirus plumulosus*, *Ampelisca abdita*, and *Neanthes arenaceodentata*. Testing for the amphipod *Leptocheirus plumulosus* showed that it did not meet the offshore disposal criteria specified in the SERIM, but upon further investigation, the high levels of fine-grained material in the project samples were the likely cause of the high mortality. Testing was repeated using a different amphipod species, *Ampelisca abdita*. Results for both *Ampelisca abdita* and the polychaete *Neanthes arenaceodentata* showed that the sediment met the offshore disposal criteria.

Bioaccumulation and Tissue Chemistry

Bioaccumulation was performed on project samples SYC14-TB (composited from SYC14-TB1 and SYC14-TB2) and SYC14-AC and the project reference sample SYC14-REF. Two species were used for this phase of testing, *Neanthes virens* and *Macoma nasuta*. Survival for both species was acceptable across all samples. Once the bioaccumulation was completed, the tissues were collected from the sediment and sent to the chemistry laboratory for chemical analysis. The analytical requirements were based on sediment analytical results. Testing was

performed for trace metals, PAHs, and dioxins in all project sample tissues, and for organotins in tissues prepared from sample SYC14-TB. Tissue chemistry results showed that no concentration in the tissues exceeded the FDA action limits for human health. A summary of results where the adjusted mean in the project tissues statistically exceeded the adjusted mean in the reference tissues is provided in Section 3-7.

ADDAMS Model

Based on results of the STFATE module of the ADDAMS model, material to be dredged from SYC14-AC, SYC14-TB1, and SYC14-TB2 can be disposed of in the Charleston ODMDS without restrictions on location using a hopper, cutter, or mechanical clamshell dredge with a disposal capacity of up to 9,000 cubic yards.

1 INTRODUCTION

1.1 Project Area Description

Shipyard Creek (SYC) is a small channel off the west bank of Cooper River, which is part of the Charleston Harbor federal navigation channel. The entrance to SYC is approximately 8 miles inland from the South Carolina coastline. The channel is less than 1 mile long. The northernmost portion of the channel includes a turning basin. A map of the overall project area is shown in Exhibit 1-1 on the following page. Approximately 944,600 cubic yards (cy) of material is proposed for ocean disposal.

The Charleston Harbor federal navigation channel is located in Charleston Harbor, South Carolina, which lies approximately midway along the South Carolina coastline. The harbor covers approximately 14 square miles and is formed by the confluence of the Ashley, Cooper, and Wando rivers. The majority of upland areas around Charleston Harbor are composed of residential, commercial, and industrial developments. Harbor docking and maintenance facilities are concentrated along the west shore of the Cooper River extending from Battery Point of the peninsular city to the mouth of Goose Creek.

The purpose of the proposed development is to rehabilitate a former brownfield (Superfund) site into an economically vibrant, Charleston-based marine terminal facility with access to existing federal shipping channels, major rail carriers, and the interstate highway system. Land based improvements will result in bulk, break bulk, or roll-on/roll-off facilities with associated amenities (rail, roadway, and site improvements). Direct access into the site via rail and road is imperative.

Surrounding land use reflects the urban/industrialized nature of the area. Union Heights, a neighborhood with low-income and minority residents, is located to the west on the opposite side of the CSX rail yard well away from the Shipyard Creek site. Currently, a number of industrial businesses occupy the area south of the Shipyard Creek property. These businesses include the North Charleston Sewer District treatment facility, Kinder Morgan and Marinex Construction along with a number of truck stops and towing services. The Palmetto Railways proposes to construct and operate an Intermodal Container Transfer Facility at the former Charleston Naval Complex east-northeast of the site. The Navy Base Terminal and the proposed Charleston Port expansion (now owned by State Ports Authority) dominate the landscape east of Shipyard Creek. Land to the north above the turning basin is owned by the Federal government (law enforcement facility). West of the property is the CSX Cooper Yard and a Santee Cooper facility. All adjacent property owners were identified in the original permit submittal.

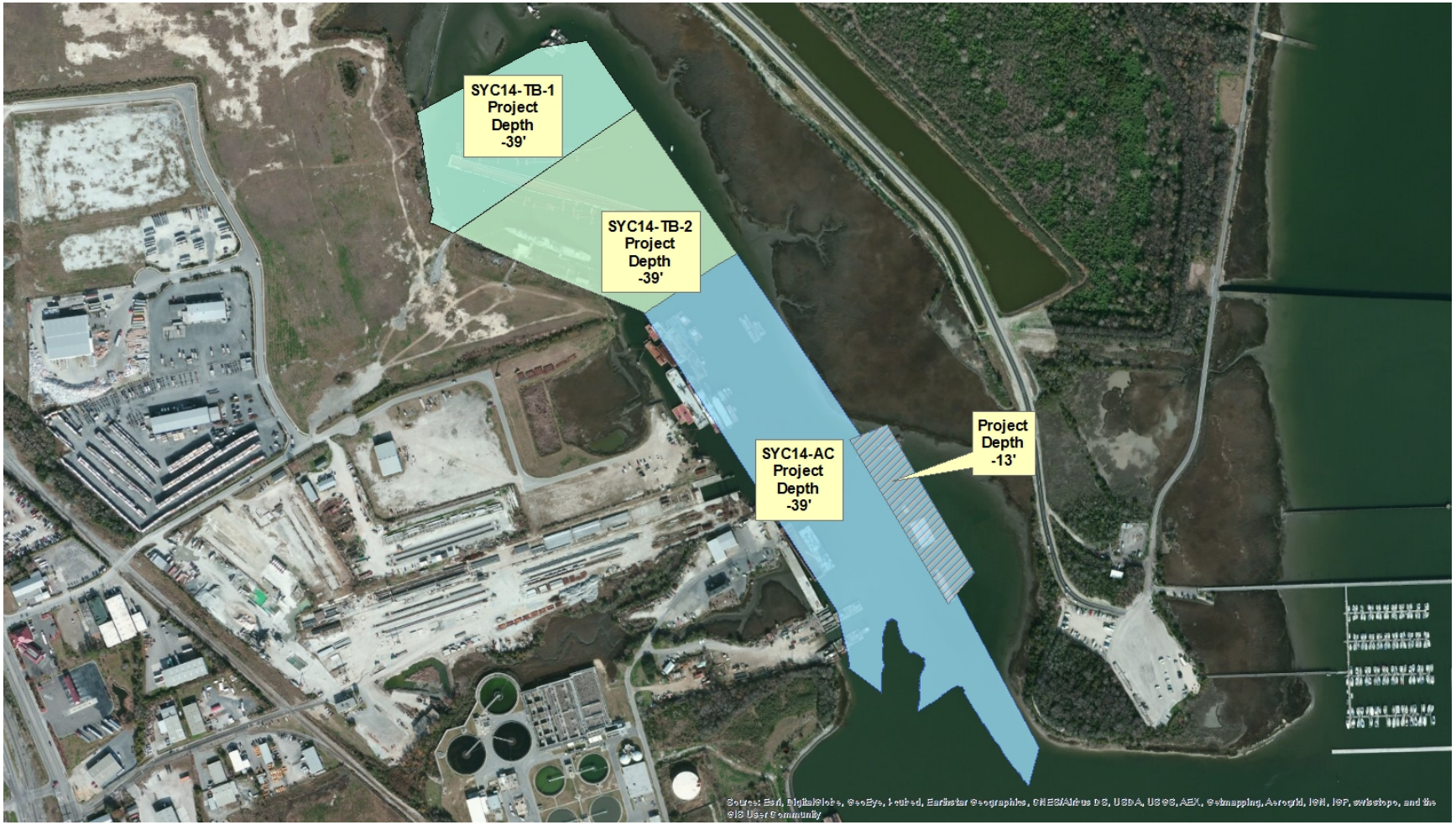


Exhibit 1-1. Shipyard Creek Dredging Units

The purpose of this report is to provide necessary and sufficient data to allow a determination by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (USEPA) of the suitability of sediment dredged from SYC for ocean disposal. The material evaluated will be the sediment to a project elevation of either -38-feet mean lower low water (MLLW) plus 1 foot of allowable overdepth for most of the dredge area, or -12 feet MLLW plus 1 foot of allowable overdepth for one section along the eastern edge in SYC14-AC. Maps 1, 2, and 3 show the location for each sample collected.

Sediment and water samples were collected from representative sites throughout each of the dredging units (DUs), along with one reference site offshore of Charleston Harbor. The samples within the DUs were collected from locations and depths coinciding with the dredging prism. These samples were analyzed for physical, chemical, toxicological, and bioaccumulation parameters that are required under the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA, as amended in 2000) Section 103 (33 U.S.C. §1413).

1.2 Description of the Testing Approach

1.2.1 Evaluation of Dredge Materials for Disposal

Sediment and suspended-phase testing are required under MPRSA Section 103 to determine the suitability of the material to be dredged for ocean disposal. Section 103 requires that all proposed operations involving the transportation and discharge of dredged material into ocean waters be evaluated to determine the potential environmental impact of such activities. The proposed dumping must be evaluated using criteria published by USEPA in Title 40 of the Code of Federal Regulations (40 CFR), Parts 220–228. Specific testing methods are described in the *Evaluation of Dredged Material Proposed for Ocean Disposal-Testing Manual* (USEPA and USACE 1991; referred to here as the 'Green Book') and in the *Southeast Regional Implementation Manual* (USEPA and USACE 2008; referred to here as the 'SERIM'). These testing manuals provide guidance to support the tiered-testing procedure for evaluating compliance with the limiting permissible concentration (LPC) as defined by the ocean dumping regulations. The procedure includes levels of increasing investigative intensity that provide information to make ocean disposal decisions and is comprehensive enough to enable sound decision-making without unnecessary expenditure of time and resources.

1.2.2 Objectives and Deliverables

As a new works project, evaluation of sediment pursuant to MPRSA Section 103 is required for ocean disposal of dredged material. For this reason, Shipyard Creek, LLC contracted with ANAMAR Environmental Consulting, Inc. to collect sediment and water samples and to conduct physical, chemical, toxicological, and bioaccumulation evaluations as required in 40 CFR Parts 220–228 and outlined in the Green Book and the SERIM. In accordance with the performance work statement and the Quality Assurance Project Plan (QAPP), the objectives of this effort are to

- Collect the required volume of representative sediment and water samples from the access channel, turning basin, and reference stations within positioning accuracy appropriate for the project objectives.
- Collect and containerize water and sediment samples according to proper protocols to ensure sample integrity.

- Test and characterize sediment and water samples for physical characteristics and chemical contaminants of concern and to perform bioaccumulation assays in accordance with the Green Book and the SERIM to determine the suitability of the materials for ocean disposal.
- Demonstrate environmental compliance of sediments to be dredged and obtain concurrence of compliance for offshore disposal of dredged sediments from USACE and USEPA according to requirements specified in the Green Book and the SERIM.
- Provide a report to USACE and USEPA on behalf of Shipyard Creek, LLC in the format outlined in Section 7.0 of the SERIM.

Deliverables for this project include the following:

- A QAPP that was approved by USACE Charleston District and EPA Region 4 before sampling and testing were initiated. Quality assurance (QA) is an integral component of dredge material sampling and analysis, and an effective QA program ensures that the laboratory's test data are defensible and of sufficiently high quality to support the final LPC evaluations. The QAPP (Appendix A) addresses procedures for sampling and sample handling, storage, and analysis.
- An MPRSA Section 103 sediment testing report and supporting documentation that describe all aspects of the study and present the results of field sampling, physical and chemical analysis of sediment and elutriate samples, toxicological testing, and bioaccumulation assays. This report presents comparisons of reference and test sediments and provides the basis for a scientific recommendation regarding the acceptability of the proposed dredge material for ocean disposal. Important components of this report include:
    - A narrative addressing all aspects of field sampling, laboratory analysis, discussion of laboratory results, a review of all laboratory quality of control, and Automated Dredging and Disposal Alternatives Management System (ADDAMS) model results.
    - Laboratory results provided in condensed tables.
    - Maps of the sampling sites.
    - A Chemical Quality Assurance Report (CQAR [Appendix D]), which evaluates all representative data from the project field sampling and laboratory analyses. The CQAR summarizes the overall usability of the data for its intended purpose.
    - Daily Quality Control Reports (Appendix B) prepared by the project manager for each day of field sampling and during compositing.

ANAMAR coordinated and directed operations for this project and worked closely with Shipyard Creek, LLC; USACE; and USEPA to develop sampling and analysis schemes, schedules, and deliverables. ANAMAR also reviewed all data and produced this report summarizing the results of the physical, chemical, and toxicological analyses of sediment, elutriate, water, and tissue samples collected from the project area. Exhibits 1-2 and 1-3 indicate the principal data users and their respective areas of responsibility and subcontractors associated with this evaluation.

Exhibit 1-2. Principal Data Users and Decision Makers Associated with This Project

Agency or Company	Area(s) of Responsibility
Shipyard Creek, LLC Contact: Richard Lee 3340 Peachtree Road NE, Suite 840 Atlanta, GA 30326	Prepare plan for developing SYC area and coordinate contractors to provide all documents needed to complete the plan.
USACE, Charleston District	Permit and maintain the harbor with the dredge material to be potentially disposed at the Charleston Ocean Dredged Material Disposal Site (ODMDS)
USEPA Region 4 (Atlanta, Georgia)	Give concurrence to environmental requirements of dredged sediment for approval for offshore disposal per the Green Book and SERIM

Exhibit 1-3. Subcontractors and Responsibilities Associated with This Report

Company, Location, Website	Area(s) of Responsibility
Athena Technologies, Inc. (McClellanville, South Carolina) www.athenatechnologies.com	Support for field collection of sediment samples requiring vibracore and grab sampling equipment
ALS Environmental (Kelso, Washington) www.caslab.com/Kelso-Laboratory	Laboratory preparation and chemical analysis of sediment, elutriate, and tissue samples; sample holding and archiving
ENVIRON (formerly NewFields Northwest and Port Gamble Environmental Services) (Port Gamble, Washington) http://www.environcorp.com/home.aspx	Laboratory preparation for suspended phase, solid phase, and bioaccumulation potential analyses; sample holding and archiving
AMEC (Jacksonville, Florida) www.amec.com	Laboratory preparation and physical analysis of sediment; sample holding and archiving

2 MATERIALS AND METHODS

2.1 Project Design and Rationale

The overall project area was divided into two DUs (see Exhibit 2-1). Due to prior use in the area, including a superfund site, and recent chemical analysis, the turning basin DU was further divided into two sub-units for physical properties, elutriate chemistry, water column toxicology, and benthic toxicology. A more thorough discussion of the site's history may be found in Section 5 of the QAPP. Each DU was expected to have consistent characteristics relative to the project area as a whole (Green Book, SERIM). All sampling stations were positioned to represent material that may be disposed of at the Charleston Harbor ODMDS.

Exhibit 2-1. Dredging Units, Sample IDs, Project Elevation, and Dredging Volumes

Reach	Composite Sample ID	Core Samples Collected	Project Elevation, feet (MLLW)	Volume to Project Elevation, cubic yards
Shipyard Creek Turning Basin (Divided into 2 DUs)	SYC14-TB1	A	-39	253,000
		B		
		C		
	SYC14-TB2	D	-39	249,400
		E		
		F		
Shipyard Creek Access Channel	SYC14-AC	A	-39 for all except D, -13 for D	442,200
		B		
		C		
		D		
		E		
		F		
			Project Total	944,600

Three cores were collected at each of the two turning basin DUs. Two composites samples were prepared as shown in the table. An additional composite of all the subsamples was prepared and given the sample number SYC14-TB. Six cores were collected in the access channel DU and composited into a single sample, SYC14-AC. The composite samples were analyzed using Tier II and Tier III protocols.

Summaries of field sampling materials and methods, analytes of interest and bioassay test species, and sampling compositing scheme and sample nomenclature are provided in Exhibits 2-2 through 2-4 and in Appendix B.

Exhibit 2-2. Summary of Field Sampling Materials and Methods

FIELD SAMPLE COLLECTION:

- 2 project sediment composites as described above
- 1 reference sample
- 1 site water sample from the project area, at approximately the middle of the boundary between SYC14-AC and SYC14-TB for background chemistry analysis, toxicology, and elutriate preparation
- 1 water sample from the ODMDS for background chemistry analysis

SAMPLING GEAR:

- Vibracore
- Ponar® and Petersen-style grab samplers
- Pneumatic stainless steel pump

VESSEL:

- R/V *Artemis* (30-foot SeaArk pontoon vessel)

PRESERVATION:

- Sediment chemistry samples were kept at or below 4°C
- Site water in various containers, with or without stabilizing agents as specified per analysis; samples were kept at or below 4°C
- Holding time requirements were analyte-specific and test-specific

IN SITU WATER COLUMN DATA:

Conductivity (mS/cm)
pH
Sea State
Turbidity (NTU)
Water Temperature (°C)
Dissolved Oxygen (mg/L and % saturation)
Tide Cycle
Water Depth (feet)
Weather Observations
Salinity (analysis performed at laboratory)

Exhibit 2-3. Summary of Analytes of Interest and Bioassay Test Species

SEDIMENT PHYSICAL ANALYSES:

- Hydrometer grain size (all composite core samples and reference)
- Grain size without hydrometer (all subsamples)
- Total solids/water content (all subsamples and composite samples)
- Specific gravity (all composite core samples and reference)
- Atterberg limits (all composite core samples and reference)

SEDIMENT CHEMICAL ANALYSES (all composite samples):

- Polynuclear aromatic hydrocarbons (PAHs)
- Organotins
- Dioxins
- Ammonia
- TPH
- Polybrominated diphenyl ethers (PBDEs)
- Total organic carbon (TOC)

ELUTRIATES AND SITE WATER ANALYSES (all composite samples and site water):

- Metals
- Pesticides
- Ammonia

TISSUE CHEMICAL ANALYSES (all composite samples):

- Metals
- Organotins (SYC14-AC only)
- PAHs
- Dioxins

BIOASSAY AND BIOACCUMULATION TESTS (all composite samples):

Water Column (Suspended Particulate Phase) 48 to 96-hour toxicity tests using three species:

1. Fish: *Menidia beryllina* (inland silverside)
2. Mysid crustacean: *Americamysis bahia* (opossum shrimp)
3. Bivalve mollusk: larval *Mytilus edulis* (blue mussel)

Whole Sediment (Solid Phase) Bioassay 10-day toxicity tests using two species:

1. Infaunal amphipod crustacean: *Leptocheirus plumulosus* and *Ampelisca abdita* (no common names)
2. Epifaunal polychaete worm: *Neanthes arenaceodentata* (no common name)

Whole Sediment Bioaccumulation Potential 28-day exposure tests using two species:

1. Infaunal polychaete worm: *Neanthes virens* (sand worm)
2. Bivalve mollusk: *Macoma nasuta* (bent-nose clam)

Exhibit 2-4. Field Sampling and Compositing Scheme and Sample Nomenclature

Subsample ID	Sampling Equipment	Sampling Elevation (feet, MLLW)	Number of Cores Collected	Volume Collected* (gallons)	Subsample Analysis (if applicable)	Composite Sample ID and Analyses (see preceding table for more information)
SYC14-TB1-A	Vibracore	-21	1	8	Physical	**SYC14-TB1 (A-C), SYC14-TB2 (D-F)** Physical, elutriate chemistry, water column toxicological, and benthic toxicological **SYC14-TB (A-F)** Sediment chemistry, bioaccumulation, and tissue chemistry
SYC14-TB1-B	Vibracore	-20	1	4	Physical	
SYC14-TB1-C	Vibracore	-20	1	7	Physical	
SYC14-TB2-D	Vibracore	-20	1	3	Physical	
SYC14-TB2-E	Vibracore	-20	1	4.5	Physical	
SYC14-TB2-F	Vibracore	-29	1	8	Physical	
SYC14-AC-A	Vibracore	-18	1	6	Physical	**SYC14-AC** Physical, sediment chemistry, elutriate chemistry, water column toxicological, benthic toxicological, bioaccumulation, tissue chemistry
SYC14-AC-B	Vibracore	-28	1	8	Physical	
SYC14-AC-C	Vibracore	-18	1	7	Physical	
SYC14-AC-D	Vibracore	-6	1	7	Physical	
SYC14-AC-E	Vibracore	-26	1	7	Physical	
SYC14-AC-F	Vibracore	-21	1	4	Physical	
SYC14-REF	Grab	Sediment surface	Not applicable	28	Physical	**SYC14-REF** Physical, sediment chemistry, benthic toxicological, bioaccumulation, tissue chemistry
SYC14-ODMDS-SW	Grab	3 ft. below surface	Not applicable	4	Physical	**SYC14-ODMDS-SW** Water chemistry
SYC14-SW	Pump	3 ft. above bottom	Not applicable	65	Not applicable	**SYC14-SW** Water chemistry, water column toxicology, elutriate preparation

* Volume for vibracore-collected samples are estimated based on length and diameter of recovered core

2.2 Sample Collection Techniques

2.2.1 Project Field Effort

Field sampling took place from June 2 through June 4, 2014. Samples were shipped to the laboratories on June 10, 2014. Field personnel consisted of scientists from ANAMAR and Athena Technologies. The sampling vessel R/V *Artemis* was used for vibracoring, water and reference sample collection. All sample processing was conducted by ANAMAR at their Gainesville, Florida, office. Exhibit 2-5 is a summary of the field sampling effort.

Exhibit 2-5. Daily Activities during the June 2014 Field Effort

Date	General Activity	Samples Collected
June 2, 2014	• Collect cores from turning basin	SYC14-TB1 (A-C) SYC14-TB2 (D-F)
June 3, 2014	• Collect reference sample • Collect ODMDS and site water samples	SYC14-REF, SYC14-ODMDS-SW, SYC14-SW
June 4, 2014	• Collect cores from access channel	SYC14-AC (A-F)
June 5, 2014	• Return to Gainesville with samples	All samples
June 6, 2014 and June 9, 2014	• Composite sediment samples	All sediment samples
June 10, 2014	• Ship samples to ALS Environmental and ENVIRON	All samples
June 10, 2014	• Ship samples to AMEC	All sediment samples

2.2.2 Site Positioning

Sampling station locations were chosen to coincide with the dredging prism and were based on a bathymetric survey provided by Moffatt and Nichol. The bathymetric data were used to identify sampling station locations to best represent dredge material proposed for disposal at the Charleston ODMDS. Sampling locations are shown in Maps 1, 2, and 3.

Target coordinates are given in Appendix A. Station coordinates were uploaded to a Trimble global positioning system (GPS) (sub-meter accurate) on the R/V *Artemis.* Uploaded coordinates in all GPS units were reviewed and compared with the original coordinates to verify accuracy prior to field sampling. In addition, a second hand-held Garmin GPS was used as a backup navigation device to ensure that the correct location was occupied. The GPS antenna on the *Artemis* is located over the coring moon pool to ensure accuracy of the recorded sample location.

Navigation and positioning of the *Artemis* was handled by U.S. Coast Guard (USCG)-certified Master Captains under direction of the ANAMAR project manager or field team leader. The location for the site water station was determined in advance of field operations and was near the boundary between DUs SYC14-AC and SYC14-TB2. This location was chosen to represent hydrologic conditions within the harbor (Map 1).

Water depths during grab sampling and water sampling were recorded to the nearest 0.5-feet using a Furano fathometer. Prior to vibracore sampling, a lead line was used to verify fathometer readings, and depths were recorded to the nearest inch. Water depths were used to field-verify that target stations were located over the most appropriate sediment surface elevations, which were calculated in the field using real-time tide height data (in feet MLLW) from National Oceanic and Atmospheric Administration (NOAA) Station 8665530 at the Charleston, South Carolina, tide station.

The coordinates of each station were recorded using GPS units in the field, and waypoints were recorded on waypoint field logs and sampling field logs. Sampled locations are plotted on aerial photographs in Maps 1 and 2. Table 1 contains dates and times, coordinates, water depths, bottom elevations, and associated data for core samples. Table 2 contains dates and times, coordinates, water depths, bottom elevations, in situ water column parameters, and other field observations for sediment grab and site water samples.

2.2.3 Decontamination Procedures

All equipment contacting sediment or water samples was cleaned and decontaminated prior to sampling each day and between each DU. Decontamination procedures followed those outlined in Florida Department of Environmental Protection (FDEP) Standard Operation Procedures (SOP) FC1000. Personnel handling sediment samples and equipment wore disposable nitrile gloves, which were changed to prevent cross-contamination. Below is a summary of the decontamination process.

- Wash and scrub with site water to remove gross contamination
- Wash and scrub with Liquinox®
- Rinse with site water
- Rinse with de-ionized water
- Rinse with pesticide-grade isopropanol
- Rinse with de-ionized water
- Rinse with pesticide-grade hexane for dioxin analysis
- Rinse with de-ionized water
- Air dry

After decontamination, the equipment was either used immediately or enclosed in a decontaminated stainless steel container (with stainless steel lid) until ready for use.

Decontaminating a stainless steel bin

2.2.4 In situ Water Column Measurements

A YSI multiprobe meter and a Hach 2100P turbidimeter were used to measure water column parameters. Water parameter measurements were collected from about 3 feet below surface, mid-depth, and approximately 3 feet above the bottom and consisted of

- Time of reading
- Depth of reading (feet)
- Water temperature (°C)
- pH (units)
- Conductivity (mS/cm)
- Dissolved oxygen (mg/L and percent saturation)
- Turbidity (NTU, near-surface only)
- Salinity, which was not measured in the field, but was analyzed at ALS Environmental from the background site water sample.

Water depth measurements, tidal cycle, and weather observations were recorded on field sampling logs (Appendix B). Water column measurements were taken at the site water station.

The YSI multiprobe meter and Hach turbidimeter were calibrated prior to use. An end-of-day reading was taken to document if the instrument remained calibrated within acceptance criteria. Water column measurements and calibration logs are in Appendix B.

2.2.5 Sediment Sampling with Vibracore

Subsurface core sediment samples were obtained using a vibratory core sampler (vibracore). Vibracore services were performed by Athena Technologies under the direction of an ANAMAR team leader who was on the sampling vessel at all times to direct operations, record field notes, and containerize and label samples. The vibracore samples were collected from the *Artemis*, which is specifically outfitted for operating the vibracore equipment. The vessel carried all necessary sediment sampling equipment.

The vessel captain navigated to each target using a helms map displayed on a Panasonic Toughbook® computer. Once on-station, the vessel was immobilized using a three-point anchoring system. Vessel coordinates were compared to station coordinates loaded in a second GPS to confirm location accuracy. Depths were recorded from lead-line readings to the nearest inch. Bottom elevation was calculated in the field using real-time water level in feet MLLW as reported by NOAA Station 8665530 at the Charleston, South Carolina, tide station. Core penetration required to reach project depth was calculated by adding the sediment surface elevation (as a negative value) to the project depth.

Athena's vibracore system was deployed from the deck of the vessel and consisted of a generator with a mechanical vibrator attached via cable. This vibrator was attached directly to a 4-inch-diameter stainless steel casing. The sampler was lowered to the sea floor through a moon pool in the deck of the sampling platform by attaching lengths of drill stem. The vibracore apparatus was then activated and the sample barrel allowed to penetrate the sediment until it reached target elevation. The vibracore apparatus was then deactivated and the core retrieved using an electric winch. Once the sample was on-deck, the recovered core

length was verified. The core material was then removed from the sampler into a stainless steel bin, characterized, photographed, transferred to a Teflon® bag, labeled, and placed immediately into ice-filled coolers. All containers were properly labeled and sampling information was recorded on individual project-specific field logs. All equipment in contact with sediment was decontaminated prior to and following sampling at each zone using methods described in Section 2.2.3 and procedures outlined in FDEP SOP FC1000. At the end of each sampling day, iced sample coolers were transferred to a refrigerated truck for storage at or below 4°C.

A summary of vibracore samples, including dates and times, station coordinates, elevations, effective penetration lengths, and effective percent recovery lengths, are included in Table 1. The effective recovery length is the actual recovery length of the core minus the material intentionally discarded (if any) and the material lost during sampling (if any). The effective percent recovery is calculated by dividing the effective recovery length by the penetration length and multiplying the quotient by 100%. Copies of sediment core logs are in Appendix B.

2.2.6 Sediment Sampling with Grab Sampler

Grab samples were collected with a stainless steel 8.8-gallon-capacity custom Petersen-style grab sampler. All grab samples were taken using the *Artemis* with an ANAMAR team leader directing operations. The sampling device was lowered and raised by an electric winch.

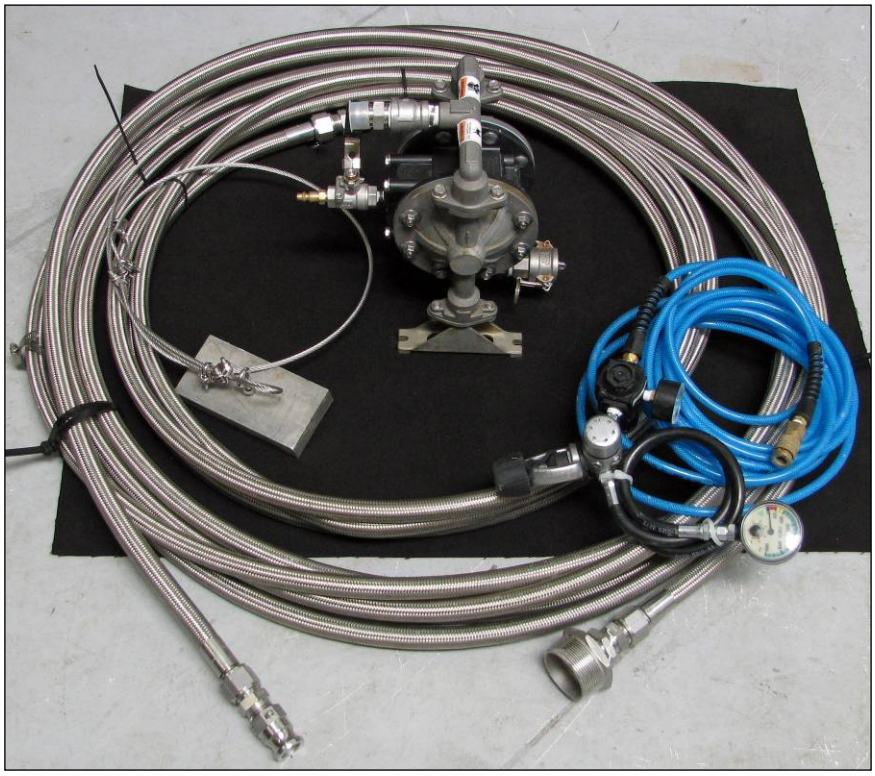
Custom Petersen-style grab sampler with sediment inside a stainless steel bin

During sampling operations, the vessel was kept in position while one person operated the winch and another person guided the sampler into a decontaminated stainless steel bin. Excess water was removed from the grab sampler through holes or screen mesh (depending on the sampler) before placing sample material in the bin. When the required volume of sediment was collected for each subsample, a photograph of the material was taken and notes on the subsample's appearance and characteristics were recorded on a project-specific field log (Appendix B). Using decontaminated stainless steel utensils (e.g., spoons, scrapers) and disposable nitrile gloves, the subsample was homogenized and placed in pre-cleaned, labeled Teflon® bags and stored on ice. At the end of each sampling day, iced sample coolers were transferred to a refrigerated truck for preservation at or below 4°C. Prior to sampling, all equipment that would be in contact with sediment was decontaminated using methods described in Section 2.2.3 and procedures outlined in FDEP SOP FC1000. Sediment grab sampling locations are shown on Map 3. Sample volumes and related information are included in Exhibit 2-4. Copies of sediment sampling logs are in Appendix B.

2.2.7 Water Sampling

Site water for elutriate preparation was collected from one station (SYC14-SW) using a stainless steel pneumatic pump attached to a woven stainless steel-encased Teflon® hose and powered by compressed air. All equipment contacting sampled water was decontaminated prior to use by methods outlined in Section 2.2.3. Since dioxins were not part of the analytical requirements, decontamination using hexane was not required and was omitted. The suction hose was lowered through the water column. A stainless steel weight was attached to the end with stainless steel cable to allow the hose to hang approximately 3 feet above the sediment surface. Another piece of stainless steel-encased Teflon® hose was attached to the discharge nozzle of the pump. Pressurized air was allowed to enter the pump, which drove a cylinder that pushed water through the Teflon® tubing. A pressure valve was used to adjust flow.

A total of 60 gallons of water was collected at the site water station in decontaminated Teflon®-lined or low-density, polyethylene 20-liter Cubitainers®. In addition, a sample for background chemistry was collected from the same station with the pneumatic pump using pre-cleaned, pre-preserved 250-mL to 1-liter glass or plastic bottles (some with nitric acid added as a stabilizer) provided by ALS Environmental.



Pneumatic water pump with regulator, pressurized air tubing, weight, and stainless steel-encased Teflon® hoses

A second water sample (SYC14-ODMDS-SW) was collected from the ODMDS approximately 3 feet below the surface using a pre-cleaned 1-gallon amber glass jar. The collected water was partitioned into pre-cleaned, pre-preserved 250-mL to 1-liter glass or plastic containers provided by ALS Environmental for background chemistry analysis. The ODMDS water was shipped the day the sample was collected to ALS Environmental for analysis.

The water sampling locations are shown on Maps 1 and 3. Water sampling dates and times, station coordinates, and related information are included in Table 2. Copies of water sampling logs are in Appendix B.

2.2.8 Sample Transport, Processing, and Custody

2.2.8.1 Transportation from Charleston, South Carolina to Gainesville, Florida

Samples were transported from Charleston to ANAMAR's office in Gainesville, Florida, on June 5, 2014. Samples were kept inside ice-filled coolers within a refrigerated truck at 4°C or less until compositing. The temperature inside the truck was monitored to ensure samples met preservation criteria. Copies of temperature logs are provided in Appendix B.

2.2.8.2 Compositing

ANAMAR personnel composited and homogenized subsamples for each composite sample using decontaminated stainless steel mixing equipment and a 40-gallon-capacity stainless steel bin. The reference sample was homogenized using the same equipment, which was decontaminated between composite samples using methods described in Section 2.2.3. Compositing was conducted in accordance with the scheme presented in Section 2.1.

After samples were composited, appropriate volumes of each sample were divided and placed in method-specific, pre-cleaned, pre-labeled Teflon® bags (for chemical analysis) or plastic bags (for physical and bioassay analysis).

2.2.8.3 Transport to the Laboratories

On the day of shipping, coolers were packed with ice, taped, sealed with custody tape, and labeled for shipment. The sediment samples were shipped in coolers to the appropriate laboratories. Chain-of-custody records for each laboratory were completed to reflect the final sample names and to identify the analyses and analytical methods required. These chain-of-custody forms accompanied the samples during shipment to the laboratories. The ODMDS water was shipped to ALS Environmental on June 3, 2014, and received on June 4, 2014. All other sediment and water samples were shipped on June 10, 2014, to ALS Environmental for chemical analysis; ENVIRON for toxicological analysis; and AMEC for physical analysis. All samples were received on June 11, 2014. Copies of final signed chain-of-custody forms are included in the laboratory reports (Appendices C, E, and G).

2.3 Physical and Chemical Analytical Procedures

2.3.1 Physical Procedures

AMEC performed physical analysis of all sediment samples. ANAMAR performed quality assurance/quality control (QA/QC) on sediment physical data and presented the data in summarized form.

2.3.1.1 Grain Size Distribution

Gradation tests were performed by AMEC in general accordance with methods ASTM D-422 and ASTM D-1140. Each representative sample was air-dried and dry-prepped in accordance with method ASTM D-421, and results of the sieve analysis of material larger than a #10 sieve (2.00-mm mesh size) were determined. The minus #10 sieve material was then soaked in a dispersing agent. Following the soaking period, the sample was placed in a mechanical stirring apparatus and then in a sedimentation cylinder where hydrometer readings were taken over a 24-hour period. After the final hydrometer reading was taken, the sample was washed over a #230 sieve (0.066-mm mesh size), placed in an oven, and dried to a constant weight. After drying, the sample was sieved over a nest of sieves to determine the gradation of the material greater than #200 sieve size. Cumulative frequency percentages were graphed and presented by AMEC on USACE Form 2087 (Appendix C). ANAMAR tabulated and graphed the grain size distribution by subsample and composited sample.

2.3.1.2 Moisture Content

Moisture content was determined in general accordance with method ASTM D-2216-80 and Plumb (1981). The sample weight was recorded and the sample was placed in an oven and dried to a constant mass at 110°C. Once a constant dry mass was obtained, the percent moisture was determined by subtracting the dry mass from the wet mass, then dividing the loss in mass due to drying (the mass of just moisture) by the wet mass. The percent total solids were reported on a 100% wet weight basis.

2.3.1.3 Specific Gravity

Specific gravity was determined for composite samples only, in general accordance with method ASTM D-854. Each sample was placed in a mechanical stirring device and de-ionized water was added to form a slurry. The slurry was then transferred to a pycnometer and was de-aired by applying a vacuum. After vacuuming, the pycnometer with sample was allowed to reach thermal equilibrium. The water level was adjusted to a calibration mark, and the pycnometer with sample was weighed. After the pycnometer with sample weight was recorded, the sample was emptied into a drying container and placed in an oven until a constant dry mass of sediment solids was obtained.

2.3.1.4 Atterberg Limits

Tests for liquid and plastic limits are performed by AMEC in general accordance with ASTM D-4318, wet method, as follows. The minus #40 sieved material is mixed with a small amount of water and placed in the liquid limit device. A groove is cut using the flat grooving tool and the liquid limit is determined by the number of drops of the cup. When the number of drops is in the desired range, a moisture sample is obtained and placed in a 230° oven and dried to a constant weight. This is repeated until three determinations have been obtained, one between 15 and 25 blows (a blow is defined as dropping the cup from a height of 10 mm onto a hard rubber pad), one between 20 and 30 blows, and one between 25 and 35 blows. The reported value is the intersecting value at 25 blows when all three are plotted.

The plastic limit is determined by slowly air-drying a small sample left over from the liquid limit determination. The sample is rolled and air-dried until the thread becomes crumbly and lacks cohesion. When this point is reached, the sample is placed in a tare and weighed, then placed in an oven and dried to a constant weight. The moisture content is the plastic limit.

2.3.2 Chemical Analytical Procedures

ALS Environmental performed all chemical analyses of sediment, water, elutriate, and tissue samples. ANAMAR performed QA/QC on the data and presented it in summarized form in tables, figures, and text.

2.3.2.1 Sediment, Soil and Elutriate Chemistry

Sediment and elutriate analyses were performed in accordance with published procedures. Analytical methods and detection limits for sediment and elutriate analyses are provided in Section 13.2 of the QAPP (Appendix A). Elutriates were generated using methods described in Section 10.1.2.1 of the Green Book, equivalent to Section 10.1.2.1 of the *Inland Testing Manual* (ITM) (USEPA and USACE 1998). Brief descriptions of the remaining analytical methods and instrumentation used for sediment and elutriate analysis are provided in Exhibit 2-6.

Exhibit 2-6. Summary of Methods and Equipment Used during Sediment and Elutriate Analysis

EPA Method	Instrument	Methodology Summary
350.1 – Ammonia in Sediment and Water	Colorimetric Autoanalyzer	Alkaline phenol and hypochlorite react with ammonia to form indophenol blue that is proportional to the ammonia concentration. The blue color is intensified with sodium nitroprusside. Once developed, the color is read using a spectrophotometer, and calculated using linear regression.
6010B/ 200.7-Trace Metals	ICP for trace metals	Inductively coupled plasma (ICP) is applicable to the determination of sub-parts per billion concentrations of a large number of elements in water samples and in waste extracts or digests. Acid digestion prior to filtration and analysis is required for aqueous samples and tissues for which total (acid-leachable) elements are required.
6020/200.8-Trace Metals	ICP/MS	Inductively coupled plasma/mass spectrometry (ICP/MS) is applicable to the determination of sub-parts per billion concentrations of a large number of elements in water samples and in waste extracts or digests. Acid digestion prior to filtration and analysis is required for aqueous samples, sediments, and tissues for which total (acid-leachable) elements are required.
7470 - Mercury in Water	Mercury Analyzer Cold Vapor Atomic Absorption (water)	Method 7470 is a cold-vapor atomic absorption procedure approved for determining the concentration of mercury in mobility-procedure extracts and aqueous wastes. All samples are subjected to an appropriate dissolution step before analysis.
7471 - Mercury in Tissues	Mercury Analyzer Cold Vapor Atomic Absorption (sediment)	Method 7471 is approved for measuring total mercury (organic and inorganic) in sediments and tissues. All samples are subjected to an appropriate dissolution step before analysis. If this dissolution procedure is not sufficient to dissolve a specific matrix type or sample, this method is not applicable for that matrix.

Exhibit 2-6. Summary of Methods and Equipment Used during Sediment and Elutriate Analysis

EPA Method	Instrument	Methodology Summary
7742 - Selenium	Borohydride Atomic Absorption	Method 7742 uses a borohydride generator for analysis. The selenium is converted to the +4-oxidation state during digestion in hydrochloric acid. Selenium is then converted to its volatile hydride using hydrogen produced from the reaction of the acidified sample with sodium borohydride in a continuous-flow hydride generator.
8270 SIM - PAHs and PBDEs	Gas Chromatograph/ Mass Spectrometer	This method is used to determine the concentration of semi-volatile/PAH organic compounds in extracts prepared from many types of solid matrices and water samples. Direct injection of a sample may be used in limited applications.
8290 -Dioxins and Furans	High Resolution Mass Spectroscopy	This method uses a high-resolution mass spectrometer to analyze sediment and tissue samples for the analysis of dioxins and furans.
9060 (Modified*)	TOC Analyzer	Method 9060 is used to determine the concentration of organic carbon in sediment by catalytic combustion or wet chemical oxidation. The carbon dioxide formed from this procedure is measured and is proportional to the TOC in the sample.
9071 – Oil & Grease	Gravimetric (Electronic Balance)	A representative portion of wet (as received) waste is acidified with concentrated hydrochloric acid and chemically dried with magnesium sulfate or sodium sulfate. Magnesium sulfate monohydrate is used to dry acidified sludges as it will combine with 75% of its own weight in water. Anhydrous sodium sulfate is used to dry soil and sediment samples.
Krone et al. (1989)	Grignard Reaction/Gas Chromatograph/ Flame Photometric	This method refers to the Grignard reaction, gas chromatograph, and flame photometric detection of di-n-butyltin, n-butyltin, and tri-n-butyltin cations in sediment and tissues. All samples are subjected to an extraction phase prior to analysis, and the concentration is determined using standard organic protocols.

***** Minor modifications were made to Method 9060 that were approved by the National Environmental Laboratory Accreditation Conference (NELAC).

2.3.2.2 Tissue Chemistry Procedures

Methods used for analyzing tissue are the same as those described above for sediments and elutriates. On day 28 of the bioaccumulation potential tests, the sediment was sieved to remove live specimens of *Neanthes virens* and *Macoma nasuta*. The surviving animals were placed in clean flow-through aquaria to depurate their gastrointestinal tract over a 24-hour period. Soft tissue was separated from the hard shells of *M. nasuta*. Whole animal tissue (minus the valves of *M. nasuta*) was then placed into certified-clean glass sample jars, frozen, and sent to ALS Environmental for chemical analysis. Any contaminant detected above the laboratory reporting limit for sediment samples specified in the SERIM was analyzed in the corresponding tissue samples. Additionally, analysis for trace metals was not performed on the sediment samples, since detectable levels of metals had been found during chemical analysis of sediment collected from SYC in 2013. Tissue analysis for metals was required as detailed in the QAPP.

2.4 Bioaccumulation and Toxicology Procedures

A complete report describing bioaccumulation and toxicology procedures and results is presented in Appendix G and includes the following information:

- Test species used and the supplier or collection site for the test species
- Source of control sediment samples
- Source of water used
- Test experimental design and endpoint
- Any deviations from test protocol
- Statistical analysis procedures
- Summary of QA/QC information on maintaining the test species. Details should be provided in the appendix.

2.5 Applicable Technical Quality Standards

Raw field and laboratory data were summarized and compiled into tables. Figures and maps were used to depict data trends and to associate the results spatially with respect to sampling locations.

2.5.1 Sediment Chemistry

Results of laboratory analyses of sediment samples are compared to published sediment screening values as appropriate and in conformance with the Green Book and the SERIM. These levels are the threshold effects level (TEL), the effects range low (ERL), the effects range median (ERM), and the apparent effects threshold (AET) for dioxins only. The TEL represents the concentration below which adverse effects are expected to occur only rarely. The ERL is the value at which toxicity may begin to be observed in sensitive species (Buchman 2008). The ERM is the lowest concentration at which biological effects frequently occur. The AET is defined as the highest concentration associated with a nontoxic sample, such that only toxic samples are observed at higher concentrations. These comparisons are for reference use only and are not intended for regulatory decision-making.

2.5.2 Elutriate and Site Water Chemistry

Results of elutriate and water sample analyses were compared to the latest published EPA water quality criteria of criteria maximum concentration (CMC [synonymous with 'acute']) established in USEPA (2009). The CMC is an estimate of the highest concentration of a pollutant in saltwater to which an aquatic community can be exposed briefly without resulting in an unacceptable effect (USEPA 2006, Buchman 2008).

2.5.3 Tissue Chemistry

Results of laboratory analyses of tissue samples were compared to published tissue screening values. The U.S. Food and Drug Administration (FDA) action levels were used for comparison after accounting for steady-state adjustments. Most FDA levels were obtained from Appendix H of the SERIM. However, in light of discrepancies found in the SERIM regarding the FDA levels for cadmium in tissue, the FDA limits for this analyte were obtained instead from FDA (2001). According to FDA (2011) the action levels for arsenic, cadmium, lead, and nickel in tissue are no longer in effect. Also, Table 9-1 of FDA (2011) lacks action levels for chromium in tissue,

although an earlier version of the document does provide action levels for chromium (FDA 2001). Regardless, it was decided to use previous FDA action levels for arsenic, cadmium, lead, nickel, and chromium in this report as it is possible that such action levels may be put into effect in the near future.

Concentrations of *Neanthes virens* tissues were compared to the FDA levels for crustacea suggested in Appendix H of the SERIM, as there are no FDA levels published for polychaete worm tissue (FDA 2001 and 2011). Additionally, if mean tissue analytical results were found to statistically significantly exceed those of the reference tissue and also contained at least two replicate results greater than the method reporting limit (MRL) (conforming to Section 7.5.1 of SERIM), such mean results were then compared with taxa-specific, ecological non-specific effects threshold concentrations and the EPA Region 4 bioaccumulation table values for eastern Florida found in Appendix H of the SERIM. South Atlantic Bight background concentrations were chosen over other background concentrations because the survey area from which the concentrations are based included Charleston Harbor (Appendix H of SERIM). In the event that results statistically significantly exceeded mean reference tissue results and also exceeded EPA Region 4 bioaccumulation values, such results may be used in a risk-based evaluation by USACE.

All project and reference tissue samples had five replicates. The mean of results of each set of five replicates per sample and analyte combination was calculated and compared to the mean of the reference tissue result per analyte. Mean values of analyte concentrations were calculated as follows:

- For non-detects/U-flagged data, the method detection limit (MDL) was used in all statistical calculations.
- For J-flagged and non-flagged data, the result was used in all statistical calculations.

In cases where the mean concentration of an analyte in *N. virens* or *M. nasuta* tissue was found to exceed that of the reference tissue and at least two of the five replicate samples had concentrations above the MRL, the biostatistical software program ToxCalc v5.0.32 (Tidepool Scientific, LLC) was used to determine the relative distribution and variances among the samples tested. If the distribution was determined to be abnormal or the variances unequal, the data were treated with a reciprocal transformation and the distribution and variances were re-evaluated. If no mean tissue contaminant concentration was found to statistically exceed that of the reference tissue, then no additional analysis was necessary to demonstrate compliance with the LPC (Green Book).

2.6 Reporting Limits

The sediment chemical concentration, MDL, and MRL were reported on a dry weight basis. The tissue chemical concentration, MDL, and MRL were reported on both a dry weight basis and a wet weight basis. The MDL refers to the minimum concentration of a given analyte that can be measured and reported with a 99% confidence level that the analyte concentration is greater than zero. The procedures for determining MDLs is defined in 40 CFR Part 136 Appendix B for most chemical analyses. The MDL for dioxins is based on signal to noise ratio and is addressed as part of the method. The MRL refers to the minimum concentration at which the laboratory will report analytical chemistry data with confidence in quantitative accuracy of a given data point. Common laboratory procedures for defining an

MRL include assigning it to a fixed factor above the MDL or by using the lowest calibration standard. MRLs are often adjusted by the laboratory for sample-specific parameters such as sample weight, percent solids, or dilution.

3 RESULTS AND DISCUSSION

3.1 Field Data and In Situ Measurements

3.1.1 Weather Conditions

The field effort for this project consisted of one mobilization. Sampling at all coring, site water, and reference locations occurred from June 2 to June 4, 2014. Conditions during sampling were acceptable and consisted of clear to partly cloudy skies, calm seas in the harbor with 1- to 2-foot seas offshore and 5- to 10-knot winds.

Water column parameters were recorded at the ODMDS water station (SYC14-ODMDS-SW) and the site water station (SYC14-SW). Tables 1 and 2 provide summaries of field observations taken during vibracoring and reference sampling, and at the two water collection locations, including in situ measurements.

3.1.2 Vibracore/Grab Sampling Data (as applicable)

Table 1 provides all data related to vibracoring, including sample depth, core penetration, and recovery length. All samples were taken to project depth except as noted where refusal was met before reaching project depth.

3.2 Physical Testing Data

Grain size distribution was analyzed in all subsamples and composite samples. Complete results of physical testing for percent grain size distributions, percent solids, and Unified Soil Classification System (USCS) classes are presented in Tables 3 and 4 for subsamples and composite samples, respectively. Table 4 also includes specific gravity, Atterberg limits, and hydrometer readings for composite samples. The laboratory report of physical results using USACE Form 2087 is provided in Appendix C.

The laboratory reports showed sample SYC14-AC as 'CLAY, inorganic-H, little fine-grained sand-sized quartz, (CH) dark greenish gray.' Samples SYC14-TB1 and SYC14-TB2 were described as 'CLAY, inorganic-H, trace quartz, (CH) dark greenish gray.' Sample SYC14-REF was described as 'SAND, silty, mostly fine-grained sand-sized quartz, little silt, (SM) greenish gray.' Exhibits 3-1 and 3-2 summarize percent grain size distributions and other physical parameters for the composite samples.

Exhibit 3-1. Summary of Percent Grain Size Distribution by Composite Sample[1]

Sample ID	Grain Size Distribution[2] (percent by weight)				USCS Soil Class
	Gravel	Total Sand	Silt	Clay	
SYC14-AC	0.0	24.2	32.2	43.6	CH
SYC14-TB1	0.0	1.0	37.2	61.8	CH
SYC14-TB2	0.0	1.0	37.3	61.7	CH
SYC14-REF	0.0	79.8	17.2	3.0	SM

[1] See Table 3 for complete physical analysis results for sediment composite samples.

[2] Particle sizes: gravel ≥4.750 mm, sand = 0.075–4.749 mm, silt & clay <0.075 mm.

Exhibit 3-2. Summary of Physical Parameters by Composite Sample

Sample ID	% Solids	Specific Gravity	Atterberg Limits		
			Plastic Limit	Liquid Limit	Plasticity Index
SYC14-AC	39.9	2.680	39	125	86
SYC14-TB1	28.3	2.504	58	212	154
SYC14-TB2	28.4	2.592	53	209	156
SYC14-REF	80.6	2.728	NP	NP	NP

3.3 Sediment Chemistry

Analytical results for sediment chemistry are presented in Tables 5 through 8. Sediment chemistry analysis was performed on composite samples SYC14-AC, SYC14-TB, and SYC14-REF. Analytical results were compared to the published sediment screening criteria TEL, ERL, and ERM that are defined in Section 2.5.1. Analytical testing of the sediment samples was conducted in accordance with Tables 6-5, 10-3, and 13-2 from the QAPP.

3.3.1 TOC, Total Petroleum Hydrocarbons, and Total Ammonia

The sediment samples were analyzed for TOC, total petroleum hydrocarbons (TPH), and total ammonia to provide supplemental information about the sediment. These analytes do not have TEL, ERL, or ERM screening criteria associated with them. A summary of the results is shown in Exhibit 3-3.

Exhibit 3-3. Summary of Sediment TOC, TPH, and Total Ammonia Results

Analyte	Concentration			
	SYC14-AC	SYC14-TB	SYC14-REF	Concentration Range (Dredge Area Samples Only)
TOC (%)	2.33	3.34	0.084	2.33 - 3.34
TPH	250	720	<130	250 - 720
Total Ammonia	300	763	4.63	300 - 763

"<" less-than symbol indicates the analyte was not detected at or above the MRL (value indicates the MRL).

3.3.2 Organotins

The analysis of organotins was performed for 3 congeners; n-butyltin, di-n-butyltin, and tri-n-butyltin. No concentration of any butyltin congener in sample SYC14-AC was found at or above the laboratory reporting limit. The concentration of each congener was greater than the laboratory reporting limit in sample SYC14-TB. All organotin congeners met the target detection limits specified in the SERIM. As specified in the SERIM, the corresponding tissue samples produced from bioaccumulation from sediment sample SYC14-TB were recommended for analysis for organotins. These analytes do not have TEL, ERL, or ERM screening criteria associated with them. A summary of the results is shown in Exhibit 3-4. Table 5 contains the complete results of organotin analyses.

Exhibit 3-4. Summary of Sediment Organotin Results

Analyte	Concentration (µg/kg)			
	SYC14-AC	SYC14-TB	SYC14-REF	Concentration Range (Dredge Area Samples Only)
n-Butyltin Cation	<2.5	6.1	<1.3	<2.5 - 6.1
Di-n-butyltin Cation	0.99	3.7	<1.3	0.99 - 3.7
Tri-n-butyltin Cation	<2.6	4.1	<1.3	<2.6 - 4.1
Total Organotins (as tin)	2.8	7.7	0.57	2.8 - 7.7

"<" less-than symbol indicates the analyte was not detected at or above the MRL (value indicates the MRL).

3.3.3 PAHs

Eighteen PAHs were tested as specified in section 5 of the SERIM. Of these 18 PAHs, 16 were detected above the MRL is sample SYC14-AC, and 13 were detected above the MRL in sample SYC14-TB. All PAHs met the target detection limit specified in the SERIM. As specified in the SERIM, the corresponding tissue samples produced from bioaccumulation from both sediment samples were recommended for PAH analysis. A summary of the PAH results is shown in Exhibit 3-5. Table 6 contains complete PAH results, including qualifiers, MDLs, and laboratory reporting limits.

Exhibit 3-5. Summary of Sediment PAH Results

Analyte	Concentration (µg/kg)						
	SYC14-AC	SYC14-TB	SYC14-REF	TEL	ERL	ERM	Range
1-Methylnaphthalene	<6.2	<8.8	<3.2	x	x	x	<6.2 - <8.8
2-Methylnaphthalene	<6.2	<8.8	<3.2	20.2	70	670	<6.2 - <8.8
Acenaphthene	**9.1**	<8.8	<3.2	6.71	16	500	<8.8 - 9.1
Acenaphthylene	**22**	**24**	<3.2	5.87	44	640	22 - 24
Anthracene	34	41	<3.2	46.9	85.3	1100	34 - 41
Benzo(a)anthracene	**170**	**81**	<3.2	74.8	261	1600	81 - 170
Benzo(a)pyrene	**130**	**96**	<3.2	88.8	430	1600	96 - 130
Benzo(b)fluoranthene	210	150	<3.2	x	x	x	150 - 210
Benzo(g,h,i)perylene	62	57	<3.2	x	x	x	57 - 62
Benzo(k)fluoranthene	75	56	<3.2	x	x	x	56 - 75
Chrysene	**130**	**110**	<3.2	108	384	2800	110 - 130
Dibenzo(a,h)anthracene	**16**	**15**	<3.2	6.22	63.4	260	15 - 16
Fluoranthene	**310**	**130**	<3.2	113	600	5100	130 - 310
Fluorene	8.3	<8.8	<3.2	21.2	19	540	<8.8 - 8.3
Indeno(1,2,3-cd)pyrene	72	61	<3.2	x	x	x	61 - 72
Naphthalene	13	<8.8	<3.2	34.6	160	2100	<8.8 - 13
Phenanthrene	23	16	<3.2	86.7	240	1500	16 - 23
Pyrene	**310**	140	<3.2	153	665	2600	140 - 310
Total LMW PAHs	96	78	5.9	312	552	3160	78 - 96
Total HMW PAHs	**1066**	572	4.8	655	1700	9600	572 - 1066
Total PAHs	1603	998	15	1684	4022	44792	998 - 1603

Bolded values indicate the result is greater than or equal to the TEL, ERL and/or ERM.
"<" less-than symbol indicates the analyte was not detected at or above the MRL (value indicates the MRL).
x = No TEL, ERL, or ERM published for this parameter.
LMW = low molecular weight; HMW = high molecular weight.

3.3.4 Dioxins and Furans

Dioxin and furan analyses were performed for the 17 congeners specified in Appendix M of the SERIM. The concentration for each congener was then normalized to 2,3,7,8-TCDD using the toxicity equivalency factors from the World Health Organization (2005). The sum of each normalized value was calculated to yield a single toxicity equivalence (TEQ) for each sample. The laboratory MDL met the target detection limit for all congeners specified in the SERIM, while the laboratory reporting limit slightly exceeded the target detection limit for all congeners. Individual congeners do not have any corresponding screening criteria. Total TEQs have corresponding TEL and AET screening criteria. The total TEQ exceeded both the corresponding screening criteria, and, as specified in the SERIM, the corresponding tissue samples produced from bioaccumulation from both sediment samples were recommended for dioxin and furan analysis. A summary of the total TEQ and 2,3,7,8-TCDD results is shown in Exhibit 3-6. Table 7 contains complete results for dioxin and furan analyses including qualifiers, MDLs, laboratory reporting limits, and congener-specific TEQs.

Exhibit 3-6. Summary of Sediment Dioxin Total TEQ and 2,3,7,8-TCDD Results

Analyte	Concentration (ng/kg)					
	SYC14-AC	SYC14-TB	SYC14-REF	Concentration Range (Dredge Area Samples Only)	TEL	AET
Total TEQ	**4.40**	**12.4**	0.923	4.40 - 12.4	0.85	3.6
2, 3, 7, 8 TCDD	<1.22	<1.74	<0.631	<1.22 - <1.74	x	x

Bolded values indicate the result is greater than or equal to the TEL and AET.
"<" less-than symbol indicates the analyte was not detected at or above the MRL (value indicates the MRL).

3.3.5 Polybrominated Diphenyl Ethers

The analysis of polybrominated diphenyl ethers (PBDEs) was performed testing for a list of 17 congeners. These tests are not included as part of the recommended list from the SERIM, and were requested by the National Oceanographic and Atmospheric Administration for analysis. PBDE concentrations were below the MDL for all congeners for both samples. Since no result exceeded the MDL, tissue analysis was not required for PBDE analyses and no summary exhibit is provided below. Table 8 contains complete results for PBDEs including qualifiers, MDLs, and laboratory reporting limits.

3.3.6 Metals, Pesticides, and Polychlorinated Biphenyls (PCBs)

As described in Section 6.2.1.2 of the QAPP, analysis for trace metals, pesticides, and PCBs was not required. Trace metals from a recent report produced by GEL Laboratories indicated that all metals were found at concentrations greater than the laboratory reporting limit, and that chemical analysis of the tissue samples would be performed in lieu of the sediment analysis. Chemical analysis of pesticides and PCBs was also performed by GEL Laboratories, and all results were below the laboratory reporting limits, indicating that these tests would not be required for either sediment or tissue analyses as specified in the SERIM. The GEL report is included as Attachment 5 in Appendix A.

3.4 Elutriate Chemistry

Analytical results for elutriate and site water chemistry are presented in Tables 9 and 10. Elutriate samples were prepared from the composited sediment samples SYC14-AC, SYC14-TB1,

and SYC14-TB2. Chemistry analysis was then performed on the three elutriates and two background water samples, SYC14-SW and SYC14-ODMDS-SW. Analytical results were compared to the published water quality criteria CMC defined in Section 2.5.2. Analytical testing of the sediment samples was conducted in accordance with Tables 6-5, 10-3, and 13-3 of the QAPP.

3.4.1 Ammonia

Ammonia concentrations are provided in Exhibit 3-7.

Exhibit 3-7. Summary of Elutriate and Site Water Ammonia Results

Analyte	Concentration (mg/L)						
	SYC14-AC	SYC14-TB1	SYC14-TB2	SYC14-SW	SYC14-ODMDS-SW	Concentration Range (Dredge Area Samples Only)	CMC
Total Ammonia	**28.6**	**44.8**	**43.1**	0.114	ND	28.6 - 44.8	11.6

Bolded values indicate the result is greater than the CMC.
ND indicates the analyte was not detected at or above the MDL.

The CMC is calculated using pH, temperature, and salinity values from Table 2 from *Ambient Water Quality Criteria for Ammonia (Saltwater)-1989* (USEPA 1989) found at http://water.epa.gov/scitech/swguidance/standards/upload/2001_10_12_criteria_ambientwqc_ammoniasalt1989.pdf. Interpolation was used across all readings as part of the calculation. Because all ammonia results were greater than the determined CMC, STFATE modeling will be performed on the result requiring the greatest dilution to meet the limiting permissible criteria.

3.4.2 Metals

Trace metals analyses were performed for the list of analytes shown in Table 13-3 of the QAPP. No metals concentrations for elutriate or site water samples were greater than the CMC. Beryllium, cadmium, mercury, selenium, silver, and thallium were not detected in concentrations greater than the MRL in any sample. All other metals analyzed were detected in concentrations greater than the MRL in at least one of the elutriate samples or the site water sample. All metals met the target detection limits specified in the SERIM. No concentration for any metal exceeded its corresponding CMC, where applicable. A summary of the results is shown in Exhibit 3-8. Table 9 contains complete analytical results for trace metals.

Exhibit 3-8. Summary of Elutriate and Site Water Metals Results

Analyte	Concentration (µg/L)					
	SYC14-AC	SYC14-TB1	SYC14-TB2	SYC14-SW	SYC14-ODMDS-SW	CMC
Antimony	1.45	1.97	1.44	0.516	0.756	x
Arsenic	18.9	30.2	24.8	1.60	0.98	69
Beryllium	0.006	0.008	0.009	0.010	0.001	x
Cadmium	0.010	0.009	0.008	0.019	0.012	40
Chromium	0.30	0.41	0.43	0.37	0.16	1100
Copper	0.243	0.258	0.298	0.844	0.194	4.8
Lead	0.25	0.09	0.10	0.16	0.01	210
Mercury	ND	ND	ND	ND	ND	1.8
Nickel	0.35	0.41	0.41	0.52	0.20	74
Selenium	ND	0.27	0.26	ND	0.26	290
Silver	0.003	0.002	ND	ND	ND	1.9
Thallium	ND	ND	ND	0.014	0.012	x
Zinc	0.7	0.6	0.7	1.1	0.2	90

x = No CMC published for this parameter.
ND indicates the analyte was not detected at or above the MDL.

3.4.3 Pesticides

The analysis of chlorinated pesticides was performed for the list shown in Table 13-3 of the QAPP. No pesticide concentration for elutriate or site water samples was greater than the CMC. No pesticide concentration was greater than the MRL in any sample. With the exception of technical chlordane and toxaphene, all laboratory reporting limits met the target detection limits specified in the SERIM. For technical chlordane and toxaphene, the MDL is used for comparison to the CMC stated in Table 13-3. Since all results are below the MRL for pesticides, no summary exhibit is included as part of this section. Table 10 contains complete results for trace metals analyses.

3.5 Suspended Particulate and Elutriate Phase Bioassay Data

The results of the water column toxicity tests are presented in this section. The water column tests were performed with the mysid crustacean *Americamysis bahia* (opossum shrimp), the atherinoid fish *Menidia beryllina* (inland silverside), and larvae of the bivalve mollusk *Mytilus edulis* (blue mussel). Elutriate test results are compared to results of the control (Hood Canal water). The complete laboratory report is in Appendix G.

3.5.1 *Americamysis bahia* Test Results

The analysis of *A. bahia* was initiated on July 2, 2014, concluded on July 6, 2014. and was within the EPA recommended holding time of 8 weeks after collection of the sediment sample.

The 100% elutriate concentration of samples SYC14-AC, SYC14-TB1, and SYC14-TB2 resulted in 2%, 0% and 0% mean survival, respectively, and were significantly different than that of the

control. The estimated LC_{50} values for samples SYC14-AC, SYC14-TB1, and SYC14-TB2 were 62.4%, 52%, and 41.4%, respectively.

Ammonia concentrations observed in the *A. bahia* test are summarized in Table 11. The 100% elutriate concentration for each sample and the 50% elutriate concentration for samples SYC14-TB1 and SYC14-TB2 had measured ammonia concentrations that were above the no-observed-effect-concentration (NOEC) values derived from the ammonia reference-toxicant test. This indicates that ammonia concentrations within the elutriate samples could have been a contributor to adverse biological effects observed in the test treatments.

An ammonia-reduced sediment elutriate for each of the test sediments was included in this test batch (designated by the sample name plus -AR). The ammonia reductions followed the methods cited in Section 2.3 of the ENVIRON report and were performed on whole sediment prior to elutriate preparation. Following ammonia reduction, the mean percent survival in the 100% elutriates for samples SYC14-AC, SYC14-TB1, and SYC14-TB2 improved from 2%, 0%, and 0% in the unreduced sample to 94%, 88%, and 98%, respectively. Mean percent survival in the ammonia-reduced treatments were not significantly different from the control, and the estimated LC_{50} values were >100% for all three treatments. The test results indicated that the toxicity in the unreduced elutriates was ameliorated by the ammonia-reduction procedure.

Test results are summarized in Exhibit 3-9 and complete results are provided in Tables 11 and 12.

Exhibit 3-9. Summary of 100% Concentration Data for *Americamysis bahia*

Sample ID	Concentration (%)	Mean Survival (%)	Statistically Less than Control (yes/no)	LC_{50} (%)
Control		96		
SYC14-SW		94	No	
SYC14-AC	100	2	Yes	62.4
SYC14-TB1	100	0	Yes	52.0
SYC14-TB2	100	0	Yes	41.4
SYC14-AC-AR	100	94	No	>100
SYC14-TB1-AR	100	88	No	>100
SYC14-TB2-AR	100	98	No	>100

3.5.2 *Menidia beryllina* Test Results

The analysis of *M. beryllina* was initiated on July 2, 2014, concluded on July 6, 2014, and was within the EPA recommended holding time of 8 weeks after collection of the sediment sample.

Mean percentage survival in the 100% elutriate preparations for samples SYC14-AC, SYC14-TB1, and SYC14-TB2 were 0% and were significantly different from the control. The estimated LC_{50} values for these samples were 28.2%, 22.4%, and 21.1%, respectively.

Ammonia concentrations observed in the *M. beryllina* elutriate test are summarized in Table 13. On Day 0, the un-ionized ammonia (UIA) concentrations exceeded the reference-toxicant-

derived NOEC for the 100% elutriate treatments for all test treatments. On Day 4, the UIA was above the NOEC for the 50% elutriate dilution for the SYC14-AC sample. On Day 0, the total ammonia concentration for sample SYC14-TB1 was also above the NOEC calculated from the reference-toxicant test. This suggested that ammonia may have played a role in elutriate toxicity observed in these treatments.

An ammonia-reduced sediment elutriate for each of the test sediments was included in this test batch (designated by the sample name plus -AR). Ammonia reductions followed the methods cited in Section 2.3 of the ENVIRON report and were performed on whole sediment prior to elutriate preparation. Following ammonia reduction, the mean percent survival in the 100% elutriates for samples SYC14-AC, SYC14-TB1, and SYC14-TB2 improved from 0% in all of the unreduced samples to 94%, 90%, and 96%, respectively. Mean percent survival in the ammonia-reduced treatments were not significantly different from the control, and the estimated LC_{50} values were >100% for all three treatments. The results of this test indicated that the toxicity in the unreduced elutriates was ameliorated by the ammonia-reduction procedure.

Test results are summarized in Exhibit 3-10, and complete results are provided in Tables 13 and 14.

Exhibit 3-10. Summary of 100% Concentration Data for *Menidia beryllina*

Sample ID	Concentration (%)	Mean Survival (%)	Statistically Less than Control (yes/no)	LC_{50} (%)
Control		90		
SYC14-SW		92	No	
SYC14-AC	100	0	Yes	28.2
SYC14-TB1	100	0	Yes	22.4
SYC14-TB2	100	0	Yes	21.1
SYC14-AC-AR	100	94	No	>100
SYC14-TB1-AR	100	90	No	>100
SYC14-TB2-AR	100	96	No	>100

3.5.3 *Mytilus edulis* Test Results

The water column test with *M. edulis* was initiated on June 28, 2014, concluded on June 30, 2014, and was within the EPA recommended holding time of 8 weeks after collection of the sediment sample.

As noted in Section 2-3 of the ENVIRON report, ammonia concentrations in the bulk sediment of for each test sample were sufficiently elevated to predict ammonia-related impacts in the elutriate test with larval mussels. Based on this observation, elutriate was prepared with ammonia-reduced sediment and tested concurrently with the standard elutriate preparation.

The estimated EC_{50} values for samples SYC14-AC, SYC14-TB1, and SYC14-TB2 that did not have the ammonia reduced were 15.5, 14.8, and 14.0%, respectively. Mean survivorship rates in the 100% and 50% elutriate concentrations were 0%. The estimated EC_{50} values for samples

SYC14-AC, SYC14-TB1, and SYC14-TB2 that did have the ammonia reduced were all >100%. Mean survivorship rates in the 100% elutriate concentrations were 78.1%, 76.1%, and 77.6%. Normal development and survivorship greatly increased in the ammonia-reduced treatments. Mean survivorship rates in the 100% concentration of the ammonia-reduced elutriate samples were not significantly different than that of the control. Observed toxicity in each sample was ameliorated by the ammonia-reduction procedure.

Test results are summarized in Exhibit 3-11, and complete results are provided in Tables 15 and 16.

Exhibit 3-11. *Mytilus edulis* Control Acceptability Results

Treatment	Mean Proportion Normal (%) ≥70%	Mean Proportion Survival (%) ≥90%	Mean Combined Normal Development (%)[1]	Meet Acceptability Criteria?
Control	96.0	85.9	82.5	Qualified

[1]Calculated as the number of normally developed embryos/number of embryos stocked (stocking density).

Exhibit 3-12. Summary of 100% Concentration Data for *Mytilus edulis*

Sample ID	Concentration (%)	Mean Normal Survivalship[1,2] (%)	Statistically Less than Control (yes/no)	EC_{50}[2] (%)
Control		82.5		
CPA14-SW		81.3	No	
SYC14-AC	100	0	Yes	15.5
SYC14-TB1	100	0	Yes	14.8
SYC14-TB2	100	0	Yes	14.0
SYC14-AC-AR	100	78.1	No	>100
SYC14-TB1-AR	100	76.1	No	>100
SYC14-TB2-AR	100	77.6	No	>100

[1] Calculated as the number of normally developed embryos/number of embryos stocked (stocking density).
[2] Values derived from CETIS statistical output.

3.6 Solid Phase Bioassay Data

Results of the benthic toxicity tests are presented in this section. The benthic tests were performed with two amphipod species (*Ampelisca abdita* and *Leptocheirus plumulosus)* and a polychaete worm (*Neanthes arenaceodentata)*.

3.6.1 *Leptocheirus plumulosus* Test Results

The 10-day benthic test with *L. plumulosus* was initiated on June 27, 2014, and was validated by 91% survival in the control sample, meeting the acceptability criterion of ≥90%.

Mean survival within the *L. plumulosus* benthic test ranged from 52% to 70%. Survival within all samples were statistically different from that of the reference SYC14-REF. Mean percent survival in all treatments was greater than 20% of the reference (97%). Test results are presented in Tables 17 and 18.

Based on the results, an investigation into the cause of the low survival was conducted by ENVIRON, which concluded that the most likely cause was higher levels of fines (silt and clay) in the samples. A copy of the discussion provided by ENVIRON is attached in Appendix J as *Shipyard Creek Benthic Amphipod Discussion.pdf*. The analysis was performed a second time using *Ampelisca abdita*, which is also recommended by EPA Region 4 for conducting the amphipod test.

3.6.2 *Ampelisca abdita* Test Results

The 10-day benthic test with *A. abdita* was initiated on July 28, 2014, and was validated by 98% survival in the control sample, thus meeting the acceptability criterion of ≥90%. All samples were treated for ammonia reduction in accordance with Appendix N of the SERIM.

Mean survival within the *A. abdita* benthic test ranged from 96% to 98%. Survival within all samples was not statistically different from that of the reference SYC14-REF. Mean percent survival in all treatments was within 20% of the reference (97%), indicating that the test treatments met the LPC for disposal. Results are summarized in Exhibit 3-13, and complete results are provided in Tables 19 and 20.

Exhibit 3-13. Summary of Survival Data for *Ampelisca abdita*

Sample ID	Mean Survival (%)	Standard Deviation	Statistically Less than Reference?
Control	98	4.5	
SYC14-REF	97	2.7	
SYC14-AC	96	2.2	No
SYC14-TB1	97	2.7	No
SYC14-TB2	98	2.7	No

3.6.3 *Neanthes arenaceodentata* Test Results

The 10-day benthic test with *N. arenaceodentata* was initiated on June 20, 2014, and was validated by 100% survival in the control sample, thus meeting the acceptability criterion of ≥90%.

Mean survival within the *N. arenaceodentata* benthic test ranged from 94% to 100%. Survival within all samples was not found to be statistically different from that of the reference SYC14-REF. Mean percent survival in all treatments was within 10% of the reference (98%), indicating that the test treatments met the LPC for disposal. Results are summarized in Exhibit 3-14, and complete results are provided in Tables 21 and 22.

Exhibit 3-14. Summary of Survival Data for *Neanthes arenaceodentata*

Sample ID	Mean Survival (%)	Standard Deviation	Statistically Less than Reference?
Control	100	0.0	
SYC14-REF	98	4.5	
SYC14-AC	96	8.9	No
SYC14-TB1	94	8.9	No
SYC14-TB2	100	0.0	No

3.7 Bioaccumulation Data

3.7.1 Survival Data

Bioaccumulation potential was determined by a 28-day exposure to the treatment samples. The bioaccumulation test was conducted with the polychaete *Neanthes* (formerly *Nereis*) *virens* and the clam *Macoma nasuta*. Following laboratory exposures, the gut contents of the test organisms were purged for 24-hours in clean seawater in the absence of sediment. *M. nasuta* were then shucked for tissue collection, placed in certified pre-cleaned glass jars, and frozen. *N. virens* organisms were also placed in certified pre-cleaned glass containers and frozen. Tissues from all treatments (with the exception of the laboratory control) were delivered to ALS Environmental in Kelso, Washington, for chemical analysis.

The 28-day bioaccumulation tests with *N. virens* and *M. nasuta* were initiated on June 26, 2014. Mean survival in the control samples was 100% for *N. virens* and 100% for *M. nasuta*. Reference survival was 98% for *N. virens* and 93% for *M. nasuta*. Mean percent survival was greater than 91% for all test composites for both test species. Results are summarized in Exhibit 3-15, and complete results are provided in Tables 23 and 24.

Exhibit 3-15. Summary of Survival Data for *Neanthes virens* and *Macoma nasuta*

Sample ID	*N. virens*		*M. nasuta*	
	Mean Survival (%)	Standard Deviation	Mean Survival (%)	Standard Deviation
Control	100	0.0	100	0.0
SYC14-REF	98	2.7	93	4.9
SYC14-AC	100	0.0	91	9.2
SYC14-TB	98	4.5	93	9.4

3.7.2 Tissue Chemistry

Wet and dry weight tissue chemistry results for *N. virens* and *M. nasuta* are presented in Tables 25 through 42 where they are compared to the reference (SYC14-REF) and to applicable levels, thresholds, and concentrations. The tissue chemistry laboratory reports are in Appendix E-4. Complete results of statistical analyses and transformations are in Appendix F.

3.7.2.1 Lipids and Total Solids in Tissue

Total solids were analyzed for in *N. virens* and *M. nasuta* tissues from project, reference, and pre-exposure samples. Lipids were analyzed for pre-exposure tissue only.

Neanthes virens

Analytical results for total solids and lipids for *N. virens* are presented in Table 25. Total solids ranged from 14.9% to 16.8% in project, reference, and pre-exposure samples. Lipids ranged from 0.78% to 0.94% in pre-exposure samples.

Macoma nasuta

Analytical results for total solids and lipids for *M. nasuta* are presented in Table 26. Total solids ranged from 15.8% to 18.0% in project, reference, and pre-exposure samples. Lipids ranged from 0.58% to 0.64% in pre-exposure samples.

3.7.2.2 Metals in Tissue

Twelve metals were analyzed in *N. virens* and *M. nasuta* tissues from samples SYC14-AC, SYC14-TB, SYC14-REF, and the pre-exposure tissues based on past chemical analysis within the dredge area. See Section 2.3.2.2 for more details.

Neanthes virens

Results of wet and dry weight metals analyses of *N. virens* tissues are presented in Tables 27 and 29, respectively. The laboratory MRL met the target detection limits specified in the SERIM for all metals across all samples. All metals tested were detected in concentrations greater than the MRL in all samples, except for antimony, beryllium, and thallium. No sample mean result exceeded the FDA action level for crustacea for any metal tested. Mean metals concentrations in *N. virens* tissue samples are summarized in Exhibit 3-16. Sample SYC14-AC had two metals that were statistically significantly greater than the reference, shown in bold. Sample SYC14-TB did not have any metals statistically significantly greater than the reference.

Exhibit 3-16. Summary of Mean Wet Weight Metal Results for *Neanthes virens* Tissue

	Mean Concentration (mg/kg)			Concentration (mg/kg)		
Analyte:	**SYC14-AC**	**SYC13-TB**	**SYC14-REF**	**FDA Action Levels[1]**	**Eco. Effects Threshold[1]**	**South Atlantic Bight Background[1]**
Antimony	0.0040	0.0020	0.0023	x	x	<0.22
Arsenic	2.53	2.44	2.89	76	12.6	6.2 - 46
Beryllium	0.0011	0.0007	0.0005	x	x	<0.22
Cadmium	0.0411	0.0413	0.0453	3	1.0	0.68-2.7
Chromium	0.312	0.180	0.151	12	10.0	2.8-7.1
Copper	2.55	2.31	1.84	x	0.4	2.5-3.5
Lead	0.0571	0.0530	0.0466	1.5	0.1	0.36-0.6
Mercury	0.0239	0.0256	0.0277	1	0.3	0.02-0.05
Nickel	**0.308**	0.187	0.164	70	2.2	1.6-3.5
Selenium	0.32	0.33	0.33	x	14.2	1.2-1.9
Silver	0.0191	0.0219	0.0212	x	1.0	<0.95
Thallium	0.00050	0.00018	0.00014	x	0.3	<0.22
Zinc	***39.5***	*28.2*	17.2	x	0.3	20-27

[1] Values are from the SERIM (Appendix H) and the *Fish and Fishery Products Hazards and Controls Guidance, Fourth Edition* (2011).

x = No FDA action level published for this parameter.

Concentrations in bold indicate that result is statistically significantly greater than the reference.

Concentrations that are underlined indicate results that are statistically significantly greater than the reference and average reference values that are below the MRL.

Concentrations that are italicized indicate the result is greater than either the ecological effects threshold or the South Atlantic Bight background concentration.

Macoma nasuta

Analytical results for wet and dry weight metals in *M. nasuta* tissues are presented in Tables 28 and 30, respectively. The laboratory MRL met the target detection limits specified in the SERIM for all metals across all samples. All metals tested were detected in concentrations greater than the MRL in all samples, except for thallium in samples SYC14-AC and SYC14--REF. No sample mean result exceeded the FDA action level for bivalves for any metal tested. Mean concentrations of metals in *M. nasuta* tissue samples are summarized in Exhibit 3-17.

Exhibit 3-17. Summary of Mean Wet Weight Metals Results for *Macoma nasuta* Tissue

	Mean Concentration (mg/kg)			Concentration (mg/kg)		
Analyte:	**SYC14-AC**	**SYC13-TB**	**SYC14-REF**	**FDA Action Levels[1]**	**Eco. Effects Threshold[1]**	**South Atlantic Bight Background[1]**
Antimony	0.0144	0.0107	0.0175	x	x	<0.16
Arsenic	4.27	4.59	4.63	86	12.6	4.4-8.6
Beryllium	**0.0081**	**0.0062**	0.0038	x	x	<0.19
Cadmium	0.0455	0.0386	0.0425	4	1.0	0.68-2.7
Chromium	0.609	0.628	0.548	13	6.3	0.4-4.6
Copper	*3.73*	***4.65***	*3.56*	x	0.2	1.2-2.9
Lead	***0.287***	***0.216***	*0.130*	1.7	0.1	0.05-0.77
Mercury	0.0189	0.0220	0.0230	1.0	0.3	<0.02
Nickel	0.584	0.491	0.546	80.0	2.2	0.9-3.7
Selenium	0.45	0.45	0.46	x	14.2	0.70-1.4
Silver	0.0375	**0.0473**	0.0370	x	1.0	<0.96
Thallium	**0.0043**	0.0016	0.0011	x	0.3	<0.10
Zinc	*18.6*	*17.4*	*17.9*	x	11.6	10-20

[1] Values are from the SERIM (Appendix H) and the *Fish and Fishery Products Hazards and Controls Guidance, Fourth Edition* (2011).

x = No FDA action level published for this parameter

Concentrations in bold indicate that result is statistically significantly greater than the reference.

Concentrations that are underlined indicate results that are statistically significantly greater than the reference and average reference values that are below the MRL.

Concentrations that are italicized indicate the result is greater than either the ecological effects threshold or the South Atlantic Bight background concentration.

3.7.2.3 PAHs in Tissue

Based on sediment chemistry results, 18 PAHs were analyzed in *N. virens* and *M. nasuta* tissues from samples SYC14-AC, SYC14-TB, SYC14-REF, and the pre-exposure tissues. See Section 2.3.2.2 for more details.

Neanthes virens

Results of wet and dry weight PAH analyses of *N. virens* tissues are presented in Tables 31 and 33, respectively. The laboratory MRL met the target detection limits specified in the SERIM for all PAHs across all samples. Sample SYC14-AC had concentrations of 1-methylnaphthalene, acenaphthene, fluoranthene, fluorene, and pyrene, and sample SYC14-TB had concentrations of fluoranthene and pyrene that were detected above the MRL in at least two replicates. No other PAHs were detected in concentrations greater than the MRL in any sample. In samples SYC14-AC and SYC14-TB, total HMW PAHs, fluoranthene, and pyrene had mean adjusted concentrations that were statistically significantly greater than in the reference tissues. Exhibit 3-14 provides a summary of mean adjusted wet weight PAH concentrations detected above the MRL with a comparison to the reference tissues, ecological effects threshold, and South Atlantic Bight background concentrations.

Exhibit 3-18. Summary of Mean Wet Weight PAH Results for *Neanthes virens* Tissue

Analyte:	Mean Concentration (µg/kg)			Concentration (µg/kg)	
	SYC14-AC	SYC14-TB	SYC14-REF	Ecological Effects Threshold[1]	S. Atl. Bight Background[1]
Total HMW PAHs	**17**	**23**	7.4	x	60.0
Fluoranthene	**6.2**	**10**	1.3	12.8	<20
Pyrene	**7.4**	**9.4**	1.2	x	<20

[1] Values are from the SERIM (Appendix H) and the *Fish and Fishery Products Hazards and Controls Guidance, Fourth Edition* (2011).

x = No FDA action level published for this parameter

Concentrations in bold indicate that result is statistically significantly greater than the reference.

Concentrations that are underlined indicate results that are statistically significantly greater than the reference and average reference values that are below the MRL.

Macoma nasuta

Results of wet and dry weight PAH analyses of *M. nasuta* tissues are presented in Tables 32 and 34, respectively. The laboratory MRL met the target detection limits specified in the SERIM for all PAHs across all samples. Approximately half of the PAHs analyzed had concentrations greater than the MRL in at least two of the replicates for both project samples. In both samples, total LMW PAHs, total HMW PAHs, total PAHs, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, and pyrene had mean adjusted concentrations that were statistically significantly greater than in the reference tissues. Sample SYC14-TB also had a mean adjusted anthracene concentration greater than the reference tissues. The mean adjusted concentration in at least one project sample exceeded the ecological effects threshold or South Atlantic Bight background concentration for total HMW PAHs, total PAHs, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, and pyrene. Exhibit 3-19 provides a summary of mean adjusted wet weight PAH concentrations detected above the MRL with a comparison to the reference tissues, ecological effects threshold, and south Atlantic Bight background concentrations.

Exhibit 3-19. Summary of Mean Wet Weight PAH Results for *Macoma nasuta* Tissue

Analyte:	Mean Concentration (µg/kg)			Concentration (µg/kg)	
	SYC14-AC	SYC14-TB	SYC14-REF	Eco. Effects Threshold[1]	S. Atl. Bight Background[1]
Total LMW PAHs	**10**	**14**	7.2	x	60.0
Total HMW PAHs	***76***	***172***	7.2	x	60.0
Total PAHs	**103**	***219***	18	40000	170
Anthracene	2.2	**4.8**	0.38	x	<20
Benzo(a)anthracene	**12**	***31***	1.3	x	<20
Benzo(a)pyrene	**10**	***22***	1.5	x	<20
Benzo(b)fluoranthene	***23***	***49***	1.5	x	<20
Benzo(k)fluoranthene	**9.0**	**18**	1.3	x	<20
Chrysene	**9.9**	***29***	0.78	x	<20
Fluoranthene	***27***	***64***	2.7	8.8	<20
Pyrene	***35***	***69***	2.0	x	<20

[1] Values are from the SERIM (Appendix H) and the *Fish and Fishery Products Hazards and Controls Guidance, Fourth Edition* (2011).

x = No FDA action level published for this parameter

Concentrations in bold indicate that result is statistically significantly greater than the reference.

Concentrations that are underlined indicate results that are statistically significantly greater than the reference and average reference values that are below the MRL.

Concentrations that are italicized indicate the result is greater than either the ecological effects threshold or the South Atlantic Bight background concentration.

3.7.2.4 Organotins in Tissue

Based on sediment chemistry results, three organotin cations (n-butyltin, di-n-butyltin, and tri-n-butyltin) were analyzed in *N. virens* and *M. nasuta* tissues from samples SYC14-AC, SYC14-TB, SYC14-REF, and pre-exposure tissue samples. See Section 2.3.2.2 for more details.

Neanthes virens

Results of wet and dry weight organotins analyses in *N. virens* tissues are presented in Tables 35 and 37, respectively. The laboratory MRL met the target detection limits specified in the SERIM for all organotins across all samples. No samples had concentrations of individual organotin cations or total organotins that were statistically significantly greater than the reference or that exceeded the tri-n-butyltin ecological effects threshold.

Macoma nasuta

Results of wet weight and dry weight organotins in *M. nasuta* tissues are presented in Tables 36 and 38, respectively. The laboratory MRL met the target detection limits specified in the SERIM for all organotins across all samples. N-butyltin was the only cation detected in concentrations greater than the MRL in two or more replicates in SYC14-TB and SYC14-REF. Total organotins and n-butyltin had mean concentrations statistically significantly greater than the reference. FDA action limits, ecological effects thresholds, and South Atlantic Bight background concentrations are not available for these analytes.

Exhibit 3-20. Summary of Mean Wet Weight Organotins Results for *Macoma nasuta* Tissue

Analyte:	Total Organotins as Tin (µg/kg)	n-butyltin Cation (µg/kg)
SYC14-TB	**18**	**24**
SYC14-REF	13	16

Concentrations in bold indicate that the result is statistically significantly greater than the reference.

3.7.2.5 Dioxins and Furans in Tissue

Based on sediment chemistry results, 17 dioxin and furan congeners were analyzed in *N. virens* and *M. nasuta* tissues from samples SYC14-AC, SYC14-TB, SYC14-REF, and pre-exposure tissue samples. See Section 2.3.2.2 for more details.

Neanthes virens

Results of wet and dry weight dioxins and furans analyses in *N. virens* tissues are presented in Tables 39 and 41, respectively. No dioxin or furan congeners had at least two replicate concentrations greater than the MRL, and statistical analysis was performed only on the total TEQ. The laboratory MDL met the target detection limits specified in the SERIM for most dioxins and furans, but slightly exceeded the target detection limit in several replicates for samples SYC14-AC and SYC14-TB for 2,3,7,8-TCDD and 2,3,7,8-TCDF. The mean concentration for both project samples statistically significantly exceeded the reference for the total TEQ and exceeded the South Atlantic Bight background, but this was due primarily to the elevated detection limits previously discussed. A summary of the total TEQ is presented in Exhibit 3-21.

Exhibit 3-21. Summary of Mean Wet Weight TEQ Results for *Neanthes virens* Tissues

Analyte:	SYC14-AC Comp	SYC14-TB Comp	SYC14-REF	S. Atlantic Bight Background[1]
Dioxin/Furan TEQ (ng/kg)	***1.70***	***1.32***	0.37	0.18-0.44

[1] Values are from the SERIM (Appendix H) and the *Guide for the Control of Molluscan Shellfish* (2007).

Concentrations in bold indicate that result is statistically significantly greater than the reference.
Concentrations that are italicized indicate the result is greater than either the ecological effects threshold or the South Atlantic Bight background concentration.

Macoma nasuta

Results of wet and dry weight dioxins and furans analyses in *M. nasuta* tissues are presented in Tables 40 and 42, respectively. The laboratory MRL met the target detection limits specified in the SERIM for all dioxins and furans. The mean concentration for both project samples statistically significantly exceeded the reference for the octachlorodibenzo-p-dioxin (OCDD), while the total TEQ for both samples exceeded the South Atlantic Bight background. A summary of the OCDD and total TEQ is presented in Exhibit 3-22.

Exhibit 3-22. Summary of Mean Wet Weight OCDD and TEQ Results for *Macoma nasuta* Tissues

Analyte:	SYC14-AC Comp	SYC14-TB Comp	SYC14-REF	S. Atlantic Bight Background[1]
OCDD	**19.3**	**23.4**	6.0	NA
Dioxin/Furan TEQ (ng/kg)	*0.987*	*2.32*	*1.15*	0.32-0.36

[1] Values are from the SERIM (appendix H) and the *Guide for the Control of Molluscan Shellfish* (2007).

Concentrations in bold indicate that result is statistically significantly greater than the reference.

Concentrations that are italicized indicate the result is greater than either the ecological effects threshold or the South Atlantic Bight background concentration.

NA = not available for this analyte

4 QUALITY ASSURANCE/QUALITY CONTROL

4.1 Field Sampling

Field sampling took place June 2 through 4, 2014. Sample compositing took place June 6 and 9, 2014. Sampling and compositing conformed to methods outlined in the QAPP.

During sample collection using the vibracore, recovery was consistently low at the first three sampling locations. Based on the recoveries from the first three sites, the remainder of the samples were accepted using similar recoveries. The total range of recoveries across all locations was 66% to 85%. The most likely reason for the low recoveries is a combination of compaction and some material falling from the core due to the liquid nature of the sediment.

Salinity was not measured in the field, but was instead analyzed at the chemistry laboratory.

4.2 Sample Receipt

4.2.1 AMEC

Sediment samples were received at AMEC on June 11, 2014, in good condition and consistent with the chain-of-custody form.

4.2.2 ALS Environmental

Sediment and site water samples were received at ALS Environmental on June 4 and 11, 2014, in good condition and consistent with the accompanying chain-of-custody form. The samples were stored at 4°C, and an aliquot of the sediment was frozen at -20°C upon receipt at the laboratory.

Tissue samples were received at ALS Environmental from NewFields on July 30, 2014, in good condition and consistent with the chain-of-custody form. The samples were stored in a freezer at -20°C upon receipt at the laboratory.

All analyses were performed consistent with ALS Environmental's QA program. This report contains analytical results for samples designated for Tier IV validation, including summary forms and all associated raw data for each analysis. When appropriate to the method, method blank results have been reported for each analytical test.

4.2.3 ENVIRON

All sediment and site water samples were collected between June 2 and 4, 2014, and were received at ENVIRON on June 11, 2014. Custody seals on the containers were received intact. Temperatures of the samples upon receipt ranged from 1.5ºC to 4.1ºC. One cubitainer of site water was received at 8ºC, which is slightly above the recommended temperature range of 4 C ± 2ºC. Sufficient site water was provided in multiple cubitainers and this container was excluded for testing. Site water and sediment samples were stored in a walk-in cold room at 4 C ± 2ºC in the dark. Test sediment was not sieved prior to testing. All tests were conducted within the 8-week (56-day) sediment holding time.

4.3 Physical Analysis

All physical analyses were performed by AMEC, and the results met the quality control criteria specified in the QAPP.

4.4 Sediment Chemistry

4.4.1 General Chemistry

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

4.4.2 Organotins

4.4.2.1 Calibration Verification

The analysis of butyltins by Krone requires the use of dual column confirmation. When the continuing calibration verification (CCV) criterion is met for both columns, the lower of the two sample results is generally reported. The primary evaluation criteria were not met on the confirmation column for n-butyltin. The results were reported from the column with an acceptable CCV and data quality was not affected. No further corrective action was necessary.

4.4.2.2 Matrix Spike Recovery

The matrix spike recovery of n-butyltin for sample SYC14-AC was outside control criteria. Recovery in the laboratory control sample (LCS) was acceptable, which indicated the analytical batch was in control. The matrix spike outlier suggested a potential bias in this matrix. No further corrective action was appropriate.

4.4.3 Polycyclic Aromatic Hydrocarbons by EPA Method 8270D SIM

4.4.3.1 Matrix Spike Recovery

The matrix spike recovery for several PAHs in sample SYC14-AC were outside control criteria. Recovery in the laboratory control sample (LCS) was acceptable, which indicated the analytical batch was in control. The matrix spike outlier suggested a potential low bias in this matrix. No further corrective action was appropriate.

4.4.3.2 Relative Percent Difference

The relative percent difference (RPD) criterion for the replicate analysis of numerous analytes in sample SYC14-TB was not applicable because the analyte concentration was not significantly greater than the MRL. Analytical values derived from measurements close to the detection limit are not subject to the same accuracy and precision criteria as results derived from measurements higher on the calibration range for the method.

4.4.3.3 Standard Reference Material

The advisory criterion was exceeded for fluorene and benzo(a)pyrene in the standard reference material (SRM). The true values listed for the SRM are surrogate corrected concentrations while the reported analytical results were not surrogate corrected. The recovery information reported for these analytes is for advisory purposes only, providing additional detail related to the performance of each individual compound. No further corrective action was required.

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

4.4.4 PBDE by EPA Method 8270D

4.4.4.1 Calibration Verification

The upper control criterion was exceeded for PBDE 17 in one of the CCVs. The field samples analyzed in this sequence did not contain the analyte in question. Since the apparent problem indicated a potential high bias, the data quality was not affected and no further corrective action was required.

PBDE 209 was flagged as outside the control criterion for one CCV. In accordance with the EPA method, 80% or more of the CCV analytes must have passed within 20% of the true value. The remaining analytes are allowed a 40% difference as per the ALS SOP. The CCV met these criteria and no further corrective action was required.

4.4.4.2 Surrogates

The control criteria were exceeded for PBDE 47C13 in sample SYC14-TB due to matrix interference. A duplicate extraction and analysis was performed, but produced similar results. No further corrective action was required.

4.4.4.3 Matrix Spike Recovery

The matrix spike recoveries of PBDE 28, PBDE 190, PBDE 203, PBDE 206, and PBDE 209 for sample SYC14-AC were outside control criteria because of suspected matrix interference. A matrix spike duplicate was also analyzed, but produced similar results. The results of the original analysis were reported. No further corrective action was appropriate.

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

4.4.5 Dioxins

4.4.5.1 Method Blanks

The method blank contained low levels of 1,2,3,4,6,7,8-HpCDD, OCDD and 1,2,3,4,6,7,8-HpCDF at or below the MRL. The associated compounds in the samples are qualified with 'B' flags.

4.4.5.2 Laboratory Control Spike

An LCS sample was analyzed and reported in lieu of a matrix spike/matrix spike duplicate (MS/MSD) for this extraction batch. The recovery for 1,2,3,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, and 1234678-HxCDF in the LCS were slightly above the flagging limits. Control charting of the standard indicates that the standard is trending high but within the laboratory's process control limits. The bias was determined to be due to a concentration of the spiking standard, was removed from use, and was addressed in the laboratory's corrective action system. Since this spike is used only to fortify control samples, the associated sample results likely were not impacted.

4.5 Site Water and Elutriate Chemistry

4.5.1 General Chemistry Parameters

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

4.5.2 Total Metals

The control criteria for MS/MSD recoveries of arsenic for sample SYC14-AC-Elutriate were not applicable. The analyte concentration in the sample was significantly higher than in the added spike concentration, preventing accurate evaluation of the spike recoveries.

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

4.5.3 Organochlorine Pesticides by EPA Method 8081

Most spike recoveries were below the acceptance limit. However, the RPD was within acceptance limits. This indicates a matrix interference in the sample.

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

4.6 Tissue Chemistry

4.6.1 Total Metals

4.6.1.1 Matrix Spike Recovery

The matrix spike recovery of zinc for sample Nv SYC14-AC Rep. 4 was outside the ALS control criteria as a result of the heterogeneous character of the sample as found in the replicate analysis. Since the unspiked samples contained high analyte concentrations relative to the amount spiked, the variability between replicates was sufficient to bias the percent recoveries outside normal ALS Environmental control criteria. The associated QC results indicated the analysis was in control, and no further corrective action was appropriate.

The matrix spike recovery of silver for sample Nv SYC14-REF Rep. 1 was outside control criteria. Recovery in the LCS was acceptable, which indicated the analytical batch was in control. The matrix spike outlier suggested a potential bias in this matrix. No further corrective action was appropriate.

The matrix spike recoveries of antimony and silver for sample Mn SYC14-TB Rep.2 and silver for sample Mn SYC14-REF Rep.5 were outside control criteria. Recovery in the LCS was acceptable, which indicated the analytical batch was in control. The matrix spike outliers suggested a potential low bias in this matrix. No further corrective action was appropriate.

4.6.1.2 Relative Percent Difference

The RPD for the replicate analysis of zinc in samples Nv SYC14-AC Rep.4 and Nv SYC14-REF Rep.1 was outside the project-specified control limits. The samples were homogenized, freeze-dried, then ground prior to digestion; however, this was not sufficient to achieve a completely uniform distribution of zinc in the tissue.

4.6.1.3 Standard Reference Material

Lead recovery in the SRM was below the normal ALS Environmental control limit. The lead concentration in the SRM was relatively low compared to the sensitivity of the analytical procedure. The associated QC results indicate the analysis was in control, and no further corrective action was appropriate.

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

4.6.2 Organotin Compounds

4.6.2.1 Matrix Spike

Due to limited sample mass, only one MS/MSD for organotins was run. All other batch and sample QC were acceptable.

4.6.2.2 Relative Percent Difference

The RPD criterion for the replicate analysis of n-butyltin in sample Mn SYC14-REF Rep. 4 was not applicable because the analyte concentration was not significantly greater than the reporting limit. Analytical values derived from measurements close to the detection limit are not subject to the same accuracy and precision criteria as results derived from measurements higher on the calibration range for the method.

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

4.6.3 Polynuclear Aromatic Hydrocarbons by EPA Method 8270

4.6.3.1 Standard Reference Material

The advisory criterion was exceeded for benzo(a)pyrene in one SRM. The true values listed for the SRM are surrogate-corrected concentrations, while the reported analytical results were not surrogate-corrected. The recovery information reported for these analytes is for advisory purposes only, providing additional detail related to the performance of each individual compound. No further corrective action was required.

4.6.3.2 Calibration Verification

Benzo(g,h,i)perylene was flagged as outside the control criterion for one CCV. In accordance with the EPA method, 80% or more of the CCV analytes must have passed within 20% of the true value. The remaining analytes are allowed a 40% difference per the ALS Environmental SOP. The CCV met these criteria and no further corrective action was required.

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

4.6.4 Dioxins

The method blank contained low levels of 1,2,3,4,6,7,8-HpCDD, OCDD, 1,2,3,4,6,7,8-HpCDF, and OCDF at or below the MRL. The associated compounds in the samples are qualified with 'B' flags.

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

4.7 Toxicology

The QA objectives for toxicity testing are detailed in the Green Book and in the laboratory's QA manual. The objectives for accuracy and precision involve all aspects of the testing process, including the following:

- Water and sediment sampling and handling
- Source and condition of test organisms
- Condition of equipment

- Test conditions
- Instrument calibration
- Use of reference toxicants
- Record-keeping
- Data evaluation

Each test organism was evaluated in reference toxicant tests to establish the sensitivity of the test organisms. The reference toxicant LC_{50} or EC_{50} should fall within two standard deviations of the historical laboratory mean. Water quality measurements were monitored to ensure they fell within prescribed limits.

The methods employed in every phase of the toxicity testing program are detailed in ENVIRON's standard operating practices. All ENVIRON staff members receive regular documented training in all standard operating practices and test methods. All data collected and produced as a result of the testing process were recorded on approved data sheets. If an aspect of a test deviated from protocol, the test was evaluated to determine if it was valid according to the regulatory agencies responsible for approving the proposed permitting action.

4.7.1 Water Column Toxicology

4.7.1.1 *Americamysis bahia*

The water-column test with *A. bahia* was initiated on July 2, 2014. The mysid test was validated by 96% mean survival in the seawater control, thus meeting the acceptability criterion of at least 90%. Mean percent survival in the site water sample was 94%, indicating that the site water was acceptable for testing.

Water quality parameters were within target limits throughout the duration of the 96-hour test with the exception of temperature. Temperatures were above the recommended limit of 20 ± 1°C on Days 3 and 4.

The LC_{50} for the ammonia reference-toxicant test was 24.2 mg/L total ammonia and was within two standard deviations (14.2 to 55.2 mg/L total ammonia) of the laboratory mean (34.7 mg/L total ammonia) at the time of testing, indicating that the organisms obtained from this supplier were similar in sensitivity to those previously tested at the ENVIRON laboratory. The LC_{50} value for the UIA reference-toxicant test was 0.364 mg/L and the no observed effects concentration (NOEC) was 0.353 mg/L UIA.

4.7.1.2 *Menidia beryllina*

The water-column test with *M. beryllina* was initiated on July 2, 2014. The *Menidia* test was validated by 90% mean survival in the control meeting the acceptability criterion of at least 90%. Mean percent survival in the site water sample was 92%, indicating that the site water was acceptable for testing.

Water quality parameters were within the target limits throughout the duration of the 96-hour test with the exception of temperature. Temperatures rose above the recommended limit of 20 ± 1°C on Days 3 and 4.

The LC_{50} for the ammonia reference-toxicant test was 16.5 mg/L total ammonia and was within two standard deviations (6.5 to 46.7 mg/L total ammonia) of the laboratory mean (26.6 mg/L total ammonia) at the time of testing, indicating that the population of test organisms used in this test was similar in sensitivity to those previously tested at the ENVIRON laboratory. The un-ionized LC_{50} value for the ammonia reference-toxicant test was 0.177 mg UIA and the NOEC was 0.157 mg/L UIA.

4.7.1.3 *Mytilus edulis*

The water column test with *M. edulis* was initiated on June 28, 2014. The larval mussel test resulted in 96.0% normal development (proportion normal) and 85.9% survival (proportion survival) in the control, thus meeting the recommended criteria of at least 70% proportion normal and slightly below the 90% proportion survival. The embryo stocking density was 26.6 embryos/mL of test solution, within the recommended density of 15 to 30 embryos/mL. A review of both the initial stocking density and the sample stocking density showed a slightly high bias for the initial density, indicating that the number of larval organisms in each sample replicate was approximately 10% lower based on the counts for normal and abnormal development. Mean survivorship in the site water control was 81.3%, indicating that the site water was suitable for testing and likely did not contribute to any potential reduced biological response observed in the elutriate preparations.

All water quality parameters were within target limits throughout the duration of the 48-hour test.

The EC_{50} for the ammonia reference-toxicant test was 1.06 mg/L total ammonia and was within two standard deviations (0.9 to 9.2 mg/L total ammonia) of the laboratory mean (5.0 mg/L total ammonia) at the time of testing, indicating that the population of test organisms used in this test was similar in sensitivity to those previously tested at the ENVIRON laboratory. The un-ionized EC_{50} value for the ammonia reference-toxicant test was 0.030 mg UIA, and the NOEC was 0.015 mg/L UIA.

4.7.2 Benthic Toxicology

4.7.2.1 *Leptocheirus plumulosus*

The 10-day benthic test with *L. plumulosus* was initiated on June 27, 2014, and was validated by 91% survival in the control sample, thus meeting the acceptability criterion of at least 90%. Water quality parameters were within the acceptable limits throughout the 10-day test with the exception of minor deviations in temperature. Temperatures were recorded slightly below the recommended limits, but were within the tolerance range of the test organisms.

The LC_{50} for the ammonia reference-toxicant test was 153.8 mg/L total ammonia and was within two standard deviations of the laboratory mean (91.0; range 0 to 188.1 mg/L total ammonia) at the time of testing, indicating that the test organisms used in this test were of similar sensitivity to those previously tested at the ENVIRON laboratory. The un-ionized LC_{50} value for the ammonia reference-toxicant test was 1.72 mg UIA, and the NOEC was 1.32 mg/L UIA. Ammonia concentrations measured within the benthic test were below the ammonia reference-toxicant test derived NOEC values at test initiation and termination.

Upon review of the low survival rates for *Leptocheirus plumulosus*, it was determined that the cause was related to the high silt and clay in the project samples. The testing was setup for re-analysis using *Ampelisca abdita*, which is also an approved amphipod species for EPA Region 4.

4.7.2.2 *Ampelisca abdita*

The 10-day benthic test with *A. abdita* was initiated on July 28, 2014, and was validated by 98% survival in the control sample, thus meeting the acceptability criterion of at least 90%. Water quality parameters were within the acceptable limits throughout the 10-day test.

The LC_{50} for the ammonia reference-toxicant test was 41.9 mg/L total ammonia and was within two standard deviations of the laboratory mean (52.1; range 17.0 to 87.3 mg/L total ammonia) at the time of testing, indicating that the test organisms used in this test were of similar sensitivity to those previously tested at the ENVIRON laboratory. The unionized LC_{50} value for the ammonia reference-toxicant test was 0.559 mg UIA, and the NOEC was 0.334 mg/L UIA. Ammonia concentrations measured within the benthic test were below the ammonia reference-toxicant test derived NOEC values at test initiation and termination.

Based on survival for the *Ampelisca abdita* and all other test species except *Leptocheirus plumulosus*, the results indicated that the low survival in the *Leptocheirus plumulosus* is related to the high percentage of fines and does not show high levels of toxicity in the sediment.

4.7.2.3 *Neanthes arenaceodentata*

The 10-day benthic test with *N. arenaceodentata* was initiated on June 20, 2014, and was validated by 100% survival in the control sample, thus meeting the acceptability criterion of at least 90%.

Water quality parameters were within acceptable limits throughout the 10-day test with the exception of minor deviations in temperature. Temperatures were recorded slightly above the recommended limits, but were within the tolerance range of the test organisms.

The LC_{50} for the 96-hour ammonia reference-toxicant test was 201.3 mg/L total ammonia and was within two standard deviations of the laboratory mean (151.3; range 54.8 to 247.8 mg/L total ammonia) at the time of testing, indicating that the population of test organisms used in this test was of similar sensitivity to those previously tested at the ENVIRON laboratory. The un-ionized LC_{50} value for the ammonia reference-toxicant test was 2.11 mg UIA, and the NOEC was 1.90 mg/L UIA.

4.7.3 Bioaccumulation

Assessment of bioaccumulation potential was determined by a 28-day exposure to the treatment samples. The bioaccumulation test was conducted with the polychaete *Neanthes* (formerly *Nereis*) *virens* and the clam *Macoma nasuta*. Following laboratory exposures, the gut contents of the test organisms were purged for 24 hours in clean seawater in the absence of sediment. *M. nasuta* were then shucked for tissue collection, placed in certified pre-cleaned glass jars, and frozen. *N. virens* organisms were also placed in certified pre-cleaned glass containers and frozen. Tissues from all treatments (with the exception of the laboratory control) were delivered to ALS Environmental for chemical analysis.

The 28-day bioaccumulation tests with *N. virens* and *M. nasuta* were initiated on June 26, 2014. Mean survival rates in the control samples were 100% for *N. virens* and 100% for *M. nasuta*. Reference survival was 98% for *N. virens* and 93% for *M. nasuta*. Mean percent survival was greater than 91% for all test composites for both test species.

Deviations from targeted water quality parameters for temperature were noted during both bioaccumulation tests, and appropriate actions were taken to remedy the issues. While some measurements were outside the laboratory targets, there were no deviations outside the tolerance range for test organisms.

The LC_{50} for the *N. virens* sodium dodecyl sulfate (SDS) reference-toxicant test was 21.2 mg/L SDS and was slightly below two standard deviations of the laboratory mean (43.6 mg/L; 25.1 to 62.1 mg/L SDS) at the time of testing. This reference-toxicant test indicated that the populations of test organisms used in this test were slightly more sensitive than those previously tested at the ENVIRON laboratory. The LC_{50} for the *M. nasuta* reference-toxicant test was 35.3 mg/L SDS and was within two standard deviations of the laboratory mean (30.3 mg/L; 9.6 to 51.0 mg/L SDS) at the time of testing, indicating that the populations of test organisms used in this test were similar in sensitivity to those previously tested at the ENVIRON laboratory.

5 ADDAMS MODEL

Simulations of the Short-Term Fate of Dredged Material Disposal in Open-Water Models (STFATE) module of the ADDAMS model were run to establish compliance of the water column chemistry and toxicity for the Shipyard Creek sediment samples.

Based on analytical results for elutriate chemistry, two applications (runs) of the model are presented in this report for Tier II—Water Quality Criteria (National Recommended Water Quality Criteria: 2008, Criteria Maximum Concentration). Ammonia was found above the calculated water quality criteria across all project sediment samples, and the sample requiring the greatest dilution to meet the criteria was used in the model.

Based on the LC_{50} and EC_{50} results, six applications (runs) of the model are presented in this report for Section 103 Regulatory Analysis for Ocean Water, Tier III, Short-Term Fate of Dredged Material from Split Hull Barge or Hopper/Toxicity Run.

Results across the three test species (*Americamysis bahia*, *Menidia beryllina*, and *Mytilus edulis*) show that the LC_{50} or EC_{50} was significantly different from the control sample in all project samples tested. Volumetric fractions for the modeling were determined using physical results as reported in Table 4 and calculated from the volumetric spreadsheet provided by ERDC. Data for the STFATE model input parameters used in the module are shown in Exhibits 5-1 through 5-7.

Exhibit 5-1. Simulation Type: Descent, Collapse, and Diffusion

Coefficients		
Parameter	**Keyword**	**Value**
Settling Coefficient	BETA	0.000[1]
Apparent Mass Coefficient	CM	1.000[1]
Drag Coefficient	CD	0.500[1]
Form Drag for Collapsing Cloud	CDRAG	1.000[1]
Skin Friction for Collapsing Cloud	CFRIC	0.010[1]
Drag for an Ellipsoidal Wedge	CD3	0.100[1]
Drag for a Plate	CD4	1.000[1]
Friction Between Cloud and Bottom	FRICTN	0.010[1]
4/3 Law Horizontal Diffusion Dissipation Factor	ALAMDA	0.001[1]
Unstratified Water Vertical Diffusion Coefficient	AKYO	Pritchard Expression
Cloud/Ambient Density Gradient Ratio	GAMA	0.250[1]
Turbulent Thermal Entrainment	ALPHAO	0.235[1]
Entrainment in Collapse	ALPHAC	0.100[1]
Stripping Factor	CSTRIP	0.003[1]

[1] Model Default Value

Exhibit 5-2. Site Description

Parameter	Value	Units
Number of Grid Points (left to right)	45[1]	n/a
Number of Grid Points (top to bottom)	45[1]	n/a
Spacing Between Grid Points (left to right)	350[1]	ft
Spacing Between Grid Points (top to bottom)	350[1]	ft
Constant Water Depth	36	ft
Roughness Height at Bottom of Disposal Site	0.005[2]	ft
Slope of Bottom in X-Direction	0	deg.
Slope of Bottom in Z-Direction	0	deg.
Number of Points in Ambient Density Profile Point	2	n/a
Ambient Density at Depth = 0 ft	1.0215	g/cc
Ambient Density at Depth = 36 ft	1.0220	g/cc
Distance from the Top Edge of Grid (upper left corner of site)	1,800	ft
Distance from the Left Edge of Grid (upper left corner of site)	1,800	ft
Distance from the Top Edge of Grid (lower right corner of site)	13,950	ft
Distance from the Left Edge of Grid (lower right corner of site)	13,950	ft
Number of Depths for Transport-Diffusion Output	3 (0, 18, and 36 feet)	#

Exhibit 5-3. Current Velocity Data

Parameter	Value	Units
X-Direction Velocity	0.0	ft/sec
Z-Direction Velocity	0.33	ft/sec

Exhibit 5-4. Material Data

Parameter	Value	Units
Dredging Site Water Density (average)	1.016	g/cc
Number of Layers	1	n/a
Material Velocity at Disposal (X-Dir)	0	ft/s
Material Velocity at Disposal (Z-Dir)	9.42	ft/s

Exhibit 5-5. Output Options

Parameter	Value	Units
Duration of Simulation	14,400	sec
Long-Term Time Step	600	sec

Exhibit 5-6. Disposal Operation Data

Parameter	Mechanical/Hydraulic Dredge	Units
Length of Disposal Vessel	315	ft
Width of Disposal Vessel	53	ft
Pre-Disposal Draft	25	ft
Post-Disposal Draft	10	ft
Time Needed to Empty the Bin	60	sec
Material Volume	9,000	cy

The volumetric fractions shown in Exhibit 5-7 (shaded in gray and italicized) were calculated from a spreadsheet developed by Paul Schroeder at ERDC and EPA Region 4 using laboratory grain size, specific gravity, Atterberg limits and total solids. The calculations also take into account the type of dredge that will be used. The spreadsheet is provided electronically in Appendix H on the attached CD and is titled *Shipyard Creek Volumetric Fractions.xls.*

Toxicology results in Exhibit 5-7 (shaded in yellow and underlined) were provided by ENVIRON and chemical results were provided by ALS and were used to determine the LPC used in the ADDAMS model. For water column toxicology tests, all samples were treated prior to analysis to remove ammonia. Since all ammonia-ameliorated results indicated that ammonia was solely responsible for the toxicity, the application factor was increased to 0.05. The lowest of the three values was selected for use in the STFATE model. A summary of the LC_{50}/EC_{50} values is included in Exhibit 5-7.

Exhibit 5-7. Volumetric Fractions and Toxicity Criteria of Dredge Material

Analyte	Shipyard Creek		
	SYC14-AC	SYC14-TB1	SYC14-TB2
Mechanical			
Volume Fraction - Clumps	*0.372*	*0.5*	*0.5*
Volume Fraction - Coarse	*0.006*	*0*	*0*
Volume Fraction - Silts	*0.008*	*0*	*0*
Volume Fraction - Clays	*0.011*	*0*	*0*
Volume Fraction - Water	*0.602*	*0.5*	*0.5*
Hopper/Cutter			
Volume Fraction - Clumps	*0.223*	*0.3*	*0.3*
Volume Fraction - Coarse	*0.004*	*0*	*0*
Volume Fraction - Silts	*0.005*	*0*	*0*
Volume Fraction - Clays	*0.007*	*0*	*0*
Volume Fraction - Water	*0.761*	*0.7*	*0.7*
Water Column Toxicology			
Americamysis bahia %LC_{50}	62.4	52.0	41.4
Value for STFATE input (Application factor 0.05)	3.12	2.60	2.07
Menidia beryllina %LC_{50}	28.2	22.4	21.1
Value for STFATE input (Application factor 0.05)	1.41	1.12	1.06
Mytilus edulis %EC_{50}	15.5	14.8	14.0
Value for STFATE input (Application factor 0.05)	0.78	0.74	0.70
Final Value used for STFATE modeling	0.78	0.74	0.70
Elutriate Ammonia			
Total Ammonia (mg/L)	28.6	44.8	43.1
CMC (See Section 3.4.1 for Calculation Method) (mg/L)	11.6		
Final Value used for STFATE modeling	44.8		

The input and output files are provided in Appendix H on the enclosed disc. All models were run at a disposal location of 7,875 x 7,875. Since the dredger had not been contracted for operations at the time of reporting, the model inputs were selected from representative dredges available for dredging operations. The actual dredges used may vary slightly in physical dimensions, but are unlikely to significantly alter the final results presented in this section.

Results of the initial mixing simulations after 4 hours of mixing (specified for water column evaluation) and the maximum concentration found outside the disposal area for each DU are summarized in accordance with Sections 7.3 and 7.4 of the SERIM and are shown in Exhibits 5-8 and 5-9. The locations of the maximum concentration are shown as X Location and Z Location. All samples may be disposed of without restriction for location within the disposal area using a mechanical or hydraulic cutter/hopper dredge as indicated with each DU.

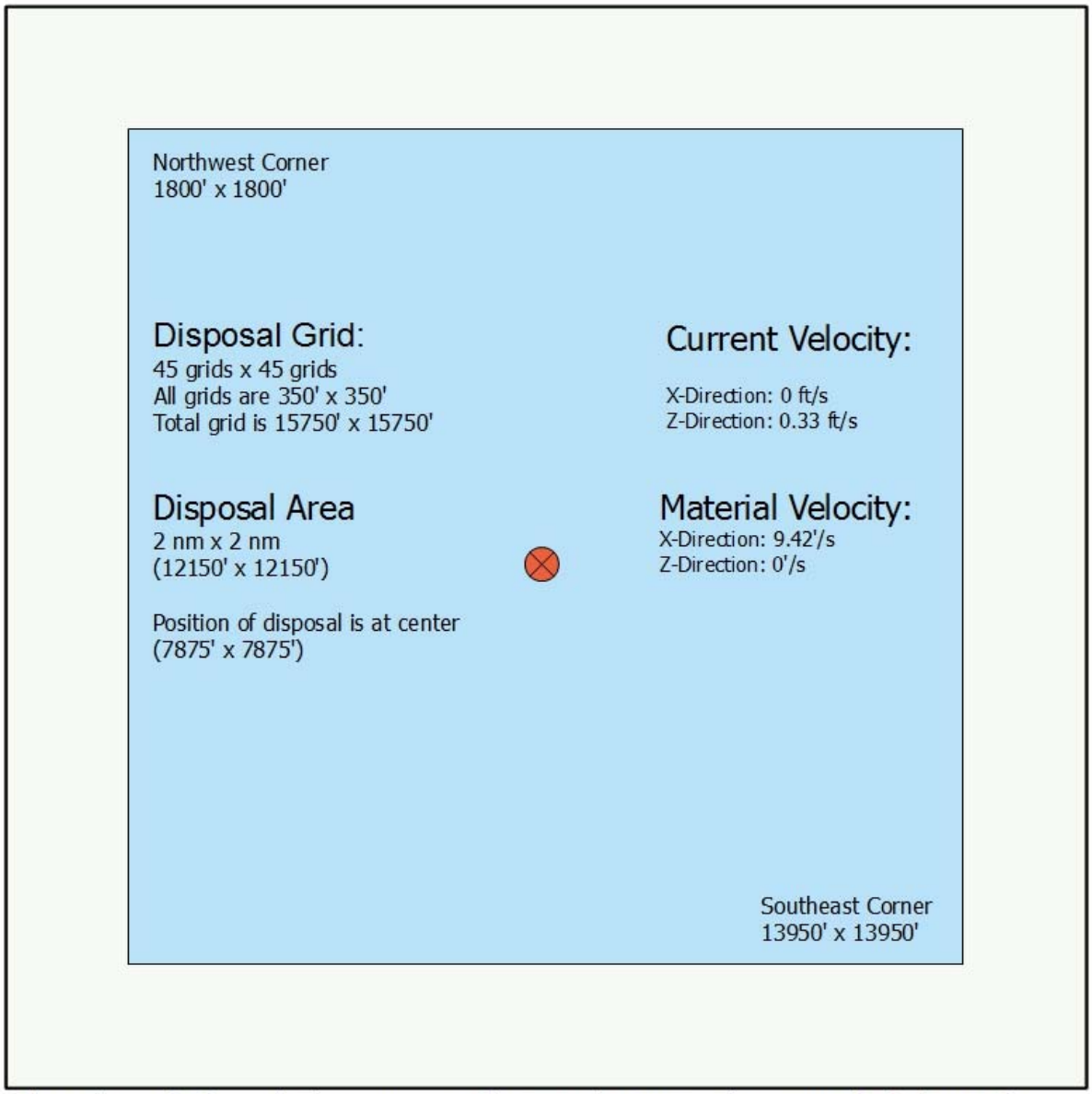
Exhibit 5-8. Four-Hour Criteria and Disposal Boundary Criteria after Initial Mixing for Toxicology

Depth, feet	Four-Hour Criteria after Initial Mixing				Disposal Site Boundary Criteria		
	% Max Conc Above Background on Grid	Dilution on Grid ($D_{a\text{-}tox}$)	X Location	Z Location	Time, hours	Max Conc Outside Disposal Area	Dilution ($D_{a\text{-}tox}$)
Sample	SYC14-AC (Mechanical Dredging @ 9,000 cy)						
0	7.97E-08	>100,000	8,400	11,900	4	0	N/A
18	6.67E-02	1498	8,400	11,900	4	0	N/A
27	3.55E-01	281	8,400	11,900	4	0	N/A
36	4.80E-02	2082	8,400	11,900	4	0	N/A
Sample	SYC14-TB1 (Mechanical Dredging @ 9,000 cy)						
0	5.77E-07	>100,000	8,400	11,900	4	0	N/A
18	8.02E-02	1246	8,400	11,900	4	0	N/A
26	3.04E-01	328	8,400	11,900	4	0	N/A
36	4.12E-02	2426	8,400	11,900	4	0	N/A
Sample	SYC14-TB2 (Mechanical Dredging @ 9,000 cy)						
0	5.77E-07	>100,000	8,400	11,900	4	0	N/A
18	8.02E-02	1246	8,400	11,900	4	0	N/A
26	3.04E-01	328	8,400	11,900	4	0	N/A
36	4.12E-02	2426	8,400	11,900	4	0	N/A
Sample	SYC14-AC (Hopper/Cutter Dredging @ 9,000 cy)						
0	9.73E-08	>100,000	8,400	11,900	4	0	N/A
18	8.35E-02	1197	8,400	11,900	4	0	N/A
27	4.47E-01	223	8,400	11,900	4	0	N/A
36	6.04E-02	1655	8,400	11,900	4	0	N/A
Sample	SYC14-TB1 (Hopper/Cutter Dredging @ 9,000 cy)						
0	4.17E-06	>100,000	8,400	11,900	4	0	N/A
18	1.44E-01	693	8,400	11,900	4	0	N/A
26	4.26E-01	234	8,400	11,900	4	0	N/A
36	5.77E-02	1732	8,400	11,900	4	0	N/A
Sample	SYC14-TB2 (Hopper/Cutter Dredging @ 9,000 cy)						
0	4.17E-06	>100,000	8,400	11,900	4	0	N/A
18	1.44E-01	693	8,400	11,900	4	0	N/A
26	4.26E-01	234	8,400	11,900	4	0	N/A
36	5.77E-02	1732	8,400	11,900	4	0	N/A

Exhibit 5-9. Four-Hour Criteria and Disposal Boundary Criteria after Initial Mixing for Ammonia

Depth, feet	Four-Hour Criteria after Initial Mixing				Disposal Site Boundary Criteria		
	% Max Conc Above Background on Grid	Dilution on Grid ($D_{a\text{-}wq}$)	X Location	Z Location	Time, hours	Max Conc Outside Disposal Area	Dilution on Grid ($D_{a\text{-}wq}$)
Sample	SYC14-TB1 (Mechanical Dredging @ 9,000 cy)						
0	2.58E-07	>100,000	8,400	11,900	4	0	N/A
18	3.59E-02	1247	8,400	11,900	4	0	N/A
26	1.36E-01	328	8,400	11,900	4	0	N/A
36	1.85E-02	2421	8,400	11,900	4	0	N/A
Sample	SYC14-TB1 (Hopper/Cutter Dredging @ 9,000 cy)						
0	1.87E-06	>100,000	8,400	11,900	4	0	N/A
18	6.46E-02	692	8,400	11,900	4	0	N/A
26	1.91E-01	234	8,400	11,900	4	0	N/A
36	2.58E-02	1735	8,400	11,900	4	0	N/A

Charleston ODMDS Disposal Map



All samples may be disposed without restriction on location in the ODMDS with a maximum load of 9,000 cubic yards for each disposal.

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