# DRAFT FINAL

# MPRSA Section 103 Sediment Characterization Testing and Analysis

# San Juan Harbor, Puerto Rico

**Contract: W912PM-15-D-0006**

**Order Number: W912EP-21-F-0026**

***Submitted to:***

**U.S. Army Corps of Engineers**
**Jacksonville District**
**701 San Marco Boulevard**
**Jacksonville, Florida 32207-8175**

***Prepared by:***

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

www.anamarinc.com

ANAMAR
Environmental Consulting, Inc.

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# ACRONYMS, ABBREVIATIONS, AND INITIALISMS

| | |
|---|---|
| ADDAMS | Automated Dredging and Disposal Alternatives Modeling System |
| ARI | Analytical Resources, Inc. |
| CCV | continuing calibration verification |
| CETIS | Comprehensive Environmental Toxicity Information System |
| CFR | Code of Federal Regulations |
| CMC | criteria maximum concentration (synonymous with 'acute') |
| CQAR | Chemical Quality Assurance Report |
| DQCR | Daily Quality Control Report |
| $EC_{50}$ | effective concentration affecting 50% of a population |
| ECD | electron capture detector |
| EPA/USEPA | U.S. Environmental Protection Agency |
| ERL | effects range-low |
| FDA | U.S. Food and Drug Administration |
| GC/MS | gas chromatography/mass spectrometry |
| GC-ECD | gas-chromatography-electron capture detection |
| HMW | high molecular weight |
| ICP/MS | inductively coupled plasma/mass spectrometry |
| ICV | initial calibration verification |
| ITM | Inland Testing Manual (EPA and USACE 1998) |
| $LC_{50}$ | lethal concentration 50% |
| LCS | laboratory control sample |
| LMW | low molecular weight |
| LPC | limiting permissible concentration |
| MDL | method detection limit |
| mg/L | milligrams per liter |
| MLLW | mean lower low water |
| MLW | mean low water |
| MPRSA | Marine Protection, Research, and Sanctuaries Act |
| MRL | method reporting limit |
| MRM | multiple reaction monitoring |
| NOAA | National Oceanic and Atmospheric Administration |
| NOEC | no-observed-effect concentration |
| NTU | nephelometric turbidity unit |
| ODMDS | ocean dredged material disposal site |
| PAH | polycyclic aromatic hydrocarbon |
| PCB | polychlorinated biphenyl |
| ppt | parts per thousand |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| RPD | relative percent difference |
| RTM | *(NY Army Corps of Engineers District) Regional Testing Manual* |
| SAP/QAPP | Sampling and Analysis Plan/Quality Assurance Project Plan |
| SDS | sodium dodecyl sulfate |
| SOP | standard operating procedure |
| SRM | standard reference material |
| TEL | threshold effects level |
| TOC | total organic carbon |
| USACE | U.S. Army Corps of Engineers |
| USCS | U.S. Soil Classification Systems |

# EXECUTIVE SUMMARY

This report details the field sampling, analysis, and results of MPRSA Section 103 sediment testing and analysis in support of the San Juan Harbor dredging operations. Sampling and testing were performed for both maintenance and new work dredging to allow for deepening and widening of the channels within the San Juan Harbor. Field sampling, compositing, and shipping preparations took place on October 19 through November 2, 2020.

Areas proposed to be dredged have been divided into reaches or dredging units. The rationale for the sampling approach is summarized in Section 2.1. All samples within each dredging unit were collected either by vibracore to project depth or refusal or by a grab sampler. Samples within each dredging unit were composited and homogenized to create one composite per dredging unit: Analysis of the composited sediment consisted of three analytical tiers: physical, chemical, and toxicological/bioaccumulation.

## Sediment Physical Results

Grain size distribution and total solids were analyzed in project composite samples, subsamples, individual clay/native material samples, and the reference sample. The following parameters were also analyzed for the composite sample: bulk density, specific gravity, and Atterberg limits. Grain size results for the composite and clay/native material samples are summarized below.

**San Juan Harbor Maintenance Reach A**
M-A-S-20-COMP was composed primarily of silt/clay (86.4%) with 13.6% sand.

**San Juan Harbor Maintenance Reach B**
M-B-S-20-COMP was composed primarily of silt/clay (68.1%) with 31.9% sand.

**Army Terminal Widener Reach**
D-ATw-20-COMP was composed primarily of silt/clay (78.2%) with 20.8% sand and 1.0% gravel.

**San Antonio Extension**
D-SAx-20-COMP was composed primarily of silt/clay (85.3%) with 14.1% sand and 0.6% gravel.

**Individual Clay/Native Material Samples**
Sample D-EC-C-2 (co-located with station M-A-S-3) from the Entrance Channel in Reach A was primarily composed of fine material with 96.7% silt/clay with 3.3% sand.

Sample D-ATw-C-1 (co-located with station D-ATw-S-1) in the Army Terminal Widener was primarily composed of fine material with 83.4% silt/clay with 15.2% sand and 1.4% gravel.

Sample D-ATw-C-2 (co-located with station D-ATw-S-2) in the Army Terminal Widener was primarily composed of fine material with 66.0% silt/clay with 34% sand.

Sample D-ATw-C-3 (co-located with station D-ATw-S-4) in the Army Terminal Widener was primarily composed of fine material with 54.7% silt/clay with 45% sand.

Sample D-ATw-C-4 (co-located with station D-ATw-S-3) in the Army Terminal Widener was primarily composed of fine material with 59.5% silt/clay with 39.1% sand and 1.4% gravel.

**Reference**
SJH20-REF was primarily composed of silt and clay (90.1%) with 9.1% sand.

## Sediment Chemistry

Sediment composites, clay/native material samples, and the reference (SJH20-REF) were analyzed for total solids, TOC, metals, pesticides, PAHs, and PCBs. The subsamples were also analyzed for total solids and TOC. Comparisons of sediment chemistry results were made to the TEL and ERL, where available.

### Metals

All nine metals analyzed were detected in concentrations above the MDL in all of the project composite samples. With the exception of cadmium, all other metals analyzed were also detected in concentrations above the MDL in the reference and several of the individual clay/native material subsamples. Concentrations of metals were below applicable TEL and ERL thresholds with the exceptions summarized below.

**Composite Samples**

- M-A-S-20-COMP: arsenic, copper, mercury and nickel exceeded the TEL and (or) ERL.
- M-B-S-20-COMP: arsenic, copper, and mercury exceeded the TEL and (or) ERL.
- D-ATw-S-20-COMP: arsenic, copper, and nickel exceeded the TEL and (or) ERL.
- D-SAx-S-20-COMP: arsenic, copper, lead, mercury, nickel, silver, and zinc exceeded the TEL and (or) ERL.

**Clay/Native Material Samples**

- D-EC-C-2: arsenic, copper, mercury, and nickel exceeded the TEL and (or) ERL.
- D-ATw-C-1, C-2, and C-4: arsenic and copper exceeded the TEL and (or) ERL.
- D-ATw-C-3: copper exceeded the TEL.

**Reference**
SJH20-REF had concentrations of arsenic, copper, and nickel that exceeded the TEL and (or) the ERL.

### Pesticides

Two of the 15 pesticides tested [o,p' (2,4')-DDE and p,p' (4,4')-DDE] were detected above the MDL (J-qualified or greater) in one or more samples. Concentrations of pesticides were below applicable TEL and ERL thresholds with the exceptions summarized below.

**Composite Samples**

- D-SAx-S-20-COMP: p,p' (4,4')-DDE concentrations exceeded the ERL and TEL.

**Clay/Native Material Samples**
None of the pesticides were detected in concentrations greater than the MDL for any of the clay samples; all results were U-qualified.

**Reference**
None of the results for SJH20-REF were detected in concentrations greater than the MDL; all results were U-qualified.

### PAHs

All 16 PAH analytes tested were detected above the MDL (J-qualified or greater) in one or more composites or subsamples. Concentrations of PAHs were below applicable TEL and ERL thresholds with the exceptions summarized below.

**Composite Samples**

- M-A-S-20-COMP, M-B-S-20-COMP, and D-SAx-20-COMP: acenaphthylene and dibenzo(a,h)anthracene concentrations exceeded the TEL.
- D-SAx-20-COMP, benzo(a)pyrene and total HMW PAHs concentrations exceeded the TEL.

**Clay/Native Material Samples**

None of the results exceeded the TEL or ERL.

**Reference**

None of the results for SJH20-REF exceeded the TEL or ERL.

**<u>PCBs</u>**

Up to 20 of the 22 PCB congeners tested were detected in concentrations above the MDL in one or more samples. Concentrations of PCBs were below applicable TEL and ERL thresholds with the exceptions summarized below.

**Composite Samples**

All composite samples had total EPA Region 2 PCB concentrations that exceeded the TEL and ERL.

**Clay/Native Material Samples**

All clay/native material samples had total EPA Region 2 PCB concentrations that exceeded the TEL and (or) ERL.

**Reference**

None of the 22 PCB congeners were detected in concentrations greater than the MDL (U-qualified) in SJH20-REF. The reference had total EPA Region 2 PCB concentrations that exceeded the TEL.

## Elutriate and Water Chemistry

Site water (SJH20-SW), reference water (SJH20-REF-SW), and elutriates generated from the four project composites were analyzed for metals, pesticides, and PCBs. Results for elutriate and water samples are compared to the CMC from EPA (2006, 2015).

**<u>Metals</u>**

None of the metals analyzed were detected in concentrations greater than the CMC in any elutriate or water sample.

**<u>Pesticides</u>**

None of the pesticides analyzed were detected in concentrations greater than the CMC or MDL in any elutriate or site water samples (U-qualified).

**<u>PCBs</u>**

None of the PCB congeners were detected in concentrations greater than the MDL in any elutriate or site water samples (U-qualified). There are no CMCs for the PCB congeners tested.

## Toxicology

**Benthic Bioassays**
Significant benthic toxicity, relative to the reference treatment, was observed in the *A. abdita* amphipod test for test sample D-ATw-S-20-COMP only. No significant toxicity was observed in *A. bahia* mysid test. Mean percent survival in the project composite samples was within the specific test criterion (20% of the reference: amphipod; 10% of the reference: mysid), indicating that the test treatments met the LPC for disposal for these tests.

**Water Column Bioassay**
No statistically significant toxicity was observed in the 100% elutriate concentrations for the *A. bahia, M. beryllina,* and *M. galloprovincialis* tests.

**Bioaccumulation Potential**
No significant toxicity was observed in the bioaccumulation tests. Survival in the reference and test treatment was ≥93.0%, suggesting that adequate tissue mass was available for chemical analyses.

## Tissue Chemistry

Wet weight tissue chemistry results for the four project samples are compared to the reference (SJH20-REF) and to applicable FDA action levels from FDA (2001, 2011).

**Lipids and Total Solids**

*M. nasuta* – Total solids ranged from 16.34% to 18.62% among the project samples, reference, and pre-exposure tissues. Lipids ranged from 1.3% to 2.5% among these samples.

*A. virens* – Total solids ranged from 14.06% to 15.68% among the project samples, reference, and pre-exposure tissues. Lipids ranged from 2.0% to 3.6% among these samples.

**Metals**

*M. nasuta* – All metals tested were detected in concentrations greater than the MRL in the project samples and the reference. Mean concentrations of lead in the project sample M-B-S-20-COMP were statistically significantly greater than those of the reference. Mean concentrations of lead, silver, and zinc in the project sample D-SAx-S-20-COMP were statistically significantly greater than those of the reference. None of the mean concentrations of metals exceeded applicable FDA action levels.

*A. virens* – All metals tested were detected in concentrations greater than the MRL in the project samples and the reference. Mean concentrations of arsenic, cadmium, and chromium in all four project samples were statistically significantly greater than those of the reference. In addition, mean concentrations of copper, nickel, and zinc were statistically significantly greater in D-ATw-S-20-COMP than those of the reference. None of the mean concentrations of metals exceeded applicable FDA action levels.

**Pesticides**

*M. nasuta* – With the exception of 4,4'-DDE in sample D-SAx-S-20-COMP, none of the pesticides were detected in concentrations greater than the MDL in any of the project samples or reference (U-qualified). Mean concentration of 4,4'-DDE (1.49 µg/kg) in sample D-SAx-S-20-COMP was statistically significantly greater than that of the reference (0.14 µg/kg). None of the mean concentrations of pesticides exceeded applicable FDA action levels.

*A. virens* – None of the pesticides were detected in concentrations greater than the MDL in the project samples or the reference. All results were U-qualified. The MDL and MRL for trans-nonachlor were elevated above the target detection limit due to matrix interference. None of the mean concentrations of pesticides exceeded applicable FDA action levels.

**PAHs**

*M. nasuta* – None of the PAHs were detected in concentrations greater than the MDL in the project samples or the reference. All results were U-qualified; therefore, no further statistical analyses or comparisons were needed.

*A. virens* – None of the PAHs were detected in concentrations greater than the MDL in the project samples or the reference. All results were U-qualified; therefore, no further statistical analyses or comparisons were needed.

**Polychlorinated Biphenyls (PCBs)**

*M. nasuta* – Nine of the PCB congeners tested were detected above the MRL in at least one of the project sample replicates. Concentrations of PCB congeners 49, 52, 101, 118, 138, and 153 and total EPA Region 2 PCBs in some of the project samples were statistically significantly greater than those of the reference, as summarized below. Total EPA Region 2 PCB mean concentration in the project samples did not exceed the FDA action level.

- M-A-S-20-COMP – PCB 153
- M-B-S-20-COMP – PCBs 49, 52, 153, and Total PCBs
- D-SAx-S-20-COMP – PCBs 49, 52, 101, 118, 138, 153 and Total PCBs

*A. virens* – Nine of the PCB congeners tested were detected above the MRL in at least one of the project sample replicates. Concentrations of PCB congeners 49, 52, 101, and total EPA Region 2 PCBs in some of the project samples were statistically significantly greater than those of the reference, as summarized below. Total EPA Region 2 PCB mean concentration in the project samples did not exceed the FDA action level.

- M-A-S-20-COMP – PCB 101
- M-B-S-20-COMP – PCB 101
- D-SAx-S-20-COMP – PCBs 49, 52, 101, and Total PCBs

**ADDAMS Model**

STFATE modeling was performed using two types of dredging equipment, a clamshell dredge combined with a separate barge or scow and a hopper or cutter dredge. Each type of dredging equipment was modeled with a capacity of 4,800 cubic yards per load based on the largest option currently available in Puerto Rico. The model was also performed with a volume of 15,000 cubic yards per load in case a larger dredging vessel becomes available. All model runs met the disposal criteria for both dredging methods and volumes. Therefore, the material may be disposed without location or volume restrictions, to a maximum volume of 15,000 cubic yards per load within the ODMDS boundaries in accordance with all criteria specified by EPA Region 2 and USACE Jacksonville District.

# 1 INTRODUCTION

## 1.1 Project Area Description

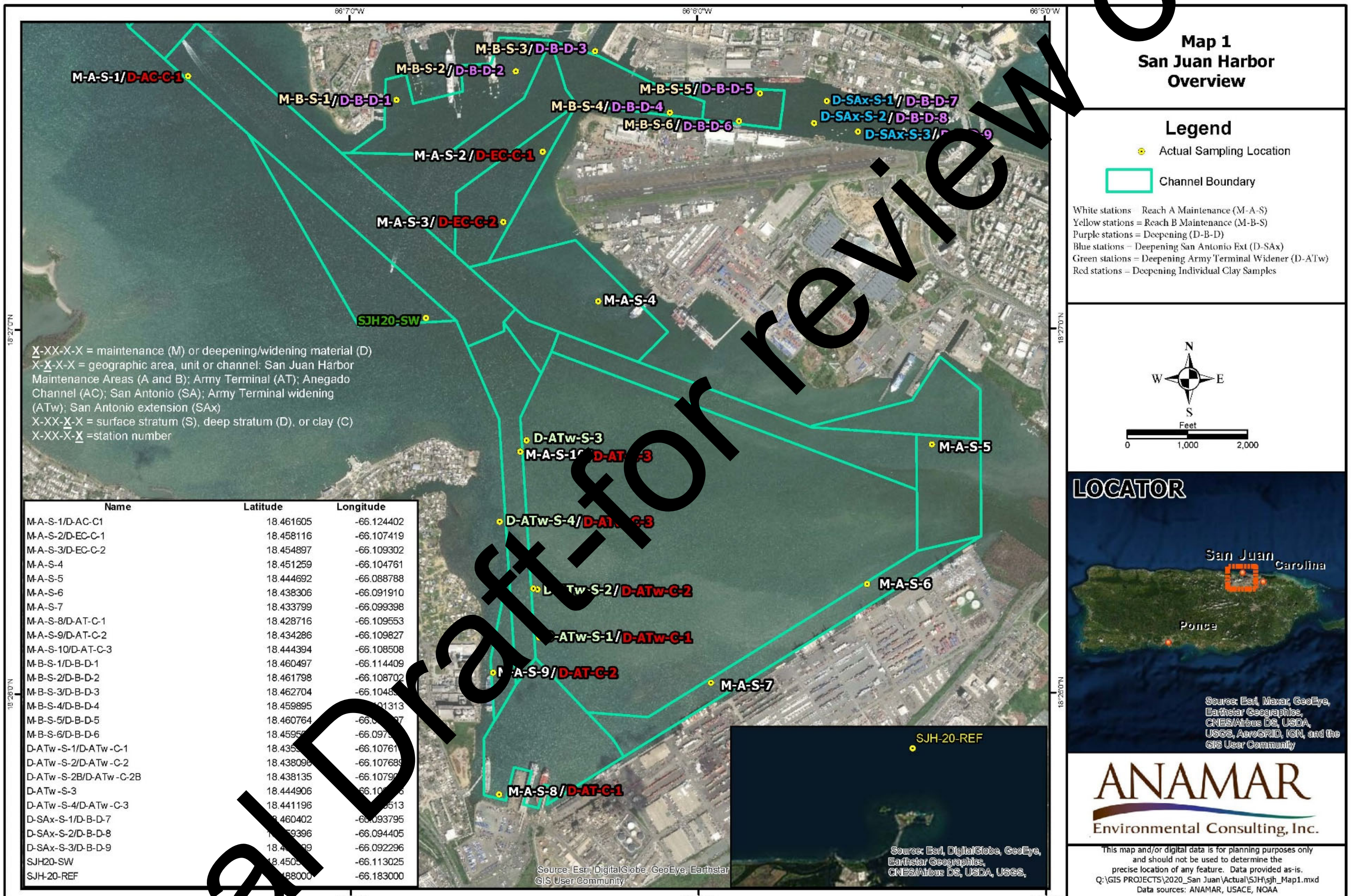
The sediment characterization and testing performed for this project includes both routine maintenance material from the San Juan Harbor navigation channels to authorized depths and proposed deepening (new work) material in support of future deepening and widening in some areas of San Juan Harbor. This report summarizes the results of the sampling and testing performed to determine the suitability of the material for disposal in the San Juan Harbor ocean dredged material disposal site (ODMDS).

Exhibit 1-1 provides an overview of the planned improvements to the San Juan Harbor Federal Navigation Project. Harbor improvements, as described in the project work scope, are broadly described below.

1) Deepening of Bar and Entrance Channels to various depths ranging from -56 to -44 feet,
2) Deepening of the Anegado and Army Terminal Channels to -44 feet + (- 2 feet overdepth) = -46 feet
3) Deepening of the San Antonio Channel and San Antonio Approach Channel to -36 feet + (- 2 feet overdepth) = -38 feet
4) Widening of Army Terminal Channel, and
5) Extending the San Antonio Channel in an easterly direction.

The project area was divided into five dredging units or reaches for sampling and testing purposes: two maintenance reaches (Reach A and Reach B) and three deepening/widening reaches (Army Terminal Widener; San Antonio Extension; Deepening Reach). In addition, individual samples of clay or native material were sampled at various locations. These data will be used to compare results from testing conducted in 2000. A detailed description of each reach and information on the sampling and compositing plan are provided in Section 2. Exhibit 1-2 provides an overview of the target sampling locations for each dredging unit/reach.


**Exhibit 1. Planned Improvements to the San Juan Harbor Federal Navigation Project (from Project Work Scope 2020)**




| Name | Latitude | Longitude |
|---|---|---|
| M-A-S-1/D-AC-C1 | 18.461605 | -66.124402 |
| M-A-S-2/D-EC-C-1 | 18.458116 | -66.107419 |
| M-A-S-3/D-EC-C-2 | 18.454897 | -66.109302 |
| M-A-S-4 | 18.451259 | -66.104761 |
| M-A-S-5 | 18.444692 | -66.088788 |
| M-A-S-6 | 18.438306 | -66.091910 |
| M-A-S-7 | 18.433799 | -66.099398 |
| M-A-S-8/D-AT-C-1 | 18.428716 | -66.109553 |
| M-A-S-9/D-AT-C-2 | 18.434286 | -66.109827 |
| M-A-S-10/D-AT-C-3 | 18.444394 | -66.108508 |
| M-B-S-1/D-B-D-1 | 18.460497 | -66.114409 |
| M-B-S-2/D-B-D-2 | 18.461798 | -66.108702 |
| M-B-S-3/D-B-D-3 | 18.462704 | [illegible] |
| M-B-S-4/D-B-D-4 | 18.459895 | [illegible] |
| M-B-S-5/D-B-D-5 | 18.460764 | [illegible] |
| M-B-S-6/D-B-D-6 | [illegible] | [illegible] |
| D-ATw-S-1/D-ATw-C-1 | [illegible] | [illegible] |
| D-ATw-S-2/D-ATw-C-2 | [illegible] | [illegible] |
| D-ATw-S-2B/D-ATw-C-2B | 18.438135 | [illegible] |
| D-ATw-S-3 | 18.444906 | [illegible] |
| D-ATw-S-4/D-ATw-C-3 | 18.441196 | [illegible] |
| D-SAx-S-1/D-B-D-7 | [illegible] | [illegible] |
| D-SAx-S-2/D-B-D-8 | [illegible] | -66.094405 |
| D-SAx-S-3/D-B-D-9 | [illegible] | -66.092296 |
| SJH20-SW | [illegible] | -66.113025 |
| SJH-20-REF | [illegible] | -66.183000 |

**Exhibit 1-2. Overview of Project Dredging Units/Reaches and Sampling Locations**

## 1.2 Description of the Testing Approach

### 1.2.1 Evaluation of Dredge Materials for Disposal

Sediment and suspended-phase testing are required under Marine Protection, Research, and Sanctuaries Act (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 placement must be evaluated using criteria published by EPA 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* (EPA and USACE 1991, referred to here as the 'Green Book') and the *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S.—Testing Manual* (Inland Testing Manual or ITM) (EPA and USACE 1998). In addition, the EPA Region 2 guidance manual, *Guidance for Performing Tests on Dredged Material Proposed for Ocean Disposal* (RTM) (USACE and EPA 2016) provides regional guidance on procedures to be followed when assessing the suitability of dredge material for ocean disposal in EPA Region 2.

The 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

Evaluation of proposed dredge material from the project area pursuant to MPRSA Section 103 is required for ocean disposal of dredged material. For this reason, USACE Jacksonville District contracted with ANAMAR Environmental Consulting, Inc. to collect sediment samples and to conduct physical, chemical, and toxicological evaluations as required in 40 CFR Parts 220–228 and outlined in the testing manuals mentioned above.

Throughout the course of this project, the procedures and criteria set forth in the Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) for sediment characterization were followed (Appendix A, ANAMAR 2020). The objectives of this effort were to

- Collect the required volume of representative sediment samples from selected stations within the project area and the reference station within positioning accuracy appropriate for the project objectives.
- Collect and containerize sediment samples according to proper protocols to ensure sample integrity.
- Test and characterize sediment samples for physical characteristics and chemical contaminants of concern and to perform toxicology bioassays in accordance with the Green Book and the RTM 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 EPA according to requirements specified in the Green Book, ITM, and RTM.
- Provide a report to USACE and EPA on behalf of USACE in the format outlined in Section 6.2.6 of the SAP/QAPP (Appendix A).

Deliverables for this project include:

- An MPRSA Section 103 sediment testing report (draft and final) and supporting documentation that describe all aspects of the study and present the results of field sampling, physical and chemical analysis of sediment samples, and toxicological bioassays. This report presents comparisons of test sediments to the reference and provides the basis for a scientific recommendation regarding the acceptability of the dredged material for ocean disposal. Important components of this report include:
  - A narrative addressing all aspects of field sampling, laboratory analysis, discussion of laboratory results, and a review of all laboratory quality control measures.
  - Laboratory results provided in condensed tables.
  - Maps of the sampling sites.
  - A Chemical Quality Assurance Report (CQAR [Appendix E]), 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 (DQCRs) (Appendix B) prepared by the project manager for each day of field sampling.

ANAMAR coordinated and directed operations for this project and worked closely with USACE and EPA 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 samples collected from the project area. Exhibits 1-3 and 1-4 indicate the principal data users and their respective areas of responsibility and subcontractors associated with this evaluation.

**Exhibit 1-3. Principal Data Users and Decision Makers Associated with This Project**

| Agency | Location | Area(s) of Responsibility |
|---|---|---|
| USACE | Jacksonville, FL | Responsible for maintenance and harbor improvements in the San Juan Harbor Federal Navigation Project and co-managing the San Juan Harbor ODMDS with EPA Region 2 |
| EPA | Region 2, New York, NY | Give concurrence to environmental requirements of dredged sediment for approval for offshore disposal per the Green Book (EPA 1991), the ITM (EPA 1998), and *Guidance for Performing Tests on Dredged Material Proposed for Ocean Disposal* (USACE and EPA 2016) |

**Exhibit 1-4. Subcontractors and Responsibilities Associated with This Report**

| Company and Contact Information | Area(s) of Responsibility |
|---|---|
| **Vibracore Subcontractor: Athena Technologies, Inc.**<br>Project Manager: Adam Freeze<br>P.O. Box 68, McClellanville, SC 29458<br>Phone: (843) 887-3800<br>adam_freeze@athenatechnologies.com | Vibracore support for field sample collection |
| **Chemistry Laboratory: Analytical Resources, Inc. (ARI)**<br>Project Manager: Kelly Bottem<br>4611 S. 134th Pl., Ste. 100; Tukwila, WA 98168-3240<br>Phone: (206) 695-6211<br>kelly.bottem@arilabs.com | Laboratory sample preparation and chemical analysis of sediment, elutriate, and tissues; sample holding and archiving |
| **Chemistry Laboratory: Materials Testing Consultants (MTC)**<br>Project Manager: Beth Goble<br>2118 Black Lake Blvd SW; Olympia, WA 98512<br>Phone: (206) 241-1974<br>beth.goble@mtc-inc.net | Preparation of elutriate samples |
| **Chemistry Laboratory: ALS Environmental, Inc.**<br>Project Manager: Todd Poyfair<br>1317 S. 13th Ave; Kelso, WA 98626<br>Phone: (800) 577-7222<br>Todd.Poyfair@alsglobal.com | Analysis of metals in the elutriate and site water samples |
| **Geotechnical Laboratory: Terracon**<br>Project Manager: Chris Martin, Sr.<br>8001 Baymeadows Way<br>Jacksonville, FL 32256<br>Phone: (904) 900-6494<br>crmartin2@terracon.com | Laboratory sample preparation and physical analysis of sediment; sample holding and archiving |
| **Toxicology Laboratory: EcoAnalysts**<br>Project Manager: Brian Hester<br>4729 NE View Drive, Port Gamble, WA 98364<br>Phone: (360) 297-6040<br>bhester@ecoanalysts.com | Laboratory sample preparation and analysis for suspended phase, solid phase, and bioaccumulation potential |
| **Offshore Vessel**<br>J.A.W. Marine Contractors, Inc.<br>*Kruger B* Research Vessel<br>San Juan, Puerto Rico | Support for field collection of sediment and water samples from the designated offshore reference station |

# 2 MATERIALS AND METHODS

## 2.1 Project Design and Rationale

Areas proposed to be dredged were divided into five sampling areas representing associated dredging units or reaches (see Exhibits 1-2 and 2-1). All sampling stations were selected by USACE and approved by EPA Region 2. EPA reviewed available geotechnical data for borings taken in the areas to identify sediment strata horizons for informing the sampling and analysis plan. According to the scope of work, stiff clay was observed at depths of -34 to -35 feet MLW along the margins of Army Terminal Channel, between depths of -40- to -42 feet MLW within the Army Terminal Channel, and between depths of -45 to -46 feet MLW within the Anegado Channel. Therefore, material associated with deepening below the channels themselves (currently at -40 feet MLW plus overdepth) is expected to be composed of stiff clay. In San Antonio Channel, sediment transitioned from gray silts and clays to sands and sand/clays at approximately -34 to -35 feet MLW. Existing channel depths in this area are -30 feet MLW plus overdepth. A brief description of each dredging unit is provided below.

<u>Reach A</u>: Composed of one composite of maintenance material (i.e., Maintenance M-A) collected from above the sand/clay interface from 10 locations spanning the Eastern Cruise Basin, Anegado Channel, Graving Dock, Puerto Nuevo and Army Terminal channels and Turning Basins.

<u>Reach B</u>: Composed of one composite of maintenance material (i.e., Maintenance M-B) collected from above the sand/clay interface from six locations spanning the Western Cruise Basin, San Antonio Channel, and San Antonio Approach Channel.

<u>Army Terminal Widener</u>: Composed of one composite of widening/deepening material (i.e., D-ATw-S) collected from above the clay interface (or project depth) from four stations in the widening area along the Army Terminal Channel.

<u>San Antonio Extension</u>: Composed of one composite of widening/deepening material (i.e., D-SAx-S) collected from above the clay interface from three stations in the San Antonio Extension.

<u>Deepening</u>: Composed of one composite of deepening material (i.e., D-B-D) collected from below the sand/clay interface from up to nine stations in San Antonio Channel, San Antonio Approach Channel, San Antonio Extension, and Western Cruise Basin.

<u>Clay Samples</u>: Composed of individual dense clay samples collected bottoms of cores, where encountered, from stations in Anegado Channel (D-AC-C), Eastern Cruise Basin (D-EC-C), Army Terminal Channel/Turning Basin (D-AT-C), and Army Terminal Widener (D-ATw-C). Individual samples were analyzed for physical and sediment chemistry parameters only.

<u>Reference</u>: The reference sediment (SJH20-REF) was collected from an offshore area in the vicinity of the San Juan ODMDS that has not been impacted by dredged material disposal. The reference station location was selected by EPA and is the same location that was sampled during the 2015 MPRSA Section 103 evaluation for San Juan Harbor.

Analyses of composite samples consisted of three analytical tiers, including sediment physical and chemical (sediment, elutriate, and tissue) analyses and toxicological bioassays. A summary of field sampling methods used during the collection process are presented in Exhibit 2-2. Sediment samples were analyzed for the contaminants of interest and bioassay test species listed in Exhibit 2-3.

**Exhibit 2-1. Summary of Sampling Scheme Including Dredging Units, Elevations, and Estimated Core Lengths**

| Dredging Unit/Reach | Subsample IDs | Estimated Mudline Elevation (ft, MLLW) [2] | Project Elevation Including 2' Allowable Overdepth (feet MLLW) [1] | Est. Core Length to Project Depth [2] (feet) | Notes |
|---|---|---|---|---|---|
| M-A (SJH Maintenance Reach A) | M-A-S-1 | -42.5 | mudline to -48 | [illegible].0 | Yellow highlight indicates sediment elevations below target project depth. Maintenance (surface) material is considered the unconsolidated layer of material above the native material. Deepening (clay) material is considered native material. |
| | D-AC-C-1 (clay) | | | | |
| | M-A-S-2 | -31.6 | mudline to -37 | 5.4 | |
| | D-EC-C-1 (clay) | | | | |
| | M-A-S-3 | -30.7 | mudline to -37 | 6.3 | |
| | D-EC-C-2 (clay) | | | | |
| | M-A-S-4 | -37.4 | mudline to -3[illegible] | -1.4 | |
| | M-A-S-5 | -39.2 | mudline to -3[illegible] | -0.2 | |
| | M-A-S-6 | -38.7 | mudline to -39 | 0.3 | |
| | M-A-S-7 | -40.5 | mudline to -39 | -1.5 | |
| | M-A-S-8 | -40.9 | mudline to -46 | 4.2 | |
| | D-AT-C-1 (clay) | | | | |
| | M-A-S-9 | -34.4 | mudline to -34 | -0.4 | |
| | D-AT-C-2 (clay) | | | | |
| | M-A-S-10 | -40.6 | mudline to -46 | 4.8 | |
| | D-AT-C-3 (clay) | | | | |
| Army Terminal Widener | D-ATw-S-1 | -19 | mudline to -44 | 25.0 | Maintenance (surface) material is considered the unconsolidated layer of material above the native material. Deepening (clay) material is considered native material. |
| | D-ATw-C-1 (clay) | | | | |
| | D-ATw-S-2 | -16 | mudline to -44 | 28.0 | |
| | D-ATw-C-2 (clay) | | | | |
| | D-ATw-S-3 | -19.4 | mudline to -44 | 24.6 | |
| | D-ATw-S-4 | -16 | mudline to -44 | 28.0 | |
| | D-ATw-C-3 (clay) | | | | |

| Dredging Unit/Reach | Subsample IDs | Estimated Mudline Elevation (ft, MLLW) [2] | Project Elevation Including 2' Allowable Overdepth (feet MLLW) [1] | Est. Core Length to Project Depth [illegible] (feet) | Notes |
|---|---|---|---|---|---|
| M-B (SJH Maintenance Reach B) | M-B-S-1 | -30.7 | mudline to -38 | 7.3 | Yellow highlight indicates sediment elevations below target project depth. Maintenance (surface) material is considered the unconsolidated layer of material above the native material. Deepening material is considered native material. |
| | D-B-D-1 | | | | |
| | M-B-S-2 | -37.7 | mudline to -38 | 0.3 | |
| | D-B-D-2 | | | | |
| | M-B-S-3 | -34.2 | mudline to -38 | 3.0 | |
| | D-B-D-3 | | | | |
| | M-B-S-4 | -38.4 | mudline to -38 | -0.4 | |
| | D-B-D-4 | | | | |
| | M-B-S-5 | -35.5 | mudline to -38 | 2.5 | |
| | D-B-D-5 | | | | |
| | M-B-S-6 | -43.9 | mudline to -38 | -5.9 | |
| | D-B-D-6 | | | | |
| San Antonio Extension | D-SAx-S-1 | -38.5 | mudline to -38 | 0.5 | Yellow highlight indicates sediment elevations below target project depth. Maintenance (surface) material is considered the unconsolidated layer of material above the native material. Deepening material is considered native material. |
| | D-B-D-7 | | | | |
| | D-SAx-S-2 | -38.0 | mudline to -38 | 0.0 | |
| | D-B-D-8 | | | | |
| | D-SAx-S-3 | -28.4 | mudline to -38 | 9.6 | |
| | D-B-D-9 | | | | |

| Dredging Unit/Reach | Subsample IDs | Estimated Mudline Elevation (ft, MLLW) [2] | Project Elevation Including 2' Allowable Overdepth (feet MLLW) [1] | Est. Core Length to Project Depth [2] (feet) | Notes |
|---|---|---|---|---|---|
| SJH20-REF (Reference station) | N/A | N/A | Grab sample | N/A | |
| **Site Water Stations** | | | | | |
| SHJ20-SW | N/A | N/A | Collect 1 m above bottom | N/A | |
| SJH20-REF-SW | N/A | N/A | Collect 1 m below surface | N/A | |

**[1]** Project elevation is the authorized deepening depth plus allowable overdepth below MLLW (feet).

**[2]** Mudline elevation and estimated core length based on August 2020 bathymetric survey data.

**X**-XX-X-X = maintenance (M) or deepening/widening material (D)

X-**X**-X-X = San Juan Harbor Maintenance Areas (A and B); Army Terminal (AT); Anegada Channel (AC); San Antonio (SA); Army Terminal widening (ATw); San Antonio extension (SAx)

X-XX-**X**-X = surface stratum (S), deep stratum (D), or clay (C)

X-XX-X-**X** =station number
MLLW = mean lower low water

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

**FIELD SAMPLE COLLECTION:**

- Project sub-samples and composite samples from each dredging unit plus reference sediment

**SAMPLING GEAR:**

- Project samples collected by vibracore or grab sampler
- Reference sediment collected with double van Veen sampler
- Water parameters measured with YSI multiprobe meter and Hach 2100P turbidimeter

**PRESERVATION:**

- Sediment 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)
Salinity (ppt)
Tide cycle
Water depth (feet)
Weather observations

### Exhibit 2-3. Analytical Requirements Per Sample Collected

| Test | Sample: | Composite | Subsamples | Clay Samples | Reference | Control | Site Water | Pre-exposure Tissues |
|---|---|---|---|---|---|---|---|---|
| Physicals | Grain Size | Y | Y | Y | Y | Y | -- | -- |
| | Atterberg Limits | Y | -- | -- | Y | -- | -- | -- |
| | % Moisture | Y | Y | Y | Y | Y | -- | -- |
| | Settling Rates | Y | -- | -- | Y | -- | -- | -- |
| | Specific Gravity | Y | -- | -- | Y | -- | -- | -- |
| | Bulk Density | Y | -- | -- | Y | -- | -- | -- |
| Sediment Chemistry | TOC | Y | Y | Y | Y | Y | -- | -- |
| | Metals | Y | -- | Y | Y | -- | -- | -- |
| | Pesticides | Y | -- | Y | Y | -- | -- | -- |
| | PCB Congeners | Y | -- | Y | Y | -- | -- | -- |
| | PAHs | Y | -- | Y | Y | -- | -- | -- |
| Elutriate Chemistry | Metals | Y | -- | -- | -- | -- | Y | -- |
| | Pesticides | Y | -- | -- | -- | -- | Y | -- |
| | PCB Congeners | Y | -- | -- | -- | -- | Y | -- |
| Tissue Chemistry | Metals | Y | -- | -- | Y | -- | -- | Y |
| | Pesticides | Y | -- | -- | Y | -- | -- | Y |
| | PCB Congeners | Y | -- | -- | Y | -- | -- | Y |
| | PAHs | Y | -- | -- | Y | -- | -- | Y |
| | % Lipids | Y | -- | -- | Y | -- | -- | Y |
| Toxicology | Suspended Phase Bioassay | Y | -- | -- | -- | Y | -- | -- |
| | Solid Phase Bioassay | Y | -- | -- | Y | Y | -- | -- |
| | Bioaccumulation Potential | Y | -- | -- | Y | Y | -- | -- |

**Y** = analysis performed; -- = analysis not performed/not required or not applicable
PCB = polychlorinated biphenyl; PAH = polycyclic aromatic hydrocarbon

## 2.2 Sample Collection Techniques

### 2.2.1 Project Field Effort

Sampling activities were conducted according to the SAP/QAPP (Appendix A) and guidance from USACE and EPA. Field mobilization and sampling took place from October 12 through November 2, 2020. Field personnel consisted of scientists from ANAMAR and Athena Technologies. The *Kruger B* vessel departed from Pier 9 of the Port of San Juan for collection of the reference sediment and water on October 29, 2020. The Athena vessel *Good Vibrations* was used to collect the project samples and site water within the project area. Sample compositing was conducted on-site by ANAMAR personnel prior to shipping samples to the laboratories.

Exhibit 2-4 is a summary of the field sampling, compositing, and shipping activities. For more details, refer to the DQCRs in Appendix B. Breaks in the field sampling schedule reflect mobilization and collection of samples at additional project sites.

**Exhibit 2-4. Field Sampling Activities**

| Date | General Activity |
|---|---|
| Oct 12 and 19, 2020 | • Mobilize to San Juan, PR; get boat out of customs and stage equipment to begin sampling operations |
| Oct 19, 2020 | • Begin collection of sediment samples from Reach A |
| Oct 20, 2020 | • Finish collection of sediment samples from Reach A |
| Oct 21, 2020 | • Begin collection of sediment samples from Army Terminal Widener<br>• Begin compositing samples |
| Oct 22, 2020 | • Finish collection of sediment samples from Army Terminal Widener<br>• Start collection of sediment samples from Reach B and San Antonio Extension<br>• Continue compositing samples |
| Oct 23, 2020 | • Finish collection of sediment samples from Reach B and San Antonio Extension<br>• Finish compositing samples<br>• Begin making arrangements for shipment of samples |
| Oct 26, 2020 | • Collect site water and background water chemistry kit |
| Oct 27, 2020 | • Pack and prepare project sediment and water samples for shipping<br>• Prepare chains of custody<br>• Ship samples to laboratories via FedEx Custom Critical |
| Oct 29, 2020 | • Collect offshore reference sample and watersample |
| Nov 2, 2020 | • Pack and prepare reference sample for shipping<br>• Prepare chains of custody<br>• Ship samples to laboratories via FedEx Custom Critical |

### 2.2.2 Site Positioning

Sediment sampling locations were provided by USACE and approved by EPA. Station coordinates were uploaded to a Panasonic Toughbook computer and associated Trimble sub-meter GPS system on the R/V *Good Vibrations* and a GPS system at the helm of the S/V *Kruger B*. A Garmin hand-held GPS was used to log sampling coordinates at the aft deck of the *Kruger B* during sampling. Sampling coordinates were also logged at coring stations with a Garmin hand-held GPS as back-up. Waypoints were recorded on sampling field logs. Navigation and positioning of the sampling vessels referenced above were handled by U.S. Coast Guard-licensed captains under direction of the ANAMAR field team leader. A graduated line was used to determine water depths at coring locations. Water depths during offshore grab sampling were determined using a depth finder.

All samples were taken within 50 feet of the target station and conformed to Subsection 11.1.3 of the SAP/QAPP. Table 1 contains dates and times, coordinates, water depths, bottom elevations, and associated data for sediment grab and core samples. Table 2 contains similar information for water column parameters recorded at the reference station and the site water location within San Juan Harbor. The sampling locations for reference and project sediment samples are shown in Maps 1 through 5.

### 2.2.3 Decontamination Procedures

All equipment contacting sediment samples was cleaned and decontaminated as described below. Work surfaces on the sampling vessel were cleaned before the sampling day began and before leaving each station. All equipment contacting sediment samples was decontaminated between dredging units and individual stations, where required, to prevent cross-contamination. Gloves used at a given sampling station were replaced with new gloves prior to sampling at the next station.

<u>Decontamination Procedures</u>

- Wash and scrub using site water or tap water to remove gross contamination
- Wash and scrub with Liquinox detergent
- Rinse with site water
- Rinse with deionized water
- Rinse 2 times with pesticide grade isopropanol
- Rinse 3 times with deionized water
- Equipment not being used immediately was air-dried and stored wrapped in new, clean aluminum foil

Any derived waste was contained and disposed of in accordance with federal, state, and local laws.

### 2.2.4 Water Column Measurements

A YSI multiprobe meter and a Hach 2100P turbidimeter were used to measure water column parameters at the reference site water station and at the San Juan Harbor site water station. Instruments were calibrated each day prior to use according to manufacturer's instructions. An end-of-day reading was also taken to document that the instrument remained calibrated within acceptance criteria. Water column measurements were recorded from 2 or 3 feet below surface, at mid-depth, and 3 feet above the bottom at the San Juan Harbor site water station. Water column measurements were taken 2 feet below the surface at the reference station. Measured water column parameters and associated data consisted of

- Time of reading
- Depth of measurement (feet)
- Water temperature (°C)
- pH (units)
- Salinity (parts per thousand [ppt])
- Conductivity (mS/cm)
- Dissolved oxygen (mg/L and percent saturation)
- Turbidity (NTU, near-surface only)

Water depth measurements, tidal cycle, and weather observations were recorded on field logs and are summarized in Table 2. Equipment calibration logs are in Appendix B.

### 2.2.5 Sediment Sampling with Vibracore

Subsurface core samples were obtained using a vibratory core sampler (vibracore). Vibracore services were performed by Athena Technologies under the guidance of an ANAMAR field team leader who was present 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 sampling vessel *Good Vibrations*, which is fitted for vibracore sampling. The vessel carried all necessary sediment sampling equipment and materials.

The vessel captain navigated to each target using a helms map displayed on a Panasonic Toughbook computer and associated Trimble GPS system. 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 to the nearest inch using lead-line readings and were then converted to the nearest tenths of a foot. Bottom elevation was calculated in the field using real-time water level data (feet MLLW) from National Oceanic and Atmospheric Administration [NOAA] Station ID 9755371 at San Juan. Core penetration required to reach project depth was calculated by adding real-time elevation of the substrate surface (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 core barrel. The sampler was lowered to the substrate 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 core barrel penetrated into the sediment until it reached target depth or refusal, whichever was reached first. Vibracore refusal is defined as the point where the core barrel is advanced to depth and additional downward force applied to the vibracore drill stem does not result in measurable penetration into the sediment. This is often the result of the end of the coring tube encountering rock or consolidated sediment.

When the vibracore reached target depth or refusal, the vibracore apparatus was deactivated and the core retrieved using an electric winch. Once the sample was on-deck, the recovered core length was determined to the nearest inch and converted to the nearest tenths of a foot. Determination of acceptance of a given core sample was based on percent recovery requirements as stated in the SAP/QAPP. The sediment sample was then removed from the core barrel and placed into a stainless steel bin for characterization, photographs, and containerizing.

When sediment cores are collected with a vibracore system, the retrieved sample is subject to material compaction. For instance, a core sample taken from a penetration depth of 10 feet may result in a recovered core of only 8 to 9 feet in length, depending on the sediment composition. Core samples were considered acceptable if the core was inserted vertically into the sediment, reached target depth or refusal, and recovered at least 75% of penetrated depth. Alternatively, the acceptance limit for each core was decreased if the first core attempted at a given station was below 75% recovery of penetration depth and subsequent cores collected were within ±15% of the initial core percent recovery. During events when collected cores showed widely varying recoveries over several attempts, the material was collected, and the recovery lengths and reason for low recoveries were recorded on the field sheets.

The number of cores collected at each station was dictated by the number needed to achieve sufficient volume for laboratory analyses. To maintain proportional volumes between subsample stations, the team tried to collect the same number of cores at each station. However, in some circumstances, it was difficult to predict how many cores would be required at each station across a dredging unit because of the requirement to separate out the clay layer from the overlying unconsolidated material. Also, some stations within a dredging unit had less than 2 feet of shoaling and therefore required a grab sample. EPA was consulted on this issue and it was recommended that if an equal number of cores could not be collected, then an equal volume of material should be collected at each station.

Once all cores or grab samples were collected at a given station, the sample material was photographed, transferred to labeled Teflon® bags, and placed into ice-filled coolers. All containers were properly labeled, and sampling information for each station was recorded on individual project-specific field logs. At the end of each sampling day and following compositing, the samples were transferred to a refrigerated truck for storage at ≤4°C prior to shipping.

Information from core logs is summarized in Table 1. Field sampling logs are in Appendix B. Photographs taken during sampling and compositing are in Appendix I.

### 2.2.6 Sediment Sampling with Grab Sampler

Within the project reaches, there were some stations with very short cores lengths or areas where the mudline elevation was below the project depth. EPA advised that if shoaling was <2 feet above the target project depth or the mudline elevation was below project depth, a grab sampler could be used to collect the material. Grab samples were collected using either a double van Veen (for the reference station) or a modified Petersen grab sampler that was lowered and raised by a winch. One person operated the winch and additional team members guided the sampler into a decontaminated stainless steel bin on the vessel. Excess water was allowed to drain from the sampler prior to placing sample material in the bin. When the required volume of sediment was collected, a photograph of the material was taken and notes on the sample's appearance and characteristics were recorded on a project-specific field log. Using decontaminated stainless steel utensils and disposable nitrile gloves, the sample was placed in pre-cleaned, labeled Teflon® bags and stored in ice-filled coolers. Upon return to the dock, the samples were transferred to a refrigerated truck for preservation at or below 4°C. Map 1 shows the location of the reference station. Table 1 and the field logs in Appendix B provide additional information on grab sampling. Photographs taken during sampling and compositing are in Appendix I.

### 2.2.7 Sample Processing, Shipping, and Custody

#### 2.2.7.1 Compositing and Homogenizing

ANAMAR personnel composited and homogenized sediment samples using decontaminated stainless steel mixing equipment and a 40-gallon-capacity stainless steel bin. Compositing was conducted in accordance with the scheme presented in Section 2.1 with the following exception. No D-B-D composite sample was collected. None of subsample stations within the D-B-D dredging unit had material representative of deepening or native sediments above the project depth; therefore, no deepening samples were collected. See Table 1 for more information.

After sediment samples were composited, appropriate volumes of each sample were divided and placed in method-specific, pre-cleaned, pre-labeled Teflon® bags or glass jars (for chemical analysis) or plastic bags or buckets (for physical analysis or for use in bioassay testing). Once composited, the samples were placed in a refrigerated truck at or below 4°C until shipment to respective laboratories. The temperature inside the truck was monitored to ensure that samples met preservation criteria. Copies of temperature logs are in Appendix B.

#### 2.2.7.2 Shipping to Laboratories

Samples were placed in refrigerated units called C-Safes and shipped to laboratories overnight via FedEx Custom Critical. The temperature within the C-Safes was monitored throughout the shipment. Copies of temperature logs are in Appendix B.

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. Copies of final signed chain-of-custody forms are included with the laboratory reports in Appendices C, D, and E.

## 2.3 Physical and Chemical Analytical Procedures

### 2.3.1 Physical Procedures

Terracon performed physical analysis of all sediment samples. ANAMAR performed quality assurance/quality control (QA/QC) on sediment physical data and presented the data for all samples in summary tables.

#### 2.3.1.1 Grain Size Distribution

Gradation tests were performed in 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 #200 sieve (0.075-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 Terracon on USACE Form 2087 (Appendix C).

#### 2.3.1.2 Moisture Content

Moisture content was performed in 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 was reported on a 100% wet weight basis.

#### 2.3.1.3 Atterberg Limits

Tests for liquid and plastic limits were performed in accordance with ASTM D-4318, wet method, as follows. The minus #40 sieved material was mixed with a small amount of water and placed in a liquid limit device. A groove was cut using a flat grooving tool and the liquid limit was determined by the number of drops of the cup. When the number of drops was in the desired range, a moisture sample was obtained, placed in a 230°C oven, and dried to a constant weight. This was repeated until three determinations had been obtained, one between 15 and 25 blows, 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 was determined by slowly air-drying a small sample left over from the liquid limit determination. The sample was rolled and air-dried until the thread became crumbly and lacked cohesion. When this point was reached, the sample was placed in a tare and weighed, then placed in an oven and dried to a constant weight. The moisture content is the plastic limit.

#### 2.3.1.4 Specific Gravity

Specific gravity was determined in accordance with method ASTM D-854. Each sample was placed in a mechanical stirring device and deionized 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.

#### 2.3.1.5 Bulk Density

Bulk density, also known as dry bulk density, is the weight of dry sediment divided by the total volume. The total sediment volume is the combined volume of solids and pores which may contain air, water, or both. The average values of air, water, and solids in soil are easily measured and are a useful indication of the sediment's physical condition.

### 2.3.2 Chemical Analytical Procedures

ARI and ALS performed chemical analyses of the sample composites and the reference in accordance with published procedures. Analytical methods, preparation methods, target detection limits, and laboratory reporting limits for sediment are in Subsection 13.3 of the SAP/QAPP (Appendix A). ANAMAR performed QA/QC on these data and presented them in summary tables. Complete laboratory reports are in Appendix D. Exhibit 2-5 provides a summary of analytical methods for chemical analysis of sediment.

ANAMAR Environmental Consulting, Inc.

**Exhibit 2-5. Summary of Methods and Equipment Used during Chemical Analysis of Sediment**

| EPA Method | Instrument/ Procedure | Methodology Summary |
|---|---|---|
| 6020A (Trace metals in water/sediments/ tissues) | Inductively Coupled Plasma/Mass Spectrometry | Inductively coupled plasma/mass spectrometry (ICP/MS) is applicable to the determination of sub-µg/L concentrations of a large number of elements in water and sediment samples. Acid digestion prior to filtration and analysis is required for aqueous samples and sediments for which total (acid-leachable) elements are required. For analysis, sample material in solution is introduced by pneumatic nebulization into radiofrequency plasma where energy transfer processes cause desolvation, atomization, and ionization. The ions are extracted from the plasma through a differentially pumped vacuum interface and separated on the basis of their mass-to-charge ratio by a quadrupole mass spectrometer. The ions transmitted through the quadrupole are detected by an electron multiplier and the ion information is processed by a data-handling system. |
| 7470/7471 (Mercury in water/sediments/ tissues) | Mercury Analyzer Cold Vapor Atomic Absorption | Method 7470 is applicable to water samples, and 7471 is applicable for measuring total mercury (organic and inorganic) in sediments. All samples are digested and oxidized at 95 ± 3°C, then mercury from the digestates is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer, and the absorbance (peak area) at 253.7 nm is measured as a function of mercury concentration. |
| 8081/8082 (Pesticides/PCBs in water/ sediments/ tissues) | Gas Chromatograph | Methods 8081 and 8082 are applicable to the determination of extracted organochlorine pesticide compounds and polychlorinated biphenyl (PCB) congeners from a variety of matrices by gas-chromatography-electron capture detection (GC-ECD). Qualitative identification of an analyte is based on its retention times on dissimilar GC columns. Quantitative analysis may be based on peak areas or height following either external or internal calibrations. Second column confirmation is typically performed and, if the relative percent difference (RPD) is ≤40%, the result is considered confirmed. If the RPD exceeds 40%, errors, chromatographic, and instrument performances are all checked. If the out-of-control situation is still not resolved, the data are reported with qualifiers. When there are no discrepancies between columns, the lower of the two results is typically reported. |
| 8270 (PAHs in sediments/ tissues) | Gas Chromatograph/ Mass Spectrometer | This method is used to determine the concentration of polycyclic aromatic hydrocarbon (PAH) organic compounds in extracts prepared from many types of solid matrices and water samples. The extracted sample aliquot is injected into a gas chromatograph/mass spectrometer (GC/MS) by large-volume injection for qualitative and quantitative determination. Data may be obtained from the mass spectrometer via one of the three modes of operation: full scan mode, selected ion monitoring (SIM), or multiple reaction monitoring (MRM). |
| Plumb (1981) (TOC in sediments) | Total Organic Carbon (TOC) Analyzer | Plumb (1981) 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. |

## 2.4 Bioaccumulation and Toxicology Procedures

EcoAnalysts conducted biological testing using sediment samples collected by ANAMAR as part of the dredged material evaluation for San Juan Harbor. The testing procedures used by EcoAnalysts (2021) is summarized in Section 2 of their report titled *Toxicity Testing Results, San Juan Harbor Puerto Rico 103 Evaluation, San Juan, Puerto Rico*. The complete laboratory report is in Appendix G (in hardcopy and on disc).

The material under consideration for ocean disposal was evaluated in accordance with procedures and criteria outlined in the Green Book and the RTM and with guidance outlined in the ITM. Biological analyses with reference sediments was performed concurrently with the test sediment evaluations.

This program included bioassay analysis of four composite samples and one reference sample. In addition, appropriate laboratory control samples (LCSs) were run with each of the selected test species. Bioassay testing for this project consisted of three water column bioassays, two whole sediment bioassays, and two whole sediment bioaccumulation potential tests. The bioassay and bioaccumulation tests are summarized in Exhibit 2-6. Exhibit 2-7 summarizes the testing objectives for each sample evaluated under this program. All tests were conducted within the eight-week (56 days) sediment holding time limit.

**Exhibit 2-6. Biological Testing Performed for Dredge Material Evaluation**

| Test Type | Type of Organism | Taxon | Project Sediments | Reference Sediment | Control Sediment/ Seawater |
|---|---|---|---|---|---|
| Suspended-Particulate Phase | Mysid shrimp | *Americamysis bahia*  Courtesy of: Alan Kennedy, ERDC | •[1] | NA | • |
| | Fish | *Menidia beryllina*  Courtesy of: MBL Aquaculture | •[1] | NA | • |
| | Larval bivalve | *Mytilus galloprovincialis*  Courtesy of: William Gardner, NewFields Northwest | •[1] | NA | • |

| Test Type | Type of Organism | Taxon | Project Sediments | Reference Sediment | Control Sediment/ Seawater |
|---|---|---|---|---|---|
| Solid-Phase | Amphipod | *Ampelisca abdita*<br><br>Courtesy of: Alan Kennedy, ERDC | • | • | • |
| | Mysid shrimp | *Americamysis bahia*<br><br>Courtesy of: Alan Kennedy, ERDC | • | • | • |
| Bioaccumulation | Polychaete | *Alitta virens*<br><br>Courtesy of: Alan Kennedy, ERDC | • | • | • |
| | Bivalve | *Macoma nasuta*<br><br>Courtesy of: Alan Kennedy, ERDC | • | • | • |

[1] Sediment elutriates of project material
NA = Tests or treatments that are not applicable to the selected tests.

**Exhibit 2-7. Biological Testing Objectives by Sample**

| Sample | Objective |
|---|---|
| SJH20-REF | Solid Phase Tests and Bioaccumulation Tests |
| SJH20-SW | Suspended Particulate Phase |
| M-A-S-20-COMP | All Phases of Testing |
| M-B-S-20-COMP | |
| D-ATw-S-20-COMP | |
| D-SAx-S-20-COMP | |

## 2.5 Tissue Analysis Recommendations

ANAMAR coordinated with USACE and EPA to determine which analytes should be tested in the corresponding tissue samples based on guidance provided in the RTM. The final list of parameters analyzed in tissue samples is summarized in Exhibit 2-3.

## 2.6 Applicable Technical Quality Standards

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

### 2.6.1 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 RTM. These levels are the threshold effects level (TEL) and effects range low (ERL). 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). These comparisons are for reference use only and are not intended for regulatory decision-making.

### 2.6.2 Elutriate and Water Chemistry

Analytical results for elutriate and water samples were compared to the latest published EPA water quality criteria of criteria maximum concentration (CMC [synonymous with 'acute']) established in EPA (2006, 2015). 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 (EPA 2006, Buchman 2008).

### 2.6.3 Toxicology

All water quality and endpoint data were entered into Microsoft Excel spreadsheets. Water quality parameters were summarized by calculating the mean, minimum, and maximum values for each test treatment. Endpoint data were calculated for each replicate, and the mean value and standard deviation were determined for each test treatment.

All hand-entered data were reviewed for data entry errors. Any errors found were corrected before summary calculations were performed. A minimum of 10% of all calculations and data sorting were reviewed for errors. Review counts were conducted on any apparent outliers.

Statistical comparisons were made according to the Green Book and were performed using SAS/STAT software or CETIS™ software (CETIS 2012). Before statistical comparisons were conducted, data were tested for normal distribution. Any data that violated the assumption of normal distribution were transformed using an arcsine square root transformation before statistical analysis. All data were tested for equality of variance using Levene's test.

Benthic test results were compared to reference results using analysis of variance (ANOVA) with SAS Proc GLM software with Dunnett's multiple comparison test on the mean values. The Dunnett's test was performed as a one-way test, testing for significantly lower organism survival than in the reference sample.

### 2.6.4 Tissue Chemistry

The project sample and reference tissues had five replicates per test species and were evaluated using guidance from Subsection 6.3 of the Green Book and Subsection 9.2.3 of the RTM. Analytical results for tissue samples were compared to published tissue screening benchmarks. The U.S. Food and Drug Administration (FDA) action levels and threshold levels were used for comparison after accounting for steady-state adjustments as applicable.

Analyte concentrations in *Macoma nasuta* tissues were compared to FDA levels for bivalve mollusks. Analyte concentrations in *Alitta virens* tissues were compared to the FDA levels for crustacea as there are no FDA levels published for polychaete worm tissue (FDA 2001, 2011).

The mean of results for each set of five replicates per composite and analyte combination was calculated for wet weight and dry weight concentrations. The wet weight concentrations of composites having two or more replicates greater than the MDL were compared to the replicate concentrations for the reference tissue per analyte. Mean values of analyte concentrations were calculated as follows:

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

In cases where the mean concentration of an analyte in *A. virens* or *M. nasuta* tissue was found to exceed that of the reference tissue, 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, no additional analysis was necessary to demonstrate compliance with the LPC (Green Book). Mean tissue analytical results found to statistically significantly exceed those of the reference tissue (of the same species) are presented in bold font in the accompanying tables. This is in accordance with Subsection 9.2.3 of the RTM.

## 2.7 Reporting Limits

Chemical concentration, MDL, and method reporting limit (MRL) were reported on a dry weight basis for sediment samples, liquid basis for site water and elutriate samples, and wet and dry weight bases for tissue samples. 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 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

Conditions during sampling at the offshore reference station and coring locations were favorable. Weather conditions (including wind direction, wind speed, and sea state) at each station are noted on the field logs in Appendix B.

### 3.1.2 Water Column Data

Water column parameters were recorded at the offshore reference station (SJH20-REF-SW) and at the site water location within the San Juan Harbor project area (SJH20-SW) and are summarized in Table 2. The water sampling field logs are in Appendix B.

### 3.1.3 Vibracore and Grab Sampling Data

A brief summary of sample collection activities within each dredging unit is provided below. EPA was consulted throughout the sampling effort. Key issues that were discussed are summarized in Subsection 4.1. Table 1 provides a summary of vibracore sampling data, including core depth, penetration, recovery length, and percent recovery. Copies of the core logs are in Appendix B.

**San Juan Harbor Maintenance Reach A Summary:**
M-A-S-1/D-AC-C-1. Project depth of -48 feet MLLW was reached at this station. Three core samples were collected in liners. No hard, stiff clay layer indicative of native (new work) material was encountered. EPA Region 2 inspected the intact cores and determined that the material throughout the profile was characteristic of maintenance material. Therefore, no clay sample (D-AC-C-1) was collected.

M-A-S-2/D-EC-C-1. Project depth of -37 feet MLLW was reached at this station. One core was collected in a liner and a second core was collected with the 4-inch unlined core barrel. There was no obvious stratification between maintenance and deepening sediment. No hard, stiff clay layer indicative of native (new work) material was encountered. The EPA Region 2 representative inspected the intact core and determined that the material throughout the profile was characteristic of maintenance material. Therefore, no clay sample (D-EC-C-1) was collected.

M-A-S-3/D-EC-C-2. Project depth of -37 feet MLLW was reached at this station. One core was collected in a liner and a second core was collected with the 4-inch unlined core barrel. There was not obvious stratification between the maintenance and deepening layer, but the material did get slightly stiffer toward the bottom 3 feet of the profile. That slight transition is where the sample was split between the maintenance and deepening. Therefore, a both a surface (M-A-S-3) and a clay sample (D-EC-C-2) were collected.

M-A-S-4 through M-A-S-7. EPA was consulted about the lack of material above project depth at these four stations. The EPA Region 2 representative advised that if the shoaling was <2 feet, a grab sample could be collected. Therefore, these four stations were collected with a grab sampler. Equal volumes were collected at each station.

M-A-S-8/D-AT-C-1. Project depth of -46 feet MLLW was reached at this station. One core was collected in a liner and a second core was collected with the 4-inch unlined core barrel. There was no obvious stratification between maintenance and deepening. No hard, stiff clay layer indicative of native (new work) material was encountered. Therefore, no clay sample (D-AT-C-1) was collected.

M-A-S-9/D-AT-C-2. This area is already below the deepening project depth. The vessel captain tried to relocate the station but could not find any shoals above the project depth. Therefore, no surface or clay sample was collected at this station.

M-A-S-10/D-AT-C-3. Project depth of -46 feet MLLW was reached at this station. Two cores were collected and retained. There was no obvious stratification between maintenance and deepening. No hard, stiff clay layer indicative of native (new work) material was encountered. Therefore, no clay sample (D-AT-C-3) was collected.

**San Juan Harbor Maintenance Reach B Summary:**
M-B-S-1/D-B-D-1. Project depth of -38 feet MLLW was reached at this station. Two cores were collected at this station. No deepening (native) material was encountered. Therefore, no deepening sample (D-B-D-1) was collected.

M-B-S-2/D-B-D-2. Sediment elevation (-38.5 feet) at this station is below project depth of -38 feet MLLW. EPA was consulted and advised ANAMAR to use a grab sampler to collect unconsolidated maintenance material at the surface. Therefore, no deepening sample (D-B-D-2) was collected.

M-B-S-3/D-B-D-3. Project depth of -38 feet MLLW was reached at this station. Two cores were collected at this station. No deepening (native) material was encountered. Therefore, no deepening sample (D-B-D-3) was collected.

M-B-S-4/D-B-D-4. Sediment elevation (-39.[illegible] feet) at this station is below project depth of -38 feet MLLW. EPA was consulted and advised ANAMAR to use a grab sampler to collect unconsolidated maintenance material at the surface. Therefore, no deepening sample (D-B-D-4) was collected.

M-B-S-5/D-B-D-5. Sediment elevation (-39.2 feet) at this station is below project depth of -38 feet MLLW. EPA was consulted and advised ANAMAR to use a grab sampler to collect unconsolidated maintenance material at the surface. Therefore, no deepening sample (D-B-D-5) was collected.

M-B-S-6/D-B-D-6. Sediment elevation (-44.6 feet) at this station is below project depth of -38 feet MLLW. EPA was consulted and advised ANAMAR to use a grab sampler to collect unconsolidated maintenance material at the surface. Therefore, no deepening sample (D-B-D-6) was collected.

**Army Terminal Widener Reach Summary:**
D-ATw-S-1/D-ATw-C-1. Refusal was encountered (-36 feet MLLW) above the project depth of -44 feet MLLW due to hard, stiff clay. One core was collected from this station, and it had material characteristic of both maintenance and new work (native) material. Therefore, both a surface (D-ATw-S-1) and a clay (D-ATw-C-1) sample were collected.

D-ATw-S-2/D-ATw-C-2. The length of core required to reach project depth of -44 feet MLLW was longer than could be reached with a 20-foot core barrel (target penetration = 27.9 feet). These limitations were discussed with EPA prior to sampling, and a "stair-step" method was suggested that involves collecting another core downslope of the target location to reach full project depth (or refusal by encountering native material). This approach was required at this station because the core penetration length at the target location was 19.6 feet (bottom core elevation of -35.7 feet MLLW) but did not encounter refusal. Therefore, ANAMAR consulted with EPA while on station for approval to use the "stair-step" approach. A second station was located downslope of the target location with a top of core elevation of -34.2 feet MLLW. At this second location, refusal was encountered at -42.2 feet MLLW due to red/gray stiff clay (native material). Therefore, both a surface (D-ATw-S-2) and a clay (D-ATw-C-2) sample were collected.

D-ATw-S-3/D-ATw-C-4. Similar to previous station, the length of core required to reach the project depth of -44 feet MLLW was longer than could be reached with a 20-foot core barrel (target penetration = 25.2 feet). The "stair-step" approach was required at this station because the core penetration length at the target location was 16.2 feet (bottom core elevation of -35.0 feet MLLW) but did not reach native material. Therefore, EPA was consulted EPA on-station for approval to use the "stair-step" approach. ANAMAR were able to find a location downslope of the target location with a top of core elevation of -34.4 feet MLLW. At this second location, refusal was encountered at -43 feet MLLW, and there was change in stratification (native material) consisting of sand/clay, large shells, and rocks. Therefore, both a surface (D-ATw-S-3) and a native (D-ATw-C-4) sample were collected.

D-ATw-S-4/D-ATw-C-3. Refusal was encountered (between -20.4 and -21.4 feet MLLW) above the project depth of -44 feet MLLW due to hard, stiff clay. Native clay material was encountered at a much shallower elevation at this station compared to the other three stations in this reach. Two cores were collected from this station to get adequate volume of material for the surface composite sample. Therefore, both a surface (D-ATw-S-4) and a clay (D-ATw-C-3) sample were collected.

Compositing Note: Given that the core lengths of maintenance material varied significantly between the four subsample stations within the Army Terminal Widener Reach, EPA advised the field team to mix proportional volumes based on feet of material recovered from the four subsamples for the composite. Those volumes were calculated and provided to the compositing team.

**San Antonio Extension Summary:**
D-SAx-S-1/D-B-D-7. Sediment elevation (-40.2 feet) at this station is below the project depth of -38 feet MLLW. EPA was consulted and advised ANAMAR to use a grab sampler to collect unconsolidated maintenance material at the surface. Therefore, no deepening sample (D-B-D-7) was collected.

D-SAx-S-2/D-B-D-8. Sediment elevation (-38.1 feet) at this station is below project depth of -38 feet MLLW. EPA was consulted and advised ANAMAR to use a grab sampler to collect unconsolidated maintenance material at the surface. Therefore, no deepening sample (D-B-D-8) was collected.

D-SAx-S-3/D-B-D-9. Project depth of -38 feet MLLW was reached at this station. Two cores were collected at this station, and no deepening (native) material was encountered. Therefore, no deepening sample (D-B-D-9) was collected.

## 3.2 Physical Testing Data

Grain size distribution and total solids were analyzed in project composite samples, subsamples, individual clay/native material samples, and the reference sample. The following parameters were also analyzed for the composite sample: bulk density, specific gravity, and Atterberg limits. Results are presented in Tables 3 through 5.

**San Juan Harbor Maintenance Reach A**

Subsamples and the composite sample from Reach A stations were primarily composed of fine-grained material (silt/clay) ranging from 53.8% to 98.2%. Exhibit 3-1 shows a bar graph of the grain size results. The U.S. Soil Classification System (USCS) class was either CH (clay of high plasticity, elastic silt) or MH (silt of high plasticity, elastic silt). Complete results are presented in Tables 3 and 5.


**Exhibit 3-1. Grain Size Distribution for Reach A**

**San Juan Harbor Maintenance Reach B**

With the exception of subsample M-B-S-2, all subsamples and the composite sample from Reach B stations were primarily composed of fine-grained material (silt/clay) ranging from 52.4% to 95.0%. M-B-S-2 was composed primarily of sand (57.7%). Exhibit 3-2 shows a bar graph of the grain size results. The USCS class was either CH (clay of high plasticity, elastic silt) or SC (clayey sand). Complete results are presented in Tables 3 and 5.


**Exhibit 3-2. Grain Size Distribution for Reach B**

**Army Terminal Widener Reach**

With the exception of subsample D-ATw-S-4, all subsamples and the composite sample from the Army Terminal Widener Reach were primarily composed of fine-grained material (silt/clay) ranging from 78.2% to 95.9%. D-ATw-S-4 was composed primarily of sand (54.3%) with 5.1% gravel. Exhibit 3-3 shows a bar graph of the grain size results. The USCS class was either CH (clay of high plasticity, elastic silt) or SC (clayey sand). Complete results are presented in Tables 3 and 5.

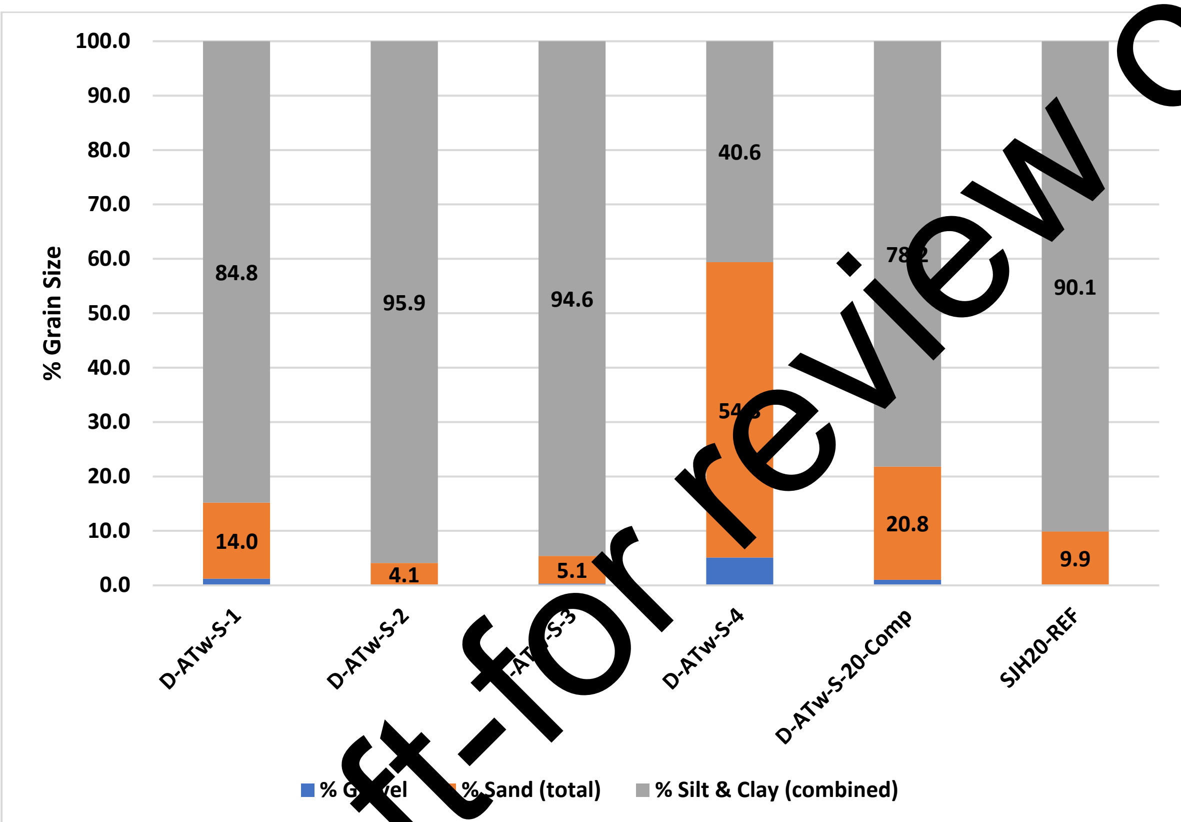



**Exhibit 3-3. Grain Size Distribution for the Army Terminal Widener**

**San Antonio Extension**

All subsamples and the composite sample from the San Antonio Extension Reach were primarily composed of fine-grained material (silt/clay) ranging from 81.8% to 90.2%. Exhibit 3-4 shows a bar graph of the grain size results. The USCS class was CH (clay of high plasticity, elastic silt). Complete results are presented in Tables 3 and 5.

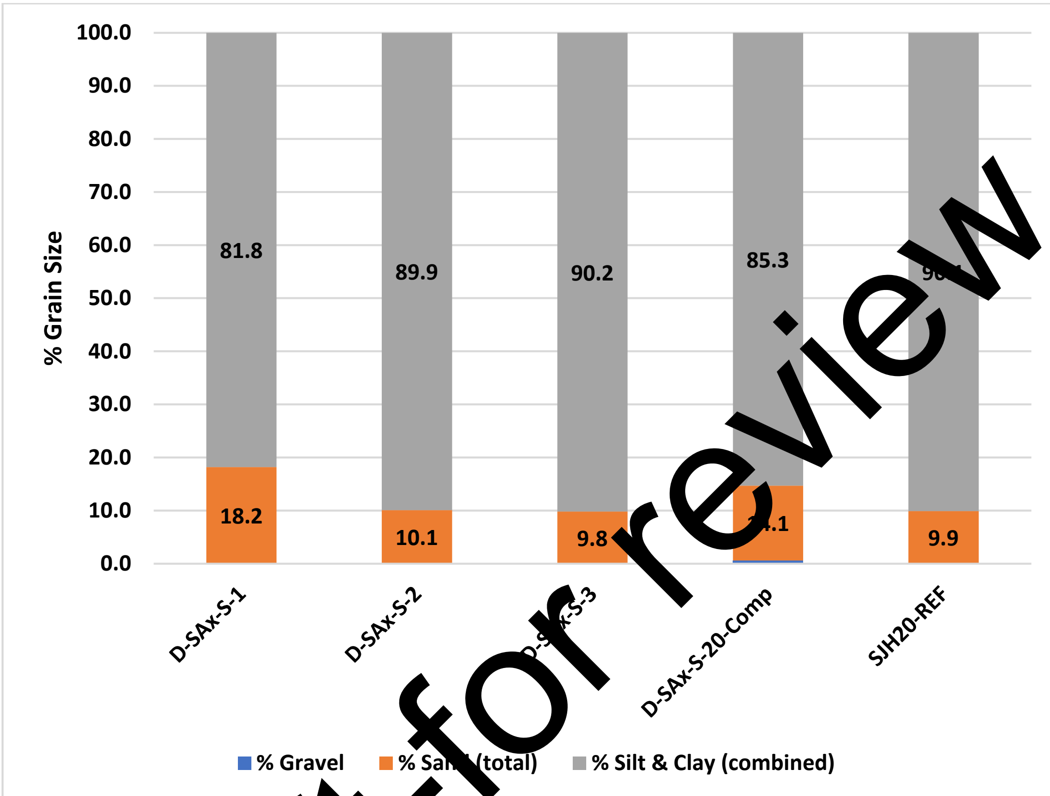



**Exhibit 3-4. Grain Size Distribution for the San Antonio Extension**

**Individual Clay/Native Material Samples**

Samples of stiff clay or material representative of native/new work material were collected at five locations: one from Reach A and four from the Army Terminal Widener. Exhibit 3-5 shows a bar graph of the grain size results. Complete results are presented in Table 4.

Sample D-EC-C-2 (co-located with station M-A-S-3) from the Entrance Channel in Reach A was primarily composed of fine material with 96.7% silt/clay. The USCS class was CH (clay of high plasticity, elastic silt).

Sample D-ATw-C-1 (co-located with station D-ATw-S-1) in the Army Terminal Widener was primarily composed of fine material with 83.4% silt/clay. The USCS class was CH (clay of high plasticity, elastic silt).

Sample D-ATw-C-2 (co-located with station D-ATw-S-2) in the Army Terminal Widener was primarily composed of fine material with 66.0% silt/clay. The USCS class was CH (clay of high plasticity, elastic silt).

Sample D-ATw-C-3 (co-located with station D-ATw-S-4) in the Army Terminal Widener was primarily composed of fine material with 54.7% silt/clay. The USCS class was CH (clay of high plasticity, elastic silt).

Sample D-ATw-C-4 (co-located with station D-ATw-S-3) in the Army Terminal Widener was primarily composed of fine material with 59.5% silt/clay. The USCS class was CH (clay of high plasticity, elastic silt).

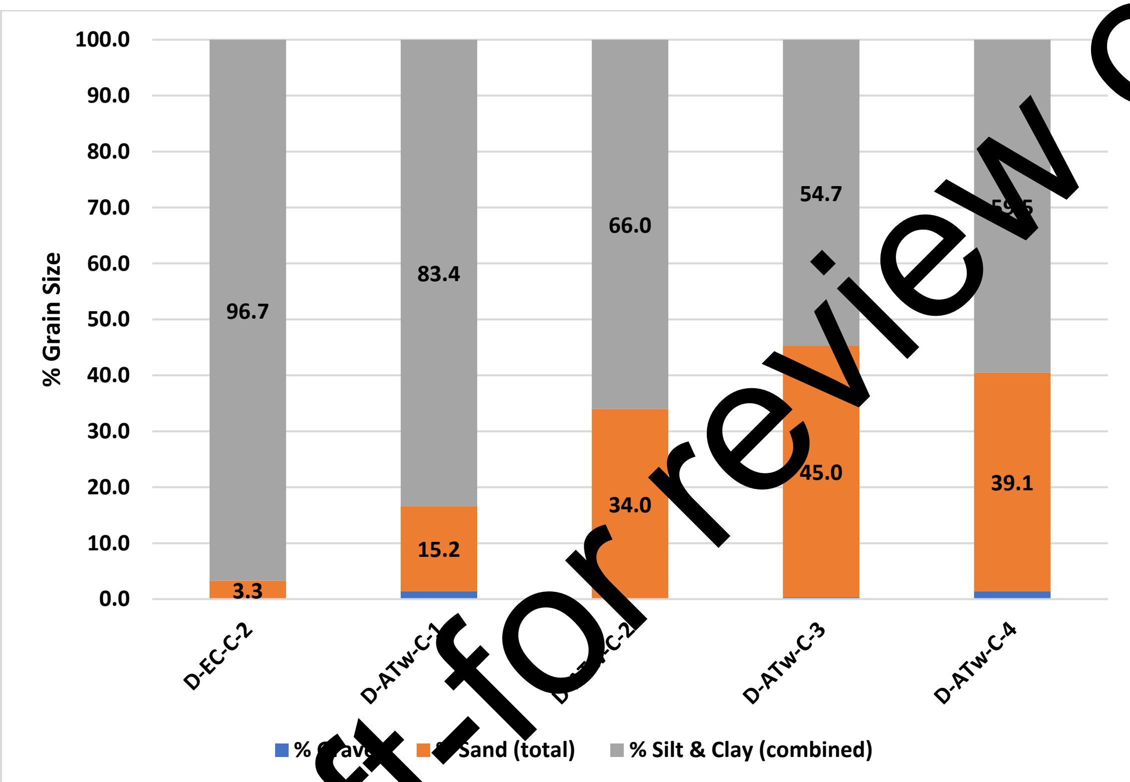



**Exhibit 3-5. Grain Size Distribution from Subsamples of Clay/Native Material**

## 3.3 Sediment Chemistry

Sediment composites, clay/native material samples, and the reference (SJH20-REF) were analyzed for total solids, TOC, metals, pesticides, PAHs, and PCBs. The subsamples were also analyzed for total solids and TOC. Analytical results for sediment chemistry are presented in Tables 6 through 16. Analytical results were compared to the published sediment screening criteria TEL and ERL from Buchman (2008). Complete sediment chemistry results are in Appendix D.

### 3.3.1 Total Solids and TOC

Complete analytical results for total solids and TOC are presented in Tables 6 through 8.

M-A-S-20 composite and subsamples had percent total solids that ranged from 36.90% to 60.23% and TOC concentrations that ranged from 0.84% to 1.96%. Clay/native material sample D-EC-C-2 had percent total solids of 58.43% and a TOC concentration of 1.36%.

M-B-S-20 composite and subsamples had percent total solids that ranged from 48.78% to 61.98% and TOC concentrations that ranged from 0.53% to 1.92%.

D-ATw-S-20 composite and subsamples had percent total solids that ranged from 54.57% to 65.98% and TOC concentrations that ranged from 0.71% to 1.56%. Clay/native material samples had percent total solids ranging from 65.56% to 78.44%, and TOC concentrations ranging from 0.51% to 0.58%.

D-SAx-S-20 composite and subsamples had percent total solids that ranged from 38.[illegible]9% to 43.52% and TOC concentrations that ranged from 1.75% to 3.26%.

The reference had 53.83% total solids and 0.90% TOC.

### 3.3.2 Metals

All nine metals analyzed were detected in concentrations above the MDL in all of the project composite samples. With the exception of cadmium, all other metals analyzed were also detected in concentrations above the MDL in the reference and several of the individual clay/native material subsamples. Exhibit 3-6 summarizes the analytical results for metals in sediment compared to the TEL and ERL. Complete results are provided in Tables 9 and 10.

**Composite Samples**
M-A-S-20-COMP had concentrations of arsenic, copper, mercury, and nickel that exceeded the TEL and (or) ERL. M-B-S-20-COMP had concentrations of arsenic, copper, and mercury that exceeded the TEL and (or) ERL. D-ATw-S-20-COMP had concentrations of arsenic, copper, and nickel that exceeded the TEL and (or) ERL. D-SAx-S-20 had concentrations of arsenic, copper, lead, mercury, nickel, silver, and zinc that exceeded the TEL and (or) ERL.

**Clay/Native Material Samples**
D-EC-C-2 had concentrations of arsenic, copper, mercury, and nickel that exceeded the TEL and and ERL. D-ATw-C-1, C-2 and C-4 had concentrations of arsenic and copper that exceeded the TEL and (or) ERL. D-ATw-C-[illegible] had concentrations of copper that exceeded the TEL.

**Reference**
SJH20-REF had concentrations of arsenic, copper, and nickel that exceeded the TEL and (or) the ERL.

**Exhibit 3-6. Summary of Analytical Results for Metals in Sediment Composites and Clay/Native Material Subsamples**

| Analyte | Concentration (mg/kg) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample ID | | | | | | | | | | TEL | ERL |
| | SJH20 REF | Composite Samples | | | | Clay/Native Subsamples | | | | | | |
| | | M-A-S-20-COMP | M-B-S-20-COMP | D-ATw-S-20-COMP | D-SAx-S-20-COMP | D-EC-C-2 | D-ATw-C-1 | D-ATw-C-2 | D-ATw-C-3 | D-ATw-C-4 | | |
| Arsenic | **13.6** | **15.0** | **11.9** | **18.4** | **13.1** | **16.5** | **24.4** | **13.1** | 6.54 | **10.5** | 7.24 | 8.2 |
| Cadmium | ND | 0.15 | 0.10 | 0.05 | 0.29 | ND | 0.06 | 0.08 | ND | ND | 0.676 | 1.2 |
| Chromium | 46.4 | 42.0 | 34.0 | 49.6 | 43.9 | 49.0 | [illegible] | 38.8 | 33.3 | 33.8 | 52.3 | 81 |
| Copper | **63.8** | **66.0** | **48.0** | **47.5** | **90.5** | **49.2** | **[illegible]** | **37.2** | **22.3** | **25.1** | 18.7 | 34 |
| Lead | 16.3 | 26.1 | 23.9 | 9.70 | **54.6** | 9.19 | 5.75 | 10.3 | 5.10 | 4.23 | 30.24 | 46.7 |
| Mercury | 0.116 | **0.342** | **0.371** | 0.105 | **2.28** | **[illegible]** | 0.0712 | 0.127 | 0.116 | 0.0375 | 0.13 | 0.15 |
| Nickel | **29.3** | **20.4** | 14.5 | **23.6** | **17.7** | **[illegible]** | 13.2 | 15.8 | 6.79 | 15.1 | 15.9 | 20.9 |
| Silver | 0.11 | 0.62 | 0.45 | 0.26 | [illegible] | [illegible] | 0.04 | 0.28 | 0.06 | 0.06 | 0.73 | 1 |
| Zinc | 73.9 | 117 | 85.6 | 69.6 | **158** | 62.9 | 45.4 | 55.7 | 17.5 | 36.6 | 124 | 150 |

**Bolded values** exceed the TEL and/or ERL.
Non-detect (ND) = The analyte was not detected at or above the MDL.
x = No TEL or ERL published for that parameter.
See Tables 9 and 10 for complete results.

### 3.3.3 Pesticides

Of the 15 pesticides tested, two [o,p' (2,4')-DDE and p,p' (4,4')-DDE] were detected above the MDL (J-qualified or greater) in one or more samples. For dieldrin, no results were greater than the MDL (U-qualified); but the MDL (0.11 µg/kg) exceeded the ERL of 0.02 µg/kg for all samples. However, the MDL for dieldrin was below the EPA Region 2 target detection limit of 1 µg/kg in Table 13-2 of the SAP/QAPP (Appendix A). Results are summarized below, and complete results are provided in Tables 11 and 12.

**Composite Samples**

M-A-S-20-COMP and M-B-S-20-COMP had a concentration of p,p' (4,4')-DDE that was greater than the MDL (J-qualified) but did not exceed the ERL or the TEL. D-SAx-S-20-COMP had concentrations of o,p' (2,4')-DDE and p,p' (4,4')-DDE that were greater than the MRL, and p,p' (4,4')-DDE concentrations exceeded the ERL and TEL. In samples M-A-S-20-COMP and D-SAx-20-COMP, the MDLs/MRLs for p,p' (4,4')-DDT and dieldrin were elevated above the EPA Region 2 target detection limit of 1 µg/kg. See Subsection 4.4.2.3 and the QAR (Appendix E) for more information. No other pesticides were detected in concentrations greater than the MDLs (U-qualified).

**Clay/Native Material Samples**

None of the results for the subsamples were detected in concentrations greater than the MDL; all results were U-qualified. The MDLs and MRLs met the EPA Region 2 target detection limit of 1 µg/kg.

**Reference**

None of the results for SJH20-REF were detected in concentrations greater than the MDL; all results were U-qualified. However, the MDL for dieldrin (0.11 µg/kg) exceeded the ERL (0.02 µg/kg). The MDLs and MRLs met the EPA Region 2 target detection limit of 1 µg/kg.

### 3.3.4 PAHs

All of the 16 PAH analytes tested were detected above the MDL (J-qualified or greater) in one or more composites or subsamples. Several composite samples had concentrations of PAH analytes that exceeded the applicable TEL or ERL. The MDLs and MRLs met the EPA Region 2 target detection limit of 100 µg/kg. Results per reach are summarized below and in Exhibit 3-7. Complete results are provided in Tables 13 and 14.

**Composite Samples**

In each of the composite samples, all PAH analytes were detected in concentrations greater than the MDL (J-qualified) or MRL with the exception of acenaphthene in M-B-S-20-COMP. In samples M-A-S-20-COMP, M-B-S-20-COMP, and D-SAx-20-COMP, acenaphthylene and dibenzo(a,h)anthracene concentrations exceeded the TEL. In sample D-SAx-20-COMP, benzo(a)pyrene and total HMW PAHs concentrations exceeded the TEL.

**Clay/Native Material Samples**

In samples D-EC-C-2 and D-AT-C-2, all but one of the PAH analytes were detected in concentrations greater than the MDL (J-qualified). In sample D-ATw-C-1, none of PAH analytes were detected in concentrations greater than the MDL (U-qualified). In sample D-ATw-C-3, one PAH analyte was detected in concentrations greater than the MDL (J-qualified). In sample D ATw-C-4, nine PAH analytes were detected in concentrations greater than the MDL (J-qualified). None of the results exceeded the TEL or ERL.

**Reference**
All PAH analytes that were detected in SJH20-REF were in concentrations greater than the MDL (J-qualified). None of the results exceeded the TEL or ERL.

### 3.3.5 PCBs

Up to 20 of the 22 PCB congeners tested were detected in concentrations above the MDL in one or more samples. All composites, subsamples, and the reference sample had total EPA Region 2 PCB concentrations that exceeded the applicable TEL or ERL. The MDLs met the EPA Region 2 target detection limit of 1 µg/kg for all samples. The MRL for PCB-5/8 was elevated above the EPA Region 2 target detection limit of 1 µg/kg because of the co-eluting of the two congeners. Results per reach are summarized below and in Exhibit 3-8. Complete results are provided in Tables 15 and 16.

**Composite Samples**
In sample M-A-S-20-COMP, 10 of the 22 PCB congeners were detected in concentrations greater than the MDL/MRL. In sample M-B-S-20-COMP, eight of the 22 PCB congeners were detected in concentrations greater than the MDL/MRL. In sample D-ATw-S-20-COMP, three of the 22 PCB congeners were detected in concentrations greater than the MDL/MRL. In sample D-SAx-S-20-COMP, 20 of the 22 PCB congeners were detected in concentrations greater than the MDL/MRL. All samples had total EPA Region 2 PCB concentrations that exceeded the TEL and ERL.

**Clay/Native Material Samples**
In samples D-EC-C-2, D-ATw-C-1, D-ATw-C-3, and D-ATw-C-4, none of the PCB congeners were detected in concentrations greater than the MDL (U-qualified). In sample D-ATw-C-2, four of the 22 PCB congeners were detected in concentrations greater than the MDL/MRL. All samples had total EPA Region 2 PCB concentrations that exceeded the TEL and (or) ERL.

**Reference**
In sample SJH20-REF, none of the 22 PCB congeners were detected in concentrations greater than the MDL (U-qualified). The reference had total EPA Region 2 PCB concentrations that exceeded the TEL.

**Exhibit 3-7. Summary of Analytical Results for PAHs in Sediment Composites and Clay/Native Material Subsamples**

| Analyte | Concentration (µg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample ID | | | | | | | | | TEL | ERL |
| | | Composite Samples | | | | Clay/Native Subsamples | | | | | |
| | SJH20 REF | M-A-S-20-COMP | M-B-S-20-COMP | D-ATw-S-20-COMP | D-SAx-S-20-COMP | D-EC-C-2 | D-ATw-C-1 | D-ATw-C-2 | D-ATw-C-3 | D-ATw-C-4 | | |
| Acenaphthene | 1.61 | 1.97 | ND | 0.59 | 4.47 | ND | ND | ND | ND | ND | 6.71 | 16 |
| Acenaphthylene | 3.60 | **7.73** | **17.8** | 1.77 | **22.1** | 2.55 | ND | [illegible] | ND | ND | 5.87 | 44 |
| Anthracene | 3.74 | 8.83 | 16.6 | 1.14 | 31.8 | 2.01 | ND | [illegible] | ND | ND | 46.9 | 85.3 |
| Benzo(a)anthracene | 15.8 | 32.0 | 45.2 | 3.27 | 68.0 | 8.51 | ND | 4.18 | ND | 0.89 | 74.8 | 261 |
| Benzo(a)pyrene | 17.8 | 45.4 | 88.7 | 5.00 | **125** | 15.1 | ND | 8.07 | ND | 1.51 | 88.8 | 430 |
| Benzo(b)fluoranthene | 12.2 | 42.6 | 91.2 | 4.50 | 141 | 13.1 | ND | 5.65 | ND | 1.39 | x | x |
| Benzo(g,h,i)perylene | 22.5 | 41.9 | 80.5 | 6.10 | 111 | 15.3 | ND | 10.2 | ND | 1.78 | x | x |
| Benzo(k)fluoranthene | 7.31 | 21.5 | 48.6 | 2.51 | 71.8 | 7.12 | ND | 3.09 | ND | ND | x | x |
| Chrysene | 15.6 | 35.1 | 53.7 | 3.78 | 73.7 | 10.0 | ND | 4.80 | ND | 1.31 | 108 | 384 |
| Dibenzo(a,h)anthracene | 3.61 | **11.3** | **20.2** | 2.01 | **28.2** | 4.17 | ND | 2.53 | ND | ND | 6.22 | 63.4 |
| Fluoranthene | 21.5 | 40.8 | 67.6 | 3.32 | 76.8 | [illegible] | ND | 5.67 | 0.56 | 1.25 | 113 | 600 |
| Fluorene | 2.76 | 4.33 | 4.12 | 0.99 | [illegible] | 0.91 | ND | 1.33 | ND | ND | 21.2 | 19 |
| Indeno(1,2,3-cd)pyrene | 13.7 | 35.9 | 70.5 | 5.27 | 95.3 | 11.1 | ND | 7.92 | ND | 1.41 | x | x |
| Naphthalene | 4.75 | 4.16 | 6.47 | 1.40 | [illegible] | 1.79 | ND | 1.30 | ND | ND | 34.6 | 160 |
| Phenanthrene | 15.4 | 20.3 | 29.5 | [illegible] | 30.1 | 3.10 | ND | 4.05 | ND | 0.97 | 86.7 | 240 |
| Pyrene | 29.1 | 48.8 | 70.9 | 5.66 | 83.9 | 11.3 | ND | 8.41 | ND | 1.76 | 153 | 665 |
| Total LMW PAHs | 31.9 | 47.3 | 75.1 | [illegible] | 103 | 10.9 | 5.13 | 10.9 | 5.14 | 5.39 | 312 | 552 |
| Total HMW PAHs | 159 | 355 | 637 | [illegible] | **875** | 105 | 8.70 | 60.5 | 8.79 | 13.0 | 655 | 1700 |
| Total PAHs | 191 | 403 | [illegible] | [illegible] | 977 | 116 | 13.8 | 71.4 | 13.9 | 18.3 | 1684 | 4022 |

**Bolded values** exceed the TEL and/or ERL.
Non-detect (ND) = The analyte was not detected at or above the MDL.
x = No TEL or ERL published for that parameter.
See Tables 13 and 14 for complete results.

**Exhibit 3-8. Summary of Analytical Results for PCBs in Sediment Composites and Clay/Native Material Subsamples**

| Analyte | Concentration (µg/kg) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample ID | | | | | | | | | | TEL | ERL |
| | SJH20-REF | Composite Samples | | | | Clay/Native Subsamples | | | | | | |
| | | M-A-S-20-COMP | M-B-S-20-COMP | D-ATw-S-20-COMP | D-SAx-S-20-COMP | D-EC-C-2 | D-ATw-C-1 | D-ATw-C-2 | D-ATw-C-3 | D-ATw-C4 | | |
| PCB-5/8 | ND | ND | ND | ND | 1.42 | ND | ND | ND | ND | ND | x | x |
| PCB-18 | ND | ND | ND | ND | 3.29 | ND | ND | ND | ND | ND | x | x |
| PCB-28 | ND | ND | ND | ND | 1.96 | ND | ND | ND | ND | ND | x | x |
| PCB-44 | ND | ND | ND | ND | 1.91 | ND | ND | ND | ND | ND | x | x |
| PCB-49 | ND | 1.51 | 1.32 | ND | 5.68 | ND | ND | ND | ND | ND | x | x |
| PCB-52 | ND | 1.84 | 1.66 | ND | 7.78 | ND | ND | ND | ND | ND | x | x |
| PCB-66 | ND | ND | ND | ND | 2.75 | ND | ND | ND | ND | ND | x | x |
| PCB-87 | ND | ND | ND | ND | 1.68 | ND | ND | ND | ND | ND | x | x |
| PCB-101 | ND | 2.41 | 1.69 | ND | 7.36 | ND | ND | ND | ND | ND | x | x |
| PCB-105 | ND | ND | ND | ND | 1.89 | ND | ND | ND | ND | ND | x | x |
| PCB-118 | ND | 1.25 | 1.24 | ND | 5.83 | ND | ND | ND | ND | ND | x | x |
| PCB-128 | ND | ND | ND | ND | [illegible] | ND | ND | ND | ND | ND | x | x |
| PCB-138 | ND | 5.13 | 3.03 | 1.19 | 14.4 | ND | ND | 1.54 | ND | ND | x | x |
| PCB-153 | ND | 8.10 | 4.64 | 1.90 | [illegible] | ND | ND | 2.50 | ND | ND | x | x |
| PCB-170 | ND | 1.73 | ND | [illegible] | 3.08 | ND | ND | ND | ND | ND | x | x |
| PCB-180 | ND | 4.08 | 1.69 | [illegible] | 6.68 | ND | ND | 1.45 | ND | ND | x | x |
| PCB-183 | ND | 1.34 | ND | [illegible] | 2.28 | ND | ND | ND | ND | ND | x | x |
| PCB-184 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | x | x |
| PCB-187 | ND | 3.68 | [illegible] | ND | 5.65 | ND | ND | 1.12 | ND | ND | x | x |
| PCB-195 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | x | x |
| PCB-206 | ND | ND | ND | ND | 1.43 | ND | ND | ND | ND | ND | x | x |
| PCB-209 | ND | ND | ND | ND | 4.75 | ND | ND | ND | ND | ND | x | x |
| Total EPA Region 2 PCBs | **22.0** | **43.1** | **30.5** | **22.9** | **101** | **22.0** | **22.0** | **24.4** | **21.8** | **22.0** | 21.6 | 22.7 |

**Bolded values** exceed the TEL and/or ERL.
Non-detect (ND) = The analyte was not detected at or above the MDL.
x = No TEL or ERL published for that parameter.
See Tables 15 and 16 for complete results.

## 3.4 Elutriate and Water Chemistry

Analytical results for metals, pesticides, and PCBs in site water (SJH20-SW), reference water (SJH20-REF-SW), and elutriates generated from the four project composites are presented in Tables 17 through 19. Results for elutriate and water samples are compared to the CMC from EPA (2006, 2015). The water and elutriate chemistry laboratory case narrative and data are in Appendix D.

### 3.4.1 Metals

None of the metals analyzed were detected in concentrations greater than the CMC in any elutriate or water sample. All metals except mercury were detected in concentrations greater than the MDL in all composite elutriate samples. All MDLs were below target reporting limits in the SAP/QAPP and below applicable CMCs. Complete results are in Table 17.

### 3.4.2 Pesticides

None of the 15 pesticides analyzed were detected in concentrations above the MDL in any elutriate or reference site water sample. Ten of the 15 pesticides analyzed were detected in concentrations above the MDL in the site water sample. All MDLs were below target reporting limits in the SAP/QAPP and below applicable CMCs. Complete results are in Table 18.

### 3.4.3 PCBs

None of the 22 PCB congeners analyzed were detected in concentrations above the MDL in any elutriate or site water samples (U-qualified). There are no CMCs for the PCB congeners tested. Total EPA Region 2 PCB concentrations were 0.0[illegible]4 ng/L for all elutriate and site water samples. All MDLs/MRLs were below target reporting limits in the SAP/QAPP. Complete results are in Table 19.

## 3.5 Benthic Bioassays

The benthic tests were performed with the species *Ampelisca abdita* and *Americamysis bahia.* The complete toxicity testing report by EcoAnalysts (2021) is provided in Appendix G.

### 3.5.1 *Ampelisca abdita*

The 10-day benthic test with *A. abdita* was initiated on December 1, 2020, and was validated by 96% mean survival in the control sediment, meeting the acceptability criterion of ≥90% survival. Mean survival for the project sediment composites ranged from 73% to 91%. Survival in the test sample D-A[illegible]-S-20-COMP was statistically different than that of the reference. Mean percent survival was within 20% of the reference (90%), indicating that the test composite met the LPC for disposal. Mean survival results are summarized in Exhibit 3-9.

Water quality parameters, ammonia concentrations, and other test conditions are summarized in Tables 3-2 through 3-4 of the toxicity report by EcoAnalysts (2021) in Appendix G. A summary table of *A. abdita* survival in each replicate and the raw data bench sheets are provided in Appendix A.1 of the toxicity testing report (Appendix G).

**Exhibit 3-9. Summary of Survival Data for the 10-Day Benthic Test with *Ampelisca abdita***

| Sample ID | Mean Survival (% ± SD) | Statistically Significantly Less Than Reference? | Meets LPC Criteria (mean % survival within 20% of Reference?) |
|---|---|---|---|
| Control | 96 (± 4.2) | | |
| SJH20-REF (reference) | 90 (± 6.1) | | |
| M-A-S-20-COMP | 91 (± 7.4) | No | Yes |
| M-B-S-20-COMP | 90 (± 10.0) | No | Yes |
| D-ATw-S-20-COMP | 73 (± 10.4) | Yes | Yes |
| D-SAx-S-20-COMP | 88 (± 10.4) | No | Yes |

SD = standard deviation

Source: Table 3-1 of EcoAnalysts (2021)

### 3.5.2 *Americamysis bahia*

The 10-day benthic test with *A. bahia* was initiated on December 8, 2020, and was validated by 90% survival in the control, meeting the acceptability criterion of ≥90%. Mean survival within the *A. bahia* benthic test ranged from 89% to 96% in the test sediments and was not statistically different than that of the reference. Mean percent survival was within 10% of the reference (94%), indicating that the test composites met the LPC for disposal. Mean survival results for all samples are summarized in Exhibit 3-10.

Water quality parameters, ammonia concentrations, and other test conditions are summarized in Tables 3-6 through 3-8 of the toxicity report by EcoAnalysts (2021) in Appendix G. A summary table of survival in each replicate and the raw data bench sheets are provided in Appendix A.2 of the toxicity testing report (Appendix G).

**Exhibit 3-10. Summary of Survival Data for the 10-Day Benthic Test with *Americamysis bahia***

| Sample ID | Mean Survival (% ± SD) | Statistically Significantly Less Than Reference? | Meets LPC Criteria (mean % survival within 10% of Reference?) |
|---|---|---|---|
| Control | 90 (± 3.5) | | |
| SJH20-REF (reference) | 94 (± 5.5) | | |
| M-A-S-20-COMP | 89 (± 8.9) | No | Yes |
| M-B-S-20-COMP | 93 (± 5.7) | No | Yes |
| D-ATw-S-20-COMP | 96 (± 4.2) | No | Yes |
| D-SAx-S-20-COMP | 95 (± 3.5) | No | Yes |

SD = standard deviation

Source: Table 3-5 of EcoAnalysts (2021)

## 3.6 Water Column Bioassays

Water column tests were performed with the mysid crustacean *Americamysis bahia* (opossum shrimp), the atherinoid fish *Menidia beryllina* (inland silverside), and the larval life stage of the bivalve mollusk *Mytilus galloprovincialis* (Mediterranean mussel). The complete toxicity testing report by EcoAnalysts (2021) is provided in Appendix G.

### 3.6.1 *Americamysis bahia*

The 96-hour water column tests with *A. bahia* were initiated on December 7, 2020. The mean survival rate in the control treatment was 94%, meeting the acceptability criterion of ≥90% survival. Mean survival in the site water sample was 98%, indicating that the site water was acceptable for testing. Stray mysids jumped out of the water and desiccated on the side of the test chamber (one each in M-A-S-20-COMP 10% Replicate 1, M-B-S-20-COMP 10% Replicate 1, and D-ATw-S-20-COMP 50% Replicate 1). These mysids were removed from statistical analysis and the start count adjusted accordingly.

Mean percent survival in the 100% elutriate concentration was ≥98% for the sediment composites. The estimated $LC_{50}$ values were >100%. Statistical comparison of the 100% test concentrations to the control survival resulted in no significant difference. The mean survivorship data are summarized in Exhibit 3-11.

Water quality measurements, ammonia concentrations, and test conditions are in Tables 3-10 through 3-12 of the toxicity testing report (Appendix G). A summary table of survival in each replicate and the raw data bench sheets are in Appendix A.3 of the toxicity testing report (Appendix G).

**Exhibit 3-11. Summary of Survival Data for Water Column Tests Using *Americamysis bahia***

| Sample ID | Concentration (%) | Mean Survival (% ± SD) | Statistically Significantly Less Than Control? | $LC_{50}$ (%) |
|---|---|---|---|---|
| Control | | 94 (± 4.2) | | |
| SHH20-SW (site water) | | 98 (± 4.5) | No | |
| M-A-S-20-COMP | 100 | 99 (± 2.2) | No | >100 |
| M-B-S-20-COMP | 100 | 98 (± 2.7) | No | >100 |
| D-ATw-S-20-COMP | 100 | 98 (± 2.7) | No | >100 |
| D-SAx-S-20-COMP | 100 | 98 (± 2.7) | No | >100 |

SD = standard deviation
Source: Table 3-9 of EcoAnalysts (2021)

### 3.6.2 *Menidia beryllina*

The water column test with *M. beryllina* was initiated December 7, 2020, and was validated by 91% mean survival in the control, meeting the acceptability criterion of ≥90%. Mean percent survival in the site water sample was 98%, indicating that it was acceptable for testing.

Mean percent survival in the 100% elutriate concentration ranged from 84% to 96%. The estimated $LC_{50}$ values were >100% for the test composites. Statistical comparison of the test treatments to the control survival resulted in no significant difference. The mean survivorship data for all samples are summarized in Exhibit 3-12.

Water quality parameters, ammonia concentrations, and other test conditions are summarized in Tables 3-14 through 3-16 of the toxicity report by EcoAnalysts (2021) in Appendix G. A summary table of survival in each replicate and the raw data bench sheets are provided in Appendix A.4 of the toxicity testing report (Appendix G).

**Exhibit 3-12. Summary of Survival Data for Water Column Tests Using *Menidia beryllina***

| Sample ID | Concentration (%) | Mean Survival (% ± SD) | Statistically Significantly Less Than Control? | $LC_{50}$ (%) |
|---|---|---|---|---|
| Control | | 91 (± 11.9) | | |
| SHH20-SW (site water) | | 98 (± 2.7) | No | |
| M-A-S-20-COMP | 100 | 96 (± 4.2) | No | >100 |
| M-B-S-20-COMP | 100 | 92 (± 2.7) | No | >100 |
| D-ATw-S-20-COMP | 100 | 90 (± 6.1) | No | >100 |
| D-SAx-S-20-COMP | 100 | 84 (± 8.2) | No | >100 |

SD = standard deviation
Source: Table 3-13 of EcoAnalysts (2021)

### 3.6.3 *Mytilus galloprovincialis*

The water column test with larval *M. galloprovincialis* was initiated on December 8, 2020, and resulted in 95.9% normal development (proportion normal) and 97.7% survival (proportion survival) in the control, meeting the recommended criteria of ≥60% proportion normal and ≥90% proportion survival. Mean survival in the site water was 99.9%. The response observed in the site water sample was not statistically different than that of the control, indicating that this material was suitable for testing and should not have contributed to any potential reduced biological response observed in the elutriate preparations. Control acceptability results are summarized in Exhibit 3-13. Mean combined normal development and mean survival results for all samples are summarized in Exhibits 3-14 and 3-15.

Water quality parameters, ammonia concentrations, and other test conditions are summarized in Tables 3-20 through 3-22 of the toxicity report by EcoAnalysts (2021) in Appendix G. A summary table of survival in each replicate and the raw data bench sheets are provided in Appendix A.5 of the toxicity testing report (Appendix G).

The estimated $EC_{50}$ value for mean proportion normal and proportion survival was >100% for all test sediments, and statistical comparison of the sample results to that of the control resulted in no significant difference.

**Exhibit 3-13. *Mytilus galloprovincialis* Control Acceptability Results**

| Treatment | Mean Proportion Survival (%) ≥90% | Mean Combined Normal Development * ≥60% | Meets Acceptability Criteria? |
|---|---|---|---|
| Control | 97.7 | 95.9 | Yes |

* Calculated as the total number of normally and abnormally developed embryos ÷ number of embryos stocked (stocking density).
Source: Table 3-17 of EcoAnalysts (2021)

**Exhibit 3-14. Mean Combined Normal Development Summary for *Mytilus galloprovincialis***

| Sample ID | Concentration (%) | Mean Combined Normal Development * (% ± SD) | Statistically Significantly Less Than Control? | $EC_{50}$ (%) |
|---|---|---|---|---|
| Control | | 95.9 (± 4.6) | | |
| SJH20-SW (site water) | | 94.7 (± 2.8) | No | |
| M-A-S-20-COMP | 100 | 98.1 (± 4.2) | No | >100 |
| M-B-S-20-COMP | 100 | 97.6 (± 4.2) | No | >100 |
| D-ATw-S-20-COMP | 100 | 99.9 (± 0.2) | No | >100 |
| D-SAx-S-20-COMP | 100 | 98.0 (± 2.3) | No | >100 |

* Calculated as the number of normally developed embryos that survived the duration of the test ÷ number of embryos stocked (stocking density).

SD = standard deviation

Source: Table 3-18 of EcoAnalysts (2021)

**Exhibit 3-15. Proportion Survival Summary for *Mytilus galloprovincialis***

| Sample ID | Concentration (%) | Mean Proportion Survival * (% ± SD) | Statistically Significantly Less Than Control? | $LC_{50}$ (%) |
|---|---|---|---|---|
| Control | | 97.[illegible] (± 3.2) | | |
| SJH20-SW (site water) | | 99.9 (± 0.2) | No | |
| M-A-S-20-COMP | 100 | 98.6 (± 3.1) | No | >100 |
| M-B-S-20-COMP | 100 | 100.0 (± 0.0) | No | >100 |
| D-ATw-S-20-COMP | 100 | 100.0 (± 0.0) | No | >100 |
| D-SAx-S-20-COMP | 100 | 99.6 (± 0.9) | No | >100 |

* Calculated as the total number of normally and abnormally developed embryos ÷ number of embryos stocked (stocking density).

SD = standard deviation

Source: Table 3-19 of EcoAnalysts (2021)

## 3.7 Bioaccumulation Potential Tests

The 28-day bioaccumulation tests with *Macoma nasuta* and *Alitta virens* were initiated on December 3 and December 14, 2020, respectively. Mean survival in the control was 100% for *M. nasuta* and 96.1% for *A. virens*. Mean survival in the reference was 96.8% for *M. nasuta* and 96.0% for *A. virens*. Mean survival in the test composite was ≥98.4% for *M. nasuta* and ≥93.0% for *A. virens*. Mean survival results for all samples are summarized in Exhibit 3-16.

Water quality parameters and other test conditions are summarized for the two test species in Tables 3-24 through 3-27 of the toxicity report by EcoAnalysts (2021) in Appendix G. A summary table of survival in each replicate and the raw data bench sheets are provided in Appendices A.6 (for *M. nasuta*) and A.7 (for *A. virens*) of the toxicity testing report (Appendix G).

**Exhibit 3-16. Summary of Survival Data for Bioaccumulation Potential Tests Using *Macoma nasuta* and *Alitta virens***

| Sample ID | Mean Survival (% ± SD) | |
|---|---|---|
| | ***M. nasuta*** | ***A. virens*** |
| Control | 100 (± 0.0) | 96.1 (± 3.5) |
| SJH20-REF (reference) | 96.8 (± 3.3) | 96.0 (± 6.5) |
| M-A-S-20-COMP | 100 (± 0.0) | 99.0 (± 2.2) |
| M-B-S-20-COMP | 99.2 (± 1.8) | 94.0 (± 6.5) |
| D-ATw-S-20-COMP | 98.4 (± 2.2) | 95.0 (± 7.1) |
| D-SAx-S-20-COMP | 100 (± 0.0) | 93.0 (± 7.[illegible]) |

SD = standard deviation
Source: Table 3-23 of EcoAnalysts (2021)

## 3.8 Toxicology Summary

**Benthic Bioassays**
Significant benthic toxicity, relative to the reference treatment, was observed in the *A. abdita* amphipod test for test sample D-ATw-S-20-COMP only. No significant toxicity was observed in *A. bahia* mysid test. Mean percent survival in the project composite samples was within the specific test criteria (20% of the reference: amphipod; 10% of the reference: mysid), indicating that the test treatments met the LPC for disposal for these tests.

**Water Column Bioassay**
No statistically significant toxicity was observed in the 100% elutriate concentrations for the *A. bahia, M. beryllina,* and *M. galloprovincialis* tests.

**Bioaccumulation Potential**
No significant toxicity was observed in the bioaccumulation tests. Survival in the reference and test treatments were ≥93.0%, suggesting adequate tissue mass was available for chemical analyses.

## 3.9 Tissue Chemistry

Tissue chemistry results for *M. nasuta* and *A. virens* are presented in Tables 20 through 37. Wet weight tissue chemistry results for four project samples are compared to the reference (SJH20-REF) and to applicable FDA action levels from FDA (2001, 2011). The laboratory case narrative for tissue chemistry is provided in Appendix D. Complete results of statistical analyses and transformations for *M. nasuta* and *A. virens* are provided in Appendix F.

For dry weight tables, the laboratory's information management system is not currently able to provide both wet and dry weight concentrations. The results reported were calculated using the wet weight concentration and percent solids provided by the laboratory.

### 3.9.1 Lipids and Total Solids in Tissue

Total solids and lipids were analyzed in *M. nasuta* and *A. virens* tissues for the project samples along with the reference and pre-exposure tissues.

***Macoma nasuta***

Total solids ranged from 16.34% to 18.62% among the project samples, reference, and pre-exposure tissues. Lipids ranged from 1.5% to 2.5% among these samples. Complete results are in Table 20.

***Alitta virens***

Total solids ranged from 14.06% to 15.68% among the project samples, reference, and pre-exposure tissues. Lipids ranged from 2.0% to 3.6% among these samples. Complete results are in Table 21.

### 3.9.2 Metals in Tissue

Nine metals were tested in *M. nasuta* and *A. virens* tissues for the project samples along with the reference and pre-exposure tissues.

***Macoma nasuta***

All metals tested were detected in concentrations greater than the MRL in the project samples and the reference. Mean concentrations of lead in the project sample M-B-S-20-COMP were statistically significantly greater than those of the reference. Mean concentrations of lead, silver, and zinc in the project sample D-SAx-S-20-COMP were statistically significantly greater than those of the reference. None of the mean concentrations of metals exceeded applicable FDA action levels.

Mean concentrations of metals in *M. nasuta* tissues are summarized in Exhibit 3-17. Complete results are in Tables 22 and 24 for wet weight and dry weight metals, respectively. Results of the ToxCalc statistical calculations are provided in Appendix F.

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

| Analyte | Concentration (mg/kg) | | | | | |
|---|---|---|---|---|---|---|
| | Mean Concentration of Replicates | | | | | |
| | M-A-S-20-COMP | M-B-S-20-COMP | D-ATw-S-20-COMP | D-SAx-S-20-COMP | SJH20-REF (reference) | FDA Action Level |
| Arsenic | 3.31 | 3.49 | 3.76 | 3.89 | 3.60 | 86 |
| Cadmium | [illegible] | 0.0365 | 0.0378 | 0.0380 | 0.0381 | 4 |
| Chromium | 0.328 | 0.381 | 0.340 | 0.344 | 0.415 | 13 |
| Copper | [illegible] | 3.70 | 3.48 | 3.42 | 3.41 | x |
| Lead | 0.227 | **0.309** | 0.154 | **0.501** | 0.228 | 1.7 |
| Mercury | 0.0100 | 0.0109 | 0.0095 | 0.0144 | 0.0133 | 1 |
| Nickel | 0.320 | 0.370 | 0.375 | 0.379 | 0.450 | 80 |
| Silver | 0.0323 | 0.0381 | 0.0375 | **0.0529** | 0.0325 | x |
| Zinc | 13.2 | 13.6 | 14.1 | **16.0** | 13.4 | x |

x = No FDA action level and (or) ecological effects threshold is published for the given parameter.
**Bolded values** indicate that the mean concentration in project tissues is statistically significantly greater than in the reference tissues, and at least two replicate results are greater than the MDL.
See Table 22 for complete results.

### ***Alitta virens***

All metals tested were detected in concentrations greater than the MRL in the project samples and the reference. Mean concentrations of arsenic, cadmium, and chromium in all four project samples were statistically significantly greater than those of the reference. In addition, mean concentrations of copper, nickel, and zinc were statistically significantly greater in D-ATw-S-20-COMP than those of the reference. None of the mean concentrations of metals exceeded applicable FDA action levels.

Mean concentrations of metals in *A. virens* tissues are summarized in Exhibit 3-18. Complete results are in Tables 23 and 25 for wet weight and dry weight metals, respectively. Results of the ToxCalc statistical calculations are provided in Appendix F.

**Exhibit 3-18. *Alitta virens* Tissue: Summary of Mean Wet Weight Metals Results**

| Analyte | Concentration (mg/kg) | | | | | |
|---|---|---|---|---|---|---|
| | Mean Concentration of Replicates | | | | | |
| | M-A-S-20-COMP | M-B-S-20-COMP | D-ATw-S-20-COMP | D-SAx-S-20-COMP | SJH20-REF (reference) | FDA Action Level |
| Arsenic | **2.35** | **2.53** | **2.54** | [illegible] | 2.02 | 76 |
| Cadmium | **0.0356** | **0.0383** | **0.0355** | [illegible] | 0.0257 | 3 |
| Chromium | **0.280** | **0.336** | **0.325** | **0.321** | 0.191 | 12 |
| Copper | 1.31 | 1.58 | **2.04** | [illegible] | 1.47 | x |
| Lead | 0.1060 | 0.135 | 0.0922 | 0.130 | 0.119 | 1.5 |
| Mercury | 0.0188 | 0.0185 | [illegible] | 0.0212 | 0.0187 | 1 |
| Nickel | 0.135 | 0.145 | [illegible] | 0.144 | 0.114 | 70 |
| Silver | 0.0260 | 0.0193 | 0.0089 | 0.0152 | 0.0123 | x |
| Zinc | 17.3 | [illegible] | **27.3** | 20.5 | 14.5 | x |

x = No FDA action level and (or) ecological effects threshold is published for the given parameter.
**Bolded values** indicate that the mean concentration in project tissues is statistically significantly greater than in the reference tissues, and at least two replicate results are greater than the MDL.
See Table 23 for complete results.

## 3.9.3 Pesticides in Tissue

Fifteen pesticides were tested in *M. nasuta* and *A. virens* tissues from the four project samples along with the reference and pre-exposure tissues.

### ***Macoma nasuta***

With the exception of 4,4'-DDE in sample D-SAx-S-20-COMP, none of the pesticides were detected in concentrations greater than the MDL in any of the project samples or reference (U-qualified). Mean concentration of 4,4'-DDE (1.49 µg/kg) in sample D-SAx-S-20-COMP was statistically significantly greater than that of the reference (0.14 µg/kg). None of the mean concentrations of pesticides exceeded applicable FDA action levels. Complete results are in Tables 26 and 28 for wet weight and dry weight pesticides, respectively. Results of the ToxCalc statistical calculations are provided in Appendix F.

***Alitta virens***

None of the pesticides were detected in concentrations greater than the MDL in the project samples or the reference. All results were U-qualified. The MDL and MRL for trans-nonachlor were elevated above the target detection limit due to matrix interference. None of the mean concentrations of pesticides exceeded applicable FDA action levels. Complete results are in Tables 27 and 29 for wet weight and dry weight pesticides, respectively. Results of the ToxCalc statistical calculations are provided in Appendix F.

### 3.9.4 PAHs in Tissue

Sixteen PAHs were tested in *M. nasuta* and *A. virens* tissues for the four project samples along with the reference and pre-exposure tissues. Total LMW, total HMW, and total PAHs were calculated from the results of the individual PAHs.

***Macoma nasuta***

None of the PAHs were detected in concentrations greater than the MDL in the project samples or the reference. All results were U-qualified; therefore, no further statistical analyses or comparisons were needed. Complete results are in Tables 30 and 32 for wet weight and dry weight PAHs, respectively.

***Alitta virens***

None of the PAHs were detected in concentrations greater than the MDL in the project samples or the reference. All results were U-qualified; therefore, no further statistical analyses or comparisons were needed. Complete results are in Tables 31 and 33 for wet weight and dry weight PAHs, respectively.

### 3.9.5 PCBs in Tissue

Twenty-two PCB congeners were analyzed in *M. nasuta* and *A. virens* tissues from the four project samples along with the reference and pre-exposure tissues. Total PCBs were calculated from the individual PCB congener results.

***Macoma nasuta***

Nine of the PCB congeners tested were detected above the MRL in at least one of the project sample replicates. Concentrations of PCB congeners 49, 52, 101, 118, 138, and 153 and total EPA Region 2 PCBs in some of the project samples were statistically significantly greater than those of the reference. Total EPA Region 2 PCB mean concentration in the project samples did not exceed the FDA action level. Mean concentrations of PCBs in *M. nasuta* tissues that were statistically significantly greater than those of the reference are summarized in Exhibit 3-19. Complete results for wet weight and dry weight PCBs are in Tables 34 and 36, respectively. Results of the ToxCalc statistical calculations are provided in Appendix F.

**Exhibit 3-19. *Macoma nasuta* Tissue: Summary of Mean Wet Weight PCBs Results That Were Statistically Significantly Greater than Those of the Reference**

| Analyte | Concentration (mg/kg) | | | | | |
|---|---|---|---|---|---|---|
| | Mean Concentration of Replicates | | | | | |
| | M-A-S-20-COMP | M-B-S-20-COMP | D-ATw-S-20-COMP | D-SAx-S-20-COMP | SJH20-REF (reference) | FDA Action Level |
| PCB 49 | 0.38 | **0.53** | 0.40 | **1.07** | 0.40 | x |
| PCB 52 | 0.39 | **0.56** | 0.40 | **1.19** | 0.40 | x |
| PCB 101 | 0.42 | 0.48 | 0.40 | **1.12** | 0.40 | x |
| PCB 118 | 0.38 | 0.39 | 0.40 | **0.68** | 0.40 | x |
| PCB 138 | 0.46 | 0.44 | 0.40 | **0.84** | 0.40 | x |
| PCB 153 | **0.92** | **0.76** | 0.40 | **1.31** | 0.40 | x |
| Total EPA Region 2 PCBs | 9.11 | **9.47** | 8.80 | **12.6** | 8.80 | 2000 |

x = No FDA action level and (or) ecological effects threshold is published for the given parameter.
**Bolded values** indicate that the mean concentration in project tissues is statistically significantly greater than in the reference tissues, and at least two replicate results are greater than the MDL.
Complete results are in Table 34.

## *Alitta virens*

Nine of the PCB congeners tested were detected above the MRL in at least one of the project sample replicates. Concentrations of PCB congeners 49, 52, 101, and total EPA Region 2 PCBs in some of the project samples were statistically significantly greater than those of the reference. Total EPA Region 2 PCB mean concentrations in the project samples did not exceed the FDA action level. Mean concentrations of PCBs in *M. nasuta* tissues that were statistically significantly greater than those of the reference are summarized in Exhibit 3-20. Complete results for wet weight and dry weight PCBs are in Tables 35 and 37, respectively. Results of the ToxCalc statistical calculations are provided in Appendix F.

**Exhibit 3-20. *Alitta virens* Tissue: Summary of Mean Wet Weight PCBs Results That Were Statistically Significantly Greater than Those of the Reference**

| Analyte | Concentration (mg/kg) | | | | | |
|---|---|---|---|---|---|---|
| | Mean Concentration of Replicates | | | | | |
| | M-A-S-20-COMP | M-B-S-20-COMP | D-ATw-S-20-COMP | D-SAx-S-20-COMP | SJH20-REF (reference) | FDA Action Level |
| PCB 49 | 0.40 | 0.41 | 0.40 | **0.54** | 0.40 | x |
| PCB 52 | 0.44 | **0.54** | 0.40 | **0.80** | 0.40 | x |
| PCB 101 | **0.58** | **0.63** | 0.40 | **0.77** | 0.40 | x |
| Total EPA Region 2 PCBs | 12.1 | 12.0 | 10.6 | **12.7** | 11.0 | 2000 |

x = No FDA action level and (or) ecological effects threshold is published for the given parameter.
**Bolded values** indicate that the mean concentration in project tissues is statistically significantly greater than in the reference tissues, and at least two replicate results are greater than the MDL. Complete results are in Table 35.

# 4 QUALITY ASSURANCE/QUALITY CONTROL

## 4.1 Coordination with EPA

EPA Region 2 was consulted throughout the sample collection effort for guidance on how to approach sample collection and processing at several stations. Key topics that required consultation involved collection of sample material at stations that required a deepening sample as described in the scope of work and how to collect samples at stations with surface elevations at or below project depth.

General guidelines provided by EPA:

- If shoaling was <2 feet above the target project depth, EPA gave permission to collect the material as a grab sample.
- For the Army Terminal Widener stations, if core length exceeded the longest core barrel available (20 feet), the "stair-step" approach of moving downslope to reach project depth is acceptable, upon final approval by EPA.
- The "clay" or "deepening" samples should represent native (new work) material regardless of the elevation encountered. EPA wanted maintenance (surface) material separated out from the native (new work) material.
- If no native (new work) material was encountered above project depth, then no "clay" or "deepening" sample was collected at that station.
- For Reach B, given that this reach was a mixture of grabs and cores, EPA advised the field team to collect equal volumes from each station for the maintenance (surface) composite sample.
- For Reach B, many stations were below the deepening project depth. EPA advised the field team to collect a grab sample of unconsolidated material at the surface for the maintenance (surface) composite sample.

A memo was prepared summarizing the field coordination with EPA. A copy of the memo was provided to USACE and EPA and is provided in Appendix J, Pertinent Correspondence.

## 4.2 Sample Receipt

### 4.2.1 ARI

Four sediment samples and one site water sample were shipped to ARI on October 27, 2020, and delivered to ARI on October 28, 2020. Sediment and site water for the preparation of elutriates were delivered to MTC on October 29, 2020. All samples were received in good condition and met holding time requirements for both sediment testing and elutriate preparation.

On November 3, 2020, ARI personnel took custody of the reference sediment and site water samples that were delivered to EcoAnalysts. All samples were received at the laboratories within analytical holding time and at proper temperature.

### 4.2.2 EcoAnalysts

One reference sample, four composite samples, and one site water sample were received in two shipments on October 28 and November 3, 2020. All test samples arrived via two cold boxes at 4.4°C and 4.2°C, respectively, and within the recommended temperature range of 0°C to 6°C upon receipt. Site water and sediment samples were stored in a walk-in cold room at 4 ± 2°C in the dark until used for testing. All tests were conducted within the 8-week (56 days) sediment holding time limit.

### 4.2.3 ALS and Terracon

The cargo container that was used in Puerto Rico was returned to ANAMAR on November 13, 2020. Along with equipment and supplies, the unit contained sediment samples, which ANAMAR packed and shipped to the laboratories on November 16, 2020. Samples shipped to ALS were received on November 18, 2020. Samples were delivered to Terracon on November 19, 2020. All samples were received in good condition.

### 4.2.4 Tissue Samples

Frozen tissue samples were received at ARI on January 14, 2021, in good condition. Samples were stored in appropriate conditions at the laboratory and thawed to allow preparation only.

## 4.3 Physical Analysis

All physical analyses were performed by Terracon. The analytical results met the quality control criteria specified in the SAP/QAPP.

## 4.4 Sediment Chemistry

### 4.4.1 Trace Metals

#### 4.4.1.1 Matrix Spike Recovery

Several spikes were outside control. The laboratory indicates that because the concentration in the sample was substantially higher than in the spike, the accuracy in the spike calculation was reduced.

#### 4.4.1.2 Holding Times

During the initial analysis conducted within holding time, the recovery for mercury in the standard reference material (SRM) was calculated outside the acceptance range. As a corrective action, samples were frozen and a new SRM was ordered. Re-analysis was performed, and the results were within acceptance criteria. It is unlikely that the reported results were substantially affected by the delay in analysis.

### 4.4.2 Pesticides and PCB Congeners

#### 4.4.2.1 Matrix Spike Recovery

Several pesticide compounds had spike recoveries below 50%, indicating a likely matrix interference. Most results were below the target detection limit and the overall impact on sample results should be low.

#### 4.4.2.2 Initial and Continuing Calibration Verification

Several compounds had slight exceedances of the acceptance criteria. The overall impact on the sample results was low.

#### 4.4.2.3 Elevated Detection Limits

Pesticide results from samples D-SAx-S-20-COMP and M-A-S-20-COMP had MDLs and MRLs that were above the Region 2 criteria because of matrix interferences. Since the corresponding tissue samples were analyzed for the affected compounds, the overall impact for these samples was likely to be low.

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

#### 4.4.2.4 Standard Reference Material

Endosulfan I for pesticides and several PCB congeners were below the acceptance criteria. Since the other batch QC were acceptable, the overall impact was likely to be low.

### 4.4.3 Polycyclic Aromatic Hydrocarbons by EPA Method 8270D

#### 4.4.3.1 Standard Reference Material

All SRM recoveries were within the acceptance limits with the exception of fluorene, anthracene, and benzo(a)pyrene. Since the remaining batch QC was acceptable, the overall impact was likely to be low.

#### 4.4.3.2 Continuing and Initial Calibration Verification

Two verification standards were outside the acceptance criteria; however, the majority were within acceptance limits. Since the exceedances were not significantly outside the acceptance criteria, the overall impact was likely to be low.

#### 4.4.3.3 Spike Recoveries

All spike recoveries were within acceptance criteria with the exception of naphthalene in the spike triplicate. The recovery was consistent with the spike and spike duplicate, indicating a potential matrix interference in the sample.

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

## 4.5 Site Water and Elutriate Chemistry

### 4.5.1 Trace Metals

#### 4.5.1.1 Matrix Spikes

Cadmium and copper had spike recoveries slightly below the acceptance limit, indicating a likely matrix interference.

Note that the spike target for chromium, lead, and nickel did not meet the criteria specified in the EPA R2 manual. The laboratory indicated that the method could not meet both the low levels needed for reporting limits for at 1 mg/L or lower for copper and silver and the spike target for metals with high reporting limits with minimum levels of 210 mg/L for chromium and 1,050 mg/L for lead. The spike recoveries were acceptable for the percent recoveries found.

### 4.5.2 Pesticides and PCB Congeners

#### 4.5.2.1 Matrix Spike Recovery

The matrix spike triplicate was not extracted for SJH20-SW due to a bench sheet error, while D-ATw-S-20-COMP had four matrix spikes samples. All of the samples were batched and had full amounts of batch QC required; however, site-specific QC may be short of spikes.

#### 4.5.2.2 Laboratory Control Standards

One LCS for Endosulfan I was outside the acceptance criteria. All other results were within the acceptance criteria.

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

## 4.6 Tissue Chemistry

### 4.6.1 Trace Metals

#### 4.6.1.1 Matrix Spike Recovery

Spike recoveries were within acceptance limits with the exception of silver for one set of spike triplicates. The relative standard deviation (RSD) for the spike triplicates indicates it was most likely due to matrix interference in the sample and isolated to silver as all other spike recoveries were acceptable.

#### 4.6.1.2 Continuing Calibration Verification (CCV)

Several CCVs for mercury exceeded the acceptance criteria, but the CCVs analyzed as the next sample were within the acceptance limits, and the samples were bounded by CCVs within the limits.

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

### 4.6.2 Pesticides and PCB Congeners

#### 4.6.2.1 Matrix Spike Recovery

Endosulfan sulfate had one spike recovery at 49%, and several spikes for PCB congeners were below the acceptance criteria, indicating a potential matrix interference in the corresponding samples. All other spikes were acceptable.

#### 4.6.2.2 Initial and Continuing Calibration Verification

Several initial calibration verifications (ICVs) and CCVs had exceedances for Endosulfan II and PCB 128. The exceedances were on one column only, with the second column having acceptable recoveries; therefore, the sample results were not impacted.

#### 4.6.2.3 Elevated Detection Limits

Trans-nonachlor had elevated detection limits in the *Alitta virens* tissue samples due to matrix interferences. All results were non-detects and the impact is low since all other compounds met the detection limit.

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

### 4.6.3 Polycyclic Aromatic Hydrocarbons by EPA Method 8270

#### 4.6.3.1 Continuing Calibration Verification

Several PAH compounds had exceedances from the acceptance limit but were within the laboratory acceptance criteria. Since all affected sample results were well below the target detection limit, the overall impact to data quality was low.

#### 4.6.3.2 Matrix Spike Recovery

Several compounds had spike recoveries slightly below the acceptance criteria. Since all sample results were well below the target detection limit, the overall impact to data quality was low.

#### 4.6.3.3 Laboratory Control Sample

Several PAH compounds had recoveries below the acceptance criteria, indicating a potential low bias in the sample results. The laboratory indicated this was due to multiple cleanup steps involved in the preparation of the sample. Since all sample results were well below the target detection limit, the overall impact to data quality was low.

## 4.7 Toxicology

The quality assurance objectives for toxicity testing are detailed in the Green Book (EPA and USACE 1991) and the laboratory's quality assurance plans. These objectives for accuracy and precision involve all aspects of the testing process, including:

- 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 during the test period to establish the sensitivity of the test organisms. The reference toxicant $LC_{50}$ or $EC_{50}$ should be 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 EcoAnalysts' Standard Operating Procedures (SOPs). All EcoAnalysts staff members receive regular, documented training in all SOPs and test methods. All data collected and produced as a result of these analyses were recorded on approved data sheets. If an aspect of a test deviated from protocol, the test was evaluated to determine validity according to the guidance of the regulatory agencies responsible for approval of the proposed permitting action.

### 4.7.1 Benthic Toxicology Testing

The results of the benthic toxicity tests are presented in this section. The benthic tests were performed with *Ampelisca abdita* and *Americamysis bahia*.

#### 4.7.1.1 *Ampelisca abdita*

The 10-day benthic test with *A. abdita* was initiated on December 1, 2020, and was validated by 96% survival in the control sample, meeting the acceptability criterion of ≥90%.

Water quality parameters were within acceptable limits throughout the 10-day test, except for pH. While pH was measured at 8.5 in the control treatment, above the targeted range of 7.8 ± 0.5. It was still within the tolerance range of the test organism and did not negatively affect survival.

The $LC_{50}$ for the ammonia reference toxicant test was 61.6 mg/L total ammonia and was within two standard deviations of the laboratory mean at the time of testing. This indicates that the test organisms used in this test were of similar sensitivity to those previously tested at the EcoAnalysts laboratory. The concurrent ammonia reference toxicant derived no observed effects concentration (NOEC) values were 34.7 mg/L (total ammonia) and 0.591 mg/L un-ionized ammonia (UIA). Ammonia concentrations measured within the benthic test were below the ammonia reference toxicant test derived NOEC values for total ammonia and UIA throughout the testing period.

#### 4.7.1.2 *Americamysis bahia*

The 10-day benthic test with *A. bahia* was initiated on December 8, 2020, and was validated by 90% survival in the control sample, meeting the acceptability criterion of ≥80%.

Water quality parameters were within the acceptable limits throughout the 10-day test. Ammonia measurements in overlying water were below the threshold of 0.3 mg/L UIA (at pH 7.8) throughout the duration of the test. No afternoon feeding was performed on Day 1 of testing due to a shortage of hatched *Artemia* available for feeding.

The $LC_{50}$ for the ammonia reference toxicant test was 46.8 mg/L total ammonia and was within two standard deviations of the laboratory mean at the time of testing. This indicates that the test organisms used in this test were of similar sensitivity to those previously tested at the EcoAnalysts laboratory. The concurrent ammonia reference toxicant derived NOEC values were 21.7 mg/L (total ammonia) and 0.380 mg/L (UIA). Ammonia concentrations measured within the benthic test were below the ammonia reference toxicant test derived NOEC values throughout the testing period.

### 4.7.2 Water Column Toxicology Testing

The results of the water column toxicity tests are presented in this section. The water column tests were performed with mysid shrimp (*A. bahia*), inland silverside fish (*M. beryllina*), and larvae of the mussel *M. galloprovincialis*.

#### 4.7.2.1 *Americamysis bahia*

The water column test with *A. bahia* was initiated on December 7, 2020. The mysid test was validated by 94% mean survival in the seawater control, meeting the acceptability criterion of ≥90%. Mean percent survival in the site water sample was 98%, indicating that the site water was acceptable for testing.

Water quality parameters were within target limits throughout the duration of the 96-hour test, except for dissolved oxygen. While dissolved oxygen levels fell below the targeted range of >4.0 mg/L on the final day of testing (measured at 3.8 mg/L), the high rate of survival observed in all test treatments indicated that it did not cause any detrimental effects to the test organisms. No afternoon feeding was performed on Day 2 of testing due to a shortage of hatched *Artemia* available for feeding.

The $LC_{50}$ for the ammonia reference toxicant test was 46.3 mg/L total ammonia and was within two standard deviations of the laboratory mean at the time of testing. This indicates that the organisms obtained from this supplier were similar in sensitivity to those previously tested at the EcoAnalysts laboratory. The NOEC values were 24.7 mg /L total ammonia and 0.546 mg/L UIA.

#### 4.7.2.2 *Menidia beryllina*

The water column test with *M. beryllina* was initiated on December 7, 2020. The test was validated by 91% mean survival in the control, meeting the acceptability criterion of ≥90%. Mean percent survival in the site water sample was 98%, indicating that the site water was acceptable for testing.

Water quality parameters were within target limits throughout the duration of the 96-hour test. No feeding was performed on Day 2 of testing due to a shortage of hatched *Artemia*.

The $LC_{50}$ for the ammonia reference toxicant test was 37.5 mg/L total ammonia and was within two standard deviations of the laboratory mean at the time of testing. Based on these results, the organisms obtained from this supplier appear to be similar in sensitivity to those previously tested at the EcoAnalysts laboratory. The NOEC values were 29.0 mg/L total ammonia and 0.618 mg/L UIA.

#### 4.7.2.3 *Mytilus galloprovincialis*

The water column test with *M. galloprovincialis* was initiated on December 8, 2020. The larval mussel test resulted in 95.9% normal development (combined proportion normal, number normal ÷ initial number) and 97.7% survival (proportion survival) in the control, meeting the recommended criteria of ≥60% proportion normal and ≥90% proportion survival. The embryo stocking density was 24.4 embryos/mL of test solution, within the recommended density of 20 to 30 embryos/mL. Mean survival in the site water was 100%. The response observed in the site water sample was not statistically significantly different than that of the control, indicating that this material was suitable for testing and should not have contributed to any potential reduced biological response observed in the elutriate preparations.

All water quality parameters were within the target limits throughout the duration of the 48-hour test. There was a significant amount of debris in 3 replicates of the 1% concentration and 1 replicate of the 10% concentration of sample D-ATw-S-20-COMP, which was indicative of vial contamination. These replicates were removed from statistical analysis.

The $EC_{50}$ for the ammonia reference toxicant test was 7.8 mg/L total ammonia and was within two standard deviations of the laboratory mean. This indicates that the population of test organisms used in this test was similar in sensitivity to those previously tested at the EcoAnalysts laboratory. The NOEC values were 5.8 mg/L total ammonia and 0.141 mg/L UIA.

### 4.7.3 Bioaccumulation Tests

The 28-day bioaccumulation tests with *A. virens* and *M. nasuta* were initiated on December 14 and December 9, 2020, respectively. Mean survival in the control samples was 96.1% for *A. virens* and 100% for *M. nasuta*. Reference survival was 96.0% for *A. virens* and 96.8% for *M. nasuta*.

All water quality parameters were within the target limits throughout the duration of the 28-day exposure, except for pH in the *A. virens* test and salinity in the *M. nasuta* test. In the *A. virens* test, pH was measured below the targeted range, at a minimum of 7.0, in 2 chambers. Water flow was increased in both chambers, and the pH subsequently increased to fall within the target range. Survival remained high in all test treatments. Salinity was measured below the targeted range at 27 ppt during depuration in one chamber of the *M. nasuta* test but was still within the tolerance range of the test organism and would not be expected to influence test results. Inadvertently, only 15 worms rather than 20 were added to Control Replicate 2. As the control tissues are not being analyzed for chemistry, this deviation was not expected to affect the results. The flow rate target per 30 seconds was incorrectly calculated, resulting in flow adjustments that exceeded the target range of 6 ± 1 volume exchanges per day.

The $LC_{50}$ for the *A. virens* sodium dodecyl sulfate (SDS) reference toxicant test was 36.8 mg/L SDS and was within two standard deviations of the laboratory mean at the time of testing. The $LC_{50}$ for the *M. nasuta* reference toxicant test was 39.9 mg/L SDS and was within two standard deviations of the laboratory mean at the time of testing. These reference-toxicant tests indicated that the populations of test organisms used in this study were similar in sensitivity to those previously tested at the EcoAnalysts laboratory.

# 5 ADDAMS MODEL

Simulations of the STFATE module of the ADDAMS model were run to establish the compliance of the water column toxicity for the San Juan Harbor sediment samples. Each sediment sample represents a separate channel reach or extension. Based on analytical results, no samples were selected for modeling Tier II Water Quality Criteria as all results were below the CMC (National Recommended Water Quality Criteria [EPA 2006, 2015]).

Based on the $EC_{50}$ results, eight applications (runs) of the models 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 for all the water column toxicology tests show that $LC_{50}/EC_{50}$ were >100% across the three species tested for all four San Juan Harbor samples. The project samples were modeled to confirm acceptable dilution of the material during disposal to meet the LPC. STFATE model input parameters used in the module are shown in Exhibits 5-1 through 5-7. The sediment physical characteristics (presented in Table 5) for all composite samples were used to calculate the volumetric fractions. Values underlined and shown with a shaded yellow background were provided by the toxicology laboratory, and the dilution required was calculated to allow entry into the simulation (Exhibit 5-7). The files used in the model runs are contained within Appendix H.

**<u>Evaluation Type: Tier III, Compare Toxicity Results</u>**

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

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

* Model default value

### Exhibit 5-2. Site Description

| Parameter | Value | Units |
|---|---|---|
| Number of Grid Points (left to right) | 96 | n/a |
| Number of Grid Points (top to bottom) | 96 | n/a |
| Spacing Between Grid Points (left to right) | 200 | ft |
| Spacing Between Grid Points (top to bottom) | 200 | ft |
| Constant Water Depth | 965 | ft |
| Roughness Height at Bottom of Disposal Site | 0.005* | 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 | 3 | n/a |
| Ambient Density at Depth = 0 ft | 1.0236 | g/cc |
| Ambient Density at Depth = 200 ft | 1.024[illegible] | g/cc |
| Ambient Density at Depth = 965 ft | 1.0279 | g/cc |
| Distance from the Top Edge of Grid (upper left corner of site) | 6,[illegible]00 | ft |
| Distance from the Left Edge of Grid (upper left corner of site) | [illegible]2,800 | ft |
| Distance from the Top Edge of Grid (lower right corner of site) | 12,500 | ft |
| Distance from the Left Edge of Grid (lower right corner of site) | 18,800 | ft |
| Number of Depths for Transport-Diffusion Output | 3 (0, 450 and 960) | # |

* Model default value

### Exhibit 5-3. Current Velocity Data

| Parameter | Value | Units |
|---|---|---|
| X-Direction Velocity | 0 | ft/sec |
| Z-Direction Velocity | -1 | ft/sec |

### Exhibit 5-4. Material Data

| Parameter | Value | Units |
|---|---|---|
| Dredging Site Water Density (average) | 1.022 | g/cc |
| Number of Layers | 1 | n/a |
| Material Velocity at Disposal (X-Dir.) | 0 | ft/s |
| Material Velocity at Disposal (Z-Dir.) | -13.5 | ft/s |

### Exhibit 5-5. Output Options

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

### Exhibit 5-6. Disposal Operation Data

| Parameter | Value, Barge/Scow | Unit |
|---|---|---|
| Length of Disposal Vessel | 200 | ft |
| Width of Disposal Vessel | 50 | ft |
| Pre-Disposal Draft | 18 | ft |
| Post-Disposal Draft | 5 | ft |
| Time Needed to Empty the Disposal Bin | 20 | seconds |
| Material Volume | 4,800 | cy |
| Location of Disposal from Top of Grid | 9,500 | ft |
| Location of Disposal from Left Edge of Grid | 15,800 | ft |

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

| Analyte | M-A-S-20-COMP | | M-B-S-20-COMP | |
|---|---|---|---|---|
| | Hopper/Cutter | Mechanical | Hopper/Cutter | Mechanical |
| ***Volumetric fractions - Clumps*** | ***0.22611*** | ***0.60297*** | ***0.26789*** | ***0.68269*** |
| ***Volumetric fractions - Coarse*** | ***0.00273*** | ***0.00729*** | ***0.00635*** | [illegible] |
| ***Volumetric fractions - Silt*** | ***0.00591*** | ***0.01576*** | ***0.00476*** | [illegible] |
| ***Volumetric fractions - Clay*** | ***0.01146*** | ***0.03056*** | ***0.00880*** | [illegible] |
| ***Solids, %*** | 48.7 | | 54.6 | |
| ***Specific gravity*** | 2.60 | | [illegible] | |
| ***Liquid limit*** | 88 | | 75 | |
| $LC_{50}/EC_{50}$ | >100 | | >100 | |
| Conc. required to meet criteria | 1.00 | | 1.00 | |
| Dilution required to meet criteria | 100 | | 100 | |

| Analyte | D-ATw-S-20-COMP | | D-SAx-S-20-COMP | |
|---|---|---|---|---|
| | Hopper/Cutter | Mechanical | Hopper/Cutter | Mechanical |
| ***Volumetric fractions - Clumps*** | ***0.32000*** | ***0.78000*** | ***0.13836*** | ***0.32284*** |
| ***Volumetric fractions - Coarse*** | ***0.00000*** | ***0.00000*** | ***0.01505*** | ***0.03511*** |
| ***Volumetric fractions - Silt*** | ***0.00000*** | ***0.00000*** | ***0.03715*** | ***0.08669*** |
| ***Volumetric fractions - Clay*** | ***0.00000*** | ***0.00000*** | ***0.05015*** | ***0.11702*** |
| ***Solids, %*** | [illegible] | | 42.6 | |
| ***Specific gravity*** | 2.72 | | 2.61 | |
| ***Liquid limit*** | 83 | | 92 | |
| $LC_{50}/EC_{50}$ | >100 | | >100 | |
| Conc. required to meet criteria | 1.00 | | 1.00 | |
| Dilution required to meet criteria | 100 | | 100 | |

Notes: ***Bolded and italicized parameters*** were calculated from Table 5 of this report. Values underlined and shown with a yellow shaded background were provided by the toxicology laboratory, and the dilution required was calculated to allow entry into the simulation. Volumetric fractions were determined using a spreadsheet developed at ERDC. The spreadsheet is provided in the appendices with the filename *SJH volumetric fractions from ERDC calculator.xls.*

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 dredging unit are summarized in Exhibit 5-8. The location of the maximum concentration is shown as X location and Z location. Input and output files are provided in Appendix H.

### Exhibit 5-8. Four-Hour Criteria and Disposal Site Boundary Criteria after Initial Mixing

| | Four Hour Disposal Criteria | | | | Disposal Boundary Criteria | | |
|---|---|---|---|---|---|---|---|
| Depth, feet | % Max Conc Above Background on Grid | Dilution on Grid ($D_{a-tox}$) | X Location | Z Location | Time, hours | Max Conc Outside Disposal Area | Dilution ($D_{a-tox}$) |
| **Sample** | **M-A-S-20-COMP Hopper Dredge (4,800 cubic yards/load)** | | | | | | |
| 0 | 6.70E-40 | >10,000 | 7,200 | 200 | 0.50 | 1.12E-38 | >10,000 |
| 450 | 2.99E-04 | >10,000 | 9,400 | 1,000 | 4.0 | 2.99E-04 | >10,000 |
| 513 (max) | 3.66E-02 | 2731 | 9,400 | 1,000 | 0.83 | 3.98E-01 | 250 |
| 960 | 6.70E-40 | >10,000 | 7,000 | 200 | 0.50 | 1.12E-38 | >10,000 |
| **Sample** | **M-A-S-20-COMP Hopper Dredge (15,000 cubic yards/load)** | | | | | | |
| 0 | 9.68E-40 | >10,000 | 7,200 | 200 | 0.50 | [illegible] | >10,000 |
| 450 | 1.05E-14 | >10,000 | 9,400 | 1,000 | 4.00 | 1.05E-14 | >10,000 |
| 858 (max) | 5.29E-02 | 1889 | 9,400 | 1,000 | 0.83 | 5.38E-01 | 185 |
| 960 | 8.59E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 8.83E-02 | 1132 |
| **Sample** | **M-A-S-20-COMP Clamshell Dredge (4,800 cubic yards/load)** | | | | | | |
| 0 | 1.73E-40 | >10,000 | 7,200 | 200 | 0.50 | 2.84E-39 | >10,000 |
| 450 | 1.62E-24 | >10,000 | 9,400 | 1,000 | 4.00 | 1.62E-24 | >10,000 |
| 879 (max) | 9.44E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 9.30E-02 | 1074 |
| 960 | 1.60E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 1.60E-02 | 6249 |
| **Sample** | **M-A-S-20-COMP Clamshell Dredge (15,000 cubic yards/load)** | | | | | | |
| 0 | 6.94E-40 | >10,000 | 6,600 | 200 | 0.33 | 7.27E-39 | >10,000 |
| 450 | 6.94E-40 | >10,000 | 6,600 | 200 | 0.33 | 7.27E-39 | >10,000 |
| 928 (max) | 3.80E-02 | [illegible] | 9,400 | 1,000 | 0.83 | 2.52E-01 | 396 |
| 960 | 8.49E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 6.07E-02 | 1646 |
| **Sample** | **M-B-S-20-COMP Hopper Dredge (4,800 cubic yards/load)** | | | | | | |
| 0 | 5.91E-40 | >10,000 | 7,000 | 200 | 0.50 | 9.33E-39 | >10,000 |
| 450 | 5.90E-06 | >10,000 | 9,400 | 1,000 | 4.0 | 5.90E-06 | >10,000 |
| 537 (max) | 3.22E-02 | 3095 | 9,400 | 1,000 | 0.83 | 3.36E-01 | 297 |
| 960 | 5.91E-40 | >10,000 | 9,400 | 1,000 | 0.50 | 9.33E-39 | >10,000 |
| **Sample** | **M-B-S-20-COMP Hopper Dredge (15,000 cubic yards/load)** | | | | | | |
| 0 | 1.00E-39 | >10,000 | 7,000 | 200 | 0.50 | 1.51E-38 | >10,000 |
| 450 | 6.30E-21 | >10,000 | 9,400 | 1,000 | 4.0 | 6.30E-21 | >10,000 |
| 874 (max) | 5.48E-02 | 1824 | 9,400 | 1,000 | 0.83 | 5.25E-01 | 189 |
| 960 | 9.19E-03 | >10,000 | 7,000 | 200 | 0.83 | 8.92E-02 | 1120 |
| **Sample** | **M-B-S-20-COMP Clamshell Dredge (4,800 cubic yards/load)** | | | | | | |
| 0 | 1.40E-40 | >10,000 | 7,200 | 200 | 0.50 | 1.40E-39 | >10,000 |
| 450 | 3.43E-29 | >10,000 | 9,400 | 1,000 | 4.0 | 3.43E-29 | >10,000 |
| 886 (max) | 7.65E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 7.33E-02 | 1364 |
| 960 | 1.32E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 1.29E-02 | 7752 |
| **Sample** | **M-B-S-20-COMP Clamshell Dredge (15,000 cubic yards/load)** | | | | | | |
| 0 | 5.41E-40 | >10,000 | 6,600 | 200 | 0.33 | 5.59E-39 | >10,000 |
| 450 | 5.41E-40 | >10,000 | 6,600 | 200 | 0.33 | 5.59E-39 | >10,000 |
| 928 (max) | 2.96E-02 | 3377 | 9,400 | 1,000 | 0.83 | 1.95E-01 | 512 |
| 960 | 6.68E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 4.74E-02 | 2109 |

### Exhibit 5-8. Four-Hour Criteria and Disposal Site Boundary Criteria after Initial Mixing

| Four Hour Disposal Criteria | | | | | Disposal Boundary Criteria | | |
|---|---|---|---|---|---|---|---|
| Depth, feet | % Max Conc Above Background on Grid | Dilution on Grid ($D_{a-tox}$) | X Location | Z Location | Time, hours | Max Conc Outside Disposal Area | Dilution ($D_{a-tox}$) |
| **Sample** | **D-SAx-S-20-COMP Hopper Dredge (4,800 cubic yards/load)** | | | | | | |
| 0 | 5.31E-40 | >10,000 | 6,800 | 200 | 0.50 | 7.26E-39 | >10,000 |
| 450 | 4.83E-36 | >10,000 | 9,400 | 1,000 | 4.0 | 4.83E-36 | >10,000 |
| 734 (max) | 2.90E-02 | 3447 | 9,400 | 1,000 | 0.83 | 2.69E-01 | 371 |
| 960 | 9.33E-24 | >10,000 | 9,400 | 1,000 | 4.0 | 9.33E-24 | >10,000 |
| **Sample** | **D-SAx-S-20-COMP Hopper Dredge (15,000 cubic yards/load)** | | | | | | |
| 0 | 1.58E-39 | >10,000 | 6,400 | 200 | 0.33 | 1.48E-38 | >10,000 |
| 450 | 1.58E-39 | >10,000 | 6,400 | 200 | 0.33 | 1.48E-38 | >10,000 |
| 934 (max) | 8.67E-02 | 1152 | 9,400 | 1,000 | 0.67 | 5.40E-01 | 184 |
| 960 | 2.12E-02 | 4716 | 9,400 | 1,000 | 0.67 | 1.48E-01 | 675 |
| **Sample** | **D-SAx-S-20-COMP Clamshell Dredge (4,800 cubic yards/load)** | | | | | | |
| 0 | 3.41E-40 | >10,000 | 6,400 | 200 | 0.33 | 3.35E-39 | >10,000 |
| 450 | 3.41E-40 | >10,000 | 6,400 | 200 | 0.33 | 3.35E-39 | >10,000 |
| 938 (max) | 1.87E-02 | 5347 | 9,400 | 1,000 | 0.83 | 1.19E-01 | 839 |
| 960 | 4.96E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 3.64E-02 | >10,000 |
| **Sample** | **D-SAx-S-20-COMP Clamshell Dredge (15,000 cubic yards/load)** | | | | | | |
| 0 | 8.96E-40 | >10,000 | 6,200 | 200 | 0.33 | 7.34E-39 | >10,000 |
| 450 | 8.96E-40 | >10,000 | 6,200 | 200 | 0.33 | 7.34E-39 | >10,000 |
| 939 (max) | 4.91E-02 | 2036 | 9,400 | 1,000 | 0.67 | 2.81E-01 | 355 |
| 960 | 1.34E-02 | 7462 | 9,400 | 1,000 | 0.67 | 9.08E-02 | 1100 |
| **Sample** | **D-ATw-S-20-COMP Hopper Dredge (4,800 cubic yards/load)** | | | | | | |
| 0 | 5.71E-40 | >10,000 | 7,200 | 200 | 0.50 | 9.10E-39 | >10,000 |
| 450 | 6.03E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 1.77E-02 | 5649 |
| 488 (max) | 3.12E-02 | 3204 | 9,400 | 1,000 | 0.83 | 3.27E-01 | 305 |
| 960 | 5.71E-40 | >10,000 | 7,200 | 200 | 0.50 | 9.10E-39 | >10,000 |
| **Sample** | **D-ATw-S-20-COMP Hopper Dredge (15,000 cubic yards/load)** | | | | | | |
| 0 | 9.24E-40 | >10,000 | 7,200 | 200 | 0.50 | 1.44E-38 | >10,000 |
| 450 | 2.97E-18 | >10,000 | 9,400 | 1,000 | 4.0 | 2.97E-18 | >10,000 |
| 868 (max) | 5.05E-02 | 1979 | 9,400 | 1,000 | 0.83 | 4.95E-01 | 201 |
| 960 | 8.36E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 8.28E-02 | 1207 |
| **Sample** | **D-ATw-S-20-COMP Clamshell Dredge (4,800 cubic yards/load)** | | | | | | |
| 0 | 1.09E-40 | >10,000 | 7,200 | 200 | 0.50 | 1.81E-39 | >10,000 |
| 450 | 2.17E-23 | >10,000 | 9,400 | 1,000 | 4.0 | 2.17E-23 | >10,000 |
| 977 (max) | 5.95E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 5.91E-02 | 1691 |
| 960 | 1.00E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 1.01E-02 | 9900 |
| **Sample** | **D-ATw-S-20-COMP Clamshell Dredge (15,000 cubic yards/load)** | | | | | | |
| 0 | 4.18E-40 | >10,000 | 6,800 | 200 | 0.50 | 4.36E-39 | >10,000 |
| 450 | 4.18E-40 | >10,000 | 6,800 | 200 | 0.50 | 4.36E-39 | >10,000 |
| 918 (max) | 2.28E-02 | 4385 | 9,400 | 1,000 | 0.83 | 1.68E-01 | 594 |
| 960 | 4.61E-03 | >10,000 | 9,400 | 1,000 | 0.83 | 3.56E-02 | 2808 |

Dilution ($D_{a-tox}$) = (100 – max conc.)/max conc.

## Conclusion

STFATE modeling was performed using two types of dredging equipment, a clamshell dredge combined with a separate barge or scow and a hopper or cutter dredge. Each type of dredging equipment was modeled with a capacity of 4,800 cubic yards per load based on the largest option currently available in Puerto Rico. The model was also performed with a volume of 15,000 cubic yards per load in case a larger dredging vessel or transport equipment becomes available in the future. All model runs met the disposal criteria for both dredging methods and volumes. Therefore, the material may be disposed without location or volume restrictions, to a maximum volume of 15,000 cubic yards per load within the ODMDS boundaries in accordance with all criteria specified by EPA Region 2 and USACE Jacksonville District.

Exhibits 5-9 and 5-10 show an aerial map of the ODMDS in relation to the northern coast of San Juan, Puerto Rico, and a computer-generated image showing specific site details, respectively.

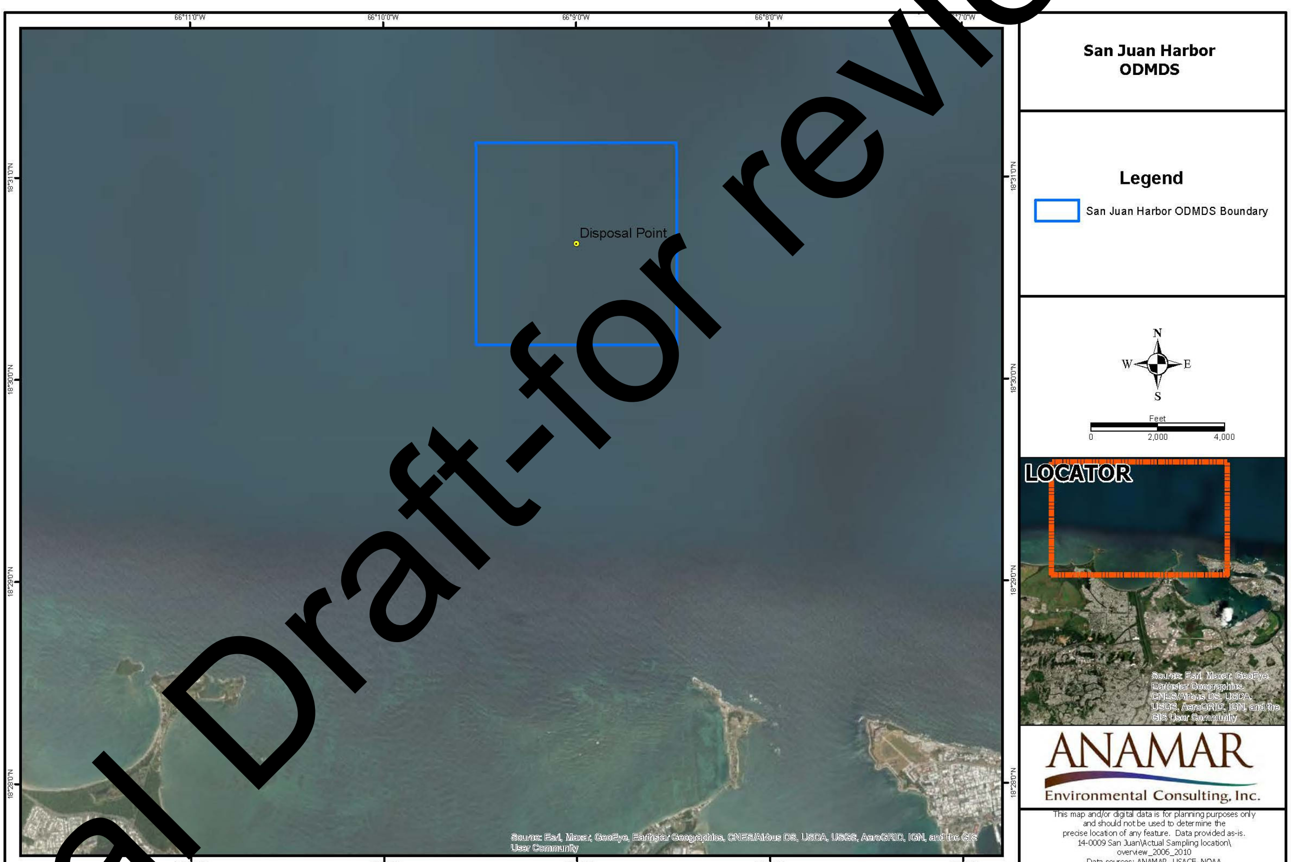



**Exhibit 5-9. Aerial Map of San Juan Harbor ODMDS with Disposal Point**


Results of the STFATE module of the ADDAMS model indicate that all material from the San Juan Harbor dredging units may be disposed of at the center of the San Juan Harbor ODMDS using a hopper dredge or clamshell with a scow or barge with a carrying capacity of up to 15,000 cubic yards per load without violating applicable disposal criteria.

**Exhibit 5-10. Computer-Generated Map of San Juan Harbor ODMDS**

# 6 REFERENCES

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