Appendix D

Bodega Bay Harbor Federal Navigation Channel

Fiscal Year 2017 Maintenance Dredging

Sediment Suitability Determination and

Sediment Sampling and Analysis Report

From:	Ross, Brian
To:	Grillo, Roxanne L CIV USARMY CESPN (US)
Cc:	Ota, Allan; Burton Evans, Jessica L CIV USARMY CESPN (US)
Subject:	[EXTERNAL] EPA Suitability Determination for Bodega Bay 2017 Federal O&M Material
Date:	Wednesday, December 28, 2016 9:59:57 AM

Hi Roxanne,

Sorry, I though the suitability letter already went out!

Based on the revised "Final Bodega Bay Harbor Federal Navigation Channel Operations and Maintenance Dredging Sampling and Analysis Report" dated November 21, 2016, EPA as determined that all of the approximately 66,000 cy of material to be dredged in 2017 from the Bodega Bay Federal navigation channels is suitable for disposal at SF-DODS, and additionally that the sandy material in sampling areas BB1, BB2, BB3-1, and BB3-2 (between 22,000 and 38,000 cy) is suitable for beneficial reuse by placement in the easternmost area of SF-8.

We will provide a separate concurrence letter, with disposal conditions for both SF-DODS and SF-8, at USACE's request once the final estimated volume breakout between sandy sediment (for SF-8) and finer sediment (for SF-DODS) is available. Note that EPA does not anticipate concurring in ocean disposal at SF-DODS for sandy material that is suitable for reused at SF-8.

==========

Brian Ross
Dredging & Sediment Management Team, WTR-2-4
U.S. Environmental Protection Agency, Region 9
75 Hawthorne Street
San Francisco, CA 94105
415-972-3475
ross.brian@epa.gov

Note: I cannot receive e-mail attachments greater than about 20 MB.
Please contact me in advance to make arrangements to share larger files.
==========

-----Original Message-----
From: Grillo, Roxanne L CIV USARMY CESPN (US) [mailto:Roxanne.Grillo@usace.army.mil]
Sent: Tuesday, December 27, 2016 5:01 PM
To: Ross, Brian <Ross.Brian@epa.gov>
Cc: Ota, Allan <Ota.Allan@epa.gov>; Burton Evans, Jessica L CIV USARMY CESPN (US) <Jessica.L.BurtonEvans@usace.army.mil>
Subject: Bodega Bay O&M Material Suitability Determination

Good afternoon, Brian,

I hope your day is going well. I would like to gently remind you that USACE does not have a suitability determination for the O&M material within the Bodega Bay Federal navigation channels yet. We would like to attach the EPA's determination to our other compliance documents, particularly the water quality certification application and the environmental assessment.

I've attached the suitability determination request to this email. The contractor sent you this letter along with the final documents on November 21. Did you receive these? If so, do you need anything else from me to issue a suitability determination for this material?

I know you and your team are very busy, but if you could please let me know your thoughts on this when you get a chance, I would greatly appreciate it.

Thank you for your time,
Roxanne

--
Roxanne Grillo, P.E.
Project Manager
U.S. Army Corps of Engineers, San Francisco District
1455 Market Street, Floor 17, 1736D
San Francisco, CA 94103-1398
(415) 503-6859

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, US ARMY CORPS OF ENGINEERS
1455 MARKET STREET,
SAN FRANCISCO CALIFORNIA 94103-1398

November 21, 2016

Mr. Brian Ross
Dredging and Sediment Management Team
U.S. Environmental Protection Agency, Region 9
75 Hawthorne Street, WTR-2-4
San Francisco, California 94105

Dear Mr. Ross:

The U.S. Army Corps of Engineers, San Francisco District (USACE) is pleased to provide you with the enclosed "Final Bodega Bay Harbor Federal Navigation Channel Operations and Maintenance Dredging Sampling and Analysis Report," dated November 2016, for your records. This document includes revisions based on your comment provided on November 16, 2016, which stated that if material will be placed at the San Francisco Channel Bar Disposal Site (SF-8), it must be placed within the easternmost portion of SF-8, within the 3-mile limit, per 40 CFR §228.15(l)(4).

Given the results of the sampling and testing described in this document, USACE requests a suitability determination that all of the material proposed to be dredged from Federal navigation channels to the congressionally authorized depth plus allowable overdepth within Bodega Bay Harbor is suitable for unconfined aquatic placement at the San Francisco Deep Ocean Disposal Site (SF-DODS). In addition, only the material that exhibited greater than 80 percent sand concentrations (sampling areas BB1, BB2, BB3-1, and BB3-2) is suitable for unconfined aquatic placement in the easternmost portion of SF-8 within the 3-mile limit.

A copy of this document has also been provided to Mr. Stephen Bargsten of the North Coast Regional Water Quality Control Board, Ms. Elizabeth Christian of the San Francisco Regional Water Quality Control Board, Mr. Mark Delaplaine of the California Coastal Commission, Ms. Sara Azat of the National Marine Fisheries Service, and Mr. Ryan Olah of the United States Fish and Wildlife Service. Please contact Roxanne Grillo at Roxanne.Grillo@usace.army.mil or by phone at 415-503-6859 if you have any questions or concerns.

Sincerely,

Jessica Burton Evans
Chief, Environmental Section B

Enclosure

Report to:

U.S. Army Corps of Engineers
San Francisco District
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San Francisco, CA 94103-1398

Sampling and Analysis Report
Operations and Maintenance Dredging
Bodega Bay Harbor Federal Navigation Channel
Bodega Bay, California

November 2016

Prepared By:

ECM Consultants

3525 Hyland Ave #200 • Costa Mesa, CA 92626 • Main: 844.321.ECMC

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APPENDICES

ACRONYMS AND ABBREVIATIONS

ALS	ALS Environmental
ASTM	American Society for Testing and Materials
Bay	San Francisco Bay
$CaCO_3$	Total hardness
COC	Chain-of-custody
CRRP	Cullinan Ranch Restoration Program
CY	Cubic yards
D.O.	Dissolved oxygen
DDT	Dichlorodiphenyltrichloroethane
DGPS	Differential global positioning system
DMMO	Dredged Material Management Office
EDL	Estimated Detection Limit
ESC	Elutriate Suitability Concentrations
ft	foot
g/L	grams per liter
GPS	Global positioning system
HDPE	high-density polyethylene
ITM	Inland Testing Manual
KCl	potassium chloride
K_{ow}	Octanol-water partitioning coefficient
LC	lethal concentration (e.g., LC50)
LCS/LCSD	Laboratory Control Spike/ Laboratory Control Spike Duplicate
LOED	Lowest observed-effect dose
LTMS	Long Term Management Strategy
MDL	method detection limit
MET	Modified Elutriate Test
mg/kg	milligram/kilogram
mg/L	milligrams per liter
mL	milliliters
MLLW	Mean lower low water
MRL	Method reporting limits
MS/MSD	Matrix spike/matrix spike duplicates
NOEC	No-observed-effect concentration
NOED	No-observed-effect dose
ng/kg	nanogram per kilogram
OTM	Ocean Testing Manual
O&M	Operations and Maintenance
OCl	Organochlorine
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PER	Pacific EcoRisk
ppt	parts per thousand
QA/QC	Quality assurance/quality control
ROH	Richmond Outer Harbor
RPD	Relative percent difference
RWQCB	Regional Water Quality Control Board
SAP	Sampling and analysis plan
SAR	Sampling and analysis report

SET	Standard Elutriate Test SF-10
SF-8	San Francisco Channel Bar Disposal Site
SF-District	San Francisco District
SF-DODS	San Francisco Deep Ocean Disposal Site
SOP	Standard operating procedures
SUAD	Suitable for undefined aquatic disposal
TOC	Total organic carbon
TRV	Toxicity reference values
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFDA	U.S. Food & Drug Administration
WET	Waste extraction test
WQO	Water quality objectives
wt	Weight
µg/kg	microgram per kilogram

DISTRIBUTION LIST

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1 INTRODUCTION

The United States Army Corps of Engineers (USACE) San Francisco District plans to conduct operations and maintenance (O&M) dredging of the Bodega Bay Harbor federal channel (**Figure 1**), including Spud Point Marina Channel (SPC), in federal fiscal year (FY) 2017. Historically, Bodega Bay Harbor has been dredged every 10-12 years. Given the period of time between maintenance dredging episodes, a Tier III Evaluation of the sediment to be dredged is required before each dredging episode. The results of the Tier III Evaluation provide determinative data on the suitability of sediment to be dredged in 2017 from the Bodega Bay Harbor federal channel for placement in the ocean at the San Francisco Channel Bar Disposal Site (SF-8) near the Golden Gate or at the San Francisco Deep Ocean Disposal Site (SF-DODS). Please note that USACE will not place any material in the westernmost portion of SF-8 (outside of the 3-mile limit). Please see Figure 1 below for the planned placement area within SF-8.

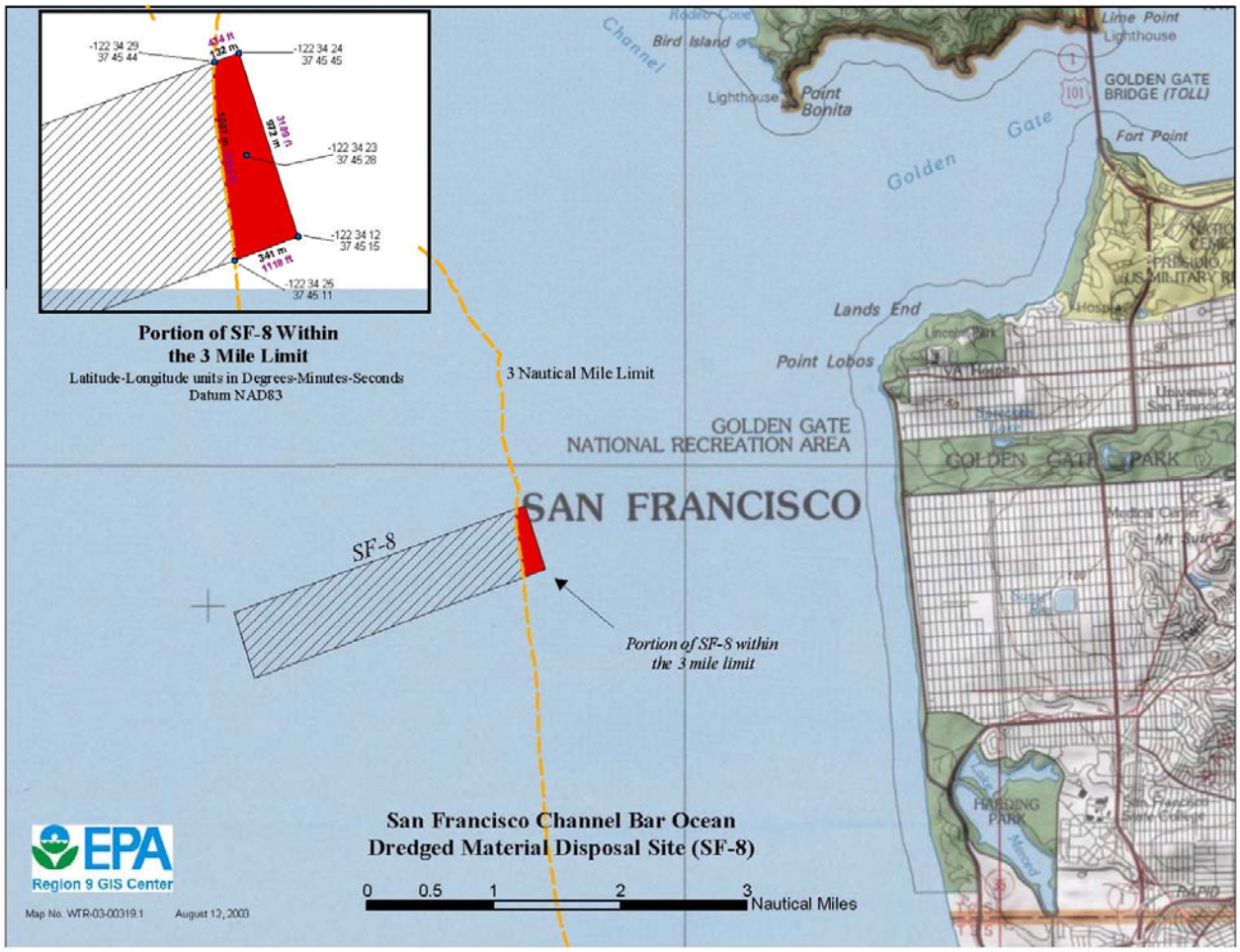


Figure 1. San Francisco Bay Channel Bar Disposal Site (SF-8) – Planned Placement Area is the easternmost portion (inshore of the 3-mile limit).

A Tier III Evaluation of the material to be dredged was completed in accordance with the Bodega Bay Harbor Federal Channel FY2017 Maintenance Dredging, Sampling and Analysis Plan (SAP). This Sampling and Analysis Report (SAR) has been prepared on behalf of the USACE to detail results of the sampling and analysis of sediments to be dredged from within the Bodega Bay Harbor. This work was performed under contract number W912P7-15-C-0018.

1.1 PROJECT DESCRIPTION

Bodega Bay is located on the Pacific coast, approximately 70 miles north of San Francisco, California. The congressionally authorized project depth throughout the federal channel is 12 feet mean lower-low water (MLLW). The USACE plans to dredge Bodega Bay Harbor to the authorized project depth plus an allowable overdepth of 2 feet MLLW (the first foot paid and a second foot unpaid) in 2017. Based on the most recent hydrographic survey conducted in August 2014, the current dredge volume is projected to be approximately 66,000 cubic yards (CY) from the entirety of the Bodega Bay Harbor federal navigation channel (Table 1-1). There is no dredging planned for the USCG station access area this dredging cycle because the most recent hydrographic survey (August 2014, *cf.* Appendix A) detected no shoaling above project depth (10').

The federal channel in Bodega Bay Harbor (Figure 2) was completed in 1943 under the Rivers and Harbors Act of 1938. In 1965, Congress authorized the construction of a baffled concrete pile breakwater and an access from the existing federal channel to Spud Point Marina which was completed in 1975. Spud Point Marina has 250 permanent berths. Bodega Bay Harbor in general houses over 300 commercial fishing boats, and this number increases significantly during commercial salmon fishing season. Along with the federal navigation channel including the Spud Point Marina access channel, the U.S. Army Corps of Engineers (USACE) historically has also maintained access to an adjacent U.S. Coast Guard (USCG) Search and Rescue Base to a depth of 10 feet MLLW.

Table 1-1. Bodega Bay Harbor Estimated Dredge Quantities

Sampling Area (Stations)		August 2014 Sediment Volume (cy)			
		Channel Project Depth (-12' MLLW) CY	**1st Foot Paid Overdepth (-13' MLLW) CY**	**2nd Foot Unpaid Overdepth (-14' MLLW) CY**	**Total Volume CY**
Sandy Material Areas	BB1-2015 (Station 0+00 to 53+00)	6,332	3,517	3,517	13,366
	BB2-2015 (Station 53+00 to 78+00)	4,380	2,061	2,061	8,502
	BB3-2015 (Station 78+00 to 165+00)	2,472	2,678	2,678	16,330
Less Sandy Material Areas	BB4-2015 (Station 165+00 to 183+02)	17,163	8,470	8,470	34,109
	SPC-2015 (Station 0+00 to 19+95)	731	589	589	1,909
TOTAL		**31,078**	**17,315**	**17,315**	**65,708**

1.2 OBJECTIVES OF THE SEDIMENT INVESTIGATION

The purpose of this pre-dredge sampling and analysis effort is to determine the suitability of sediment to be dredged in 2017 from the Bodega Bay Harbor federal channel for placement in the ocean at SF-8 near the Golden Gate or at SF-DODS. The procedures for sediment sample collection, sample processing and preparation, physical and chemical analyses, biological testing and data analyses were conducted in accordance with the approved SAP and the approved Master Sampling and Analysis Plan, USACE SF-District O&M Dredging (USACE Master SAP, 2014). The specific objectives of the scope of work were as follows:

- Collect core samples from within the five designated sampling areas following field protocols detailed in the SAP and Master SAP; and
- Conduct chemical and biological analyses to determine whether sediments are suitable for unconfined aquatic disposal (SUAD) at multiple disposal sites such as SF-8 and SF-DODS.

1.3 ORGANIZATION OF THIS DOCUMENT

Sample collection and handling procedures are discussed in Sections 2 and 3 of this report. Results of chemical analyses and biological toxicity testing are provided in Sections 4 through 6. Section 7 discusses quality control (QC) and Section 8 presents the conclusions regarding suitability of the material for unconfined aquatic disposal at SF-8 or SF-DODS.

2 FIELD SEDIMENT SAMPLE COLLECTION

All sediments and site water were collected in accordance with guidelines and procedures outlined in the SAP (USACE 2015). Sediment sampling was performed Tuesday, November 3, 2015 through Friday, November 6, 2015 under the direction of a qualified Field Manager and California Professional Geologist from Leidos. TEG Oceanographic Services provided the sampling vessel, onboard positioning system and vibracore sampling equipment.

Sediment cores were collected from 21 sampling locations within the five Bodega Harbor sampling areas (**Figure 2**). Final core station locations were determined with a differential global positioning system (DGPS) and are accurate to ± 3 m. Table 2-1 lists station identifiers, DGPS coordinates for all core station locations, actual mudline elevations, and core penetration depths for all stations.

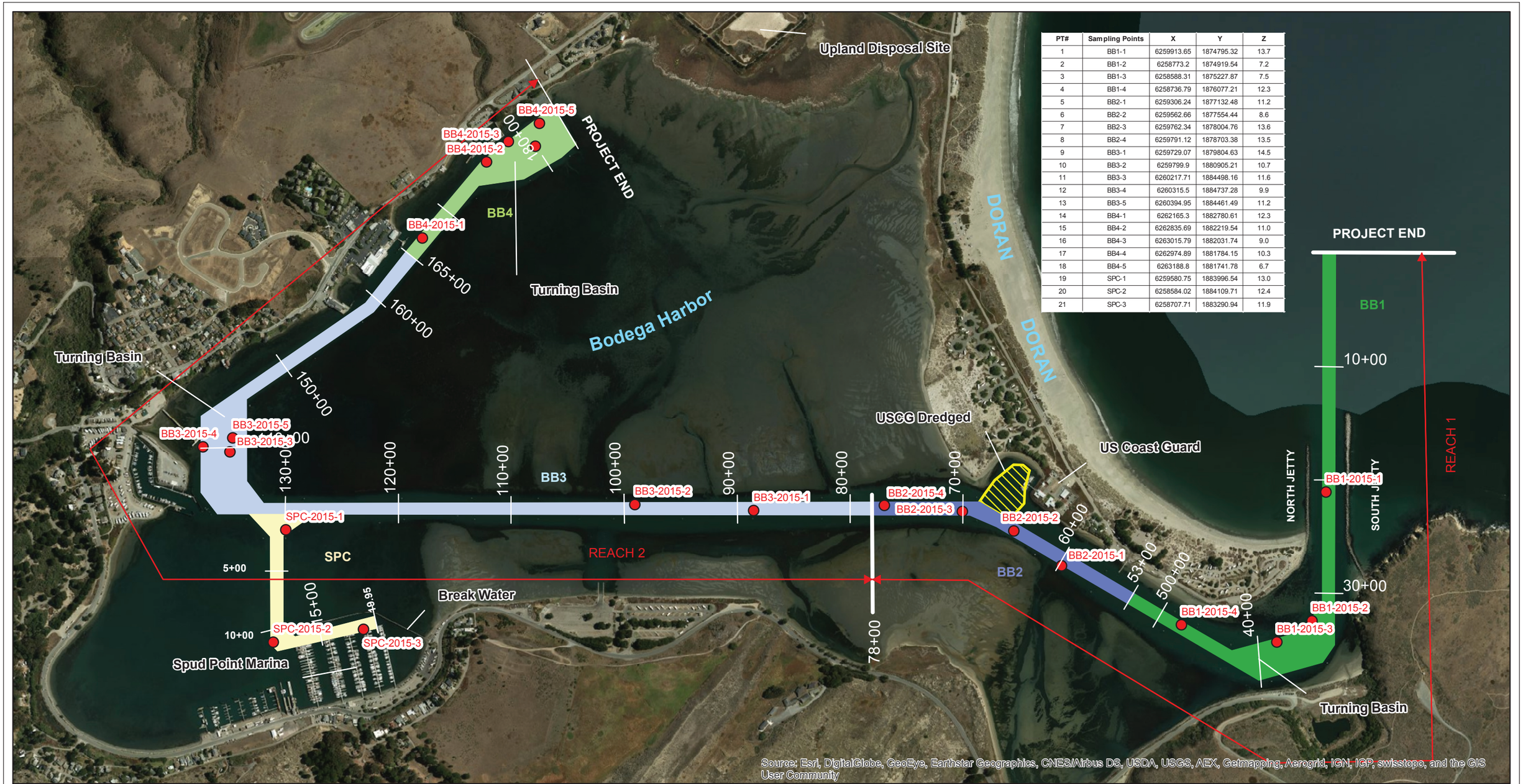
All samples were collected using an appropriate coring device. All sediment cores were collected to a depth of 0.5 ft below the project depth plus two feet of overdepth (14.5 ft MLLW). The 0.5 ft core section immediately below the 'project depth plus two feet of overdepth' (14.0 – 14.5 ft MLLW) was designated the 'Z-layer' to represent the material to be left in place after dredging occurs. Sediment cores were extruded on board the sampling vessel, and samples were removed from the portions of the core corresponding to mudline to project depth plus two feet of overdepth (mudline to 14.0 ft MLLW) and placed into laboratory supplied containers. Sediment from the 'Z-layer' section (14.0 – 14.5 ft MLLW) was also removed from each core and stored in a separate container. Any material that was collected from below the Z-layer was discarded and not incorporated into the samples for analysis.

Field log sheets are presented in Appendix A. There were no major deviations from the SAP (USACE 2015).] However, some sample locations had to be relocated as discussed with the USACE and described below:

- BB3-2015-1 was moved approximately 60 feet to the north. Mudline elevation was below the dredging level of -14.5 MLLW. Sample location was moved at the direction of USACE;
- BB4-2015-3 was moved approximately 32 feet to the west of the original location due to refusal before reaching target depth;
- BB4-2015-5 was relocated approximately 17 feet to the northwest of the original location due to refusal before reaching target depth, and;
- SPC-2015-3 was moved approximately 20 feet to the southwest due to an obstruction (mussel-raising facility) at the original sample location.

Figures 2a through 2g identify the proposed sample locations and the actual sample locations.

PT#	Sampling Points	X	Y	Z
1	BB1-1	6259913.65	1874795.32	13.7
2	BB1-2	6258773.2	1874919.54	7.2
3	BB1-3	6258588.31	1875227.87	7.5
4	BB1-4	6258736.79	1876077.21	12.3
5	BB2-1	6259306.24	1877132.48	11.2
6	BB2-2	6259562.66	1877554.44	8.6
7	BB2-3	6259762.34	1878004.76	13.6
8	BB2-4	6259791.12	1878703.38	13.5
9	BB3-1	6259729.07	1879804.63	14.5
10	BB3-2	6259799.9	1880905.21	10.7
11	BB3-3	6260217.71	1884498.16	11.6
12	BB3-4	6260315.5	1884737.28	9.9
13	BB3-5	6260394.95	1884461.49	11.2
14	BB4-1	6262165.3	1882780.61	12.3
15	BB4-2	6262835.69	1882219.54	11.0
16	BB4-3	6263015.79	1882031.74	9.0
17	BB4-4	6262974.89	1881784.15	10.3
18	BB4-5	6263188.8	1881741.78	6.7
19	SPC-1	6259580.75	1883996.54	13.0
20	SPC-2	6258584.02	1884109.71	12.4
21	SPC-3	6258707.71	1883290.94	11.9



N

Feet
0 800

Legend

Sampling Areas: BB1 to BB4, SPC

US Coast Guard Dredge

Proposed sample locations

ECM Consultants

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Bodega Bay Channel

Bodega Bay Harbor
Federal Channel, Operations and
Maintenance Dredging, Bodega Bay, CA

Figure 2

N

Feet
0 200

Note

Survey Data Collected August 27- 29, 2014

ECM Consultants
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Bodega Bay Channel

Bodega Bay Harbor
Federal Channel, Operations and
Maintenance Dredging, Bodega Bay, CA

Figure 2a

N

Feet
0 200

Note

Survey Data Collected August 27- 29, 2014

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address 3525 Hyland Ave #200 Costa Mesa, CA 92626
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Bodega Bay Channel

Bodega Bay Harbor
Federal Channel, Operations and
Maintenance Dredging, Bodega Bay, CA

Figure 2b

N

Feet
0 300

Note

Survey Data Collected August 27- 29, 2014

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address 3525 Hyland Ave #200 Costa Mesa, CA 92626
phone 714.662.2759
web ecmconsults.com

Bodega Bay Channel

Bodega Bay Harbor
Federal Channel, Operations and
Maintenance Dredging, Bodega Bay, CA

Figure 2c

N

Feet
0 250

Note

Survey Data Collected August 27- 29, 2014

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Bodega Bay Channel

Bodega Bay Harbor
Federal Channel, Operations and
Maintenance Dredging, Bodega Bay, CA

Figure 2d

N

Feet
0 200

Note

Survey Data Collected August 27- 29, 2014

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Bodega Bay Channel

Bodega Bay Harbor
Federal Channel, Operations and
Maintenance Dredging, Bodega Bay, CA

Figure 2e

N

Feet
0 200

Note

Survey Data Collected August 27- 29, 2014

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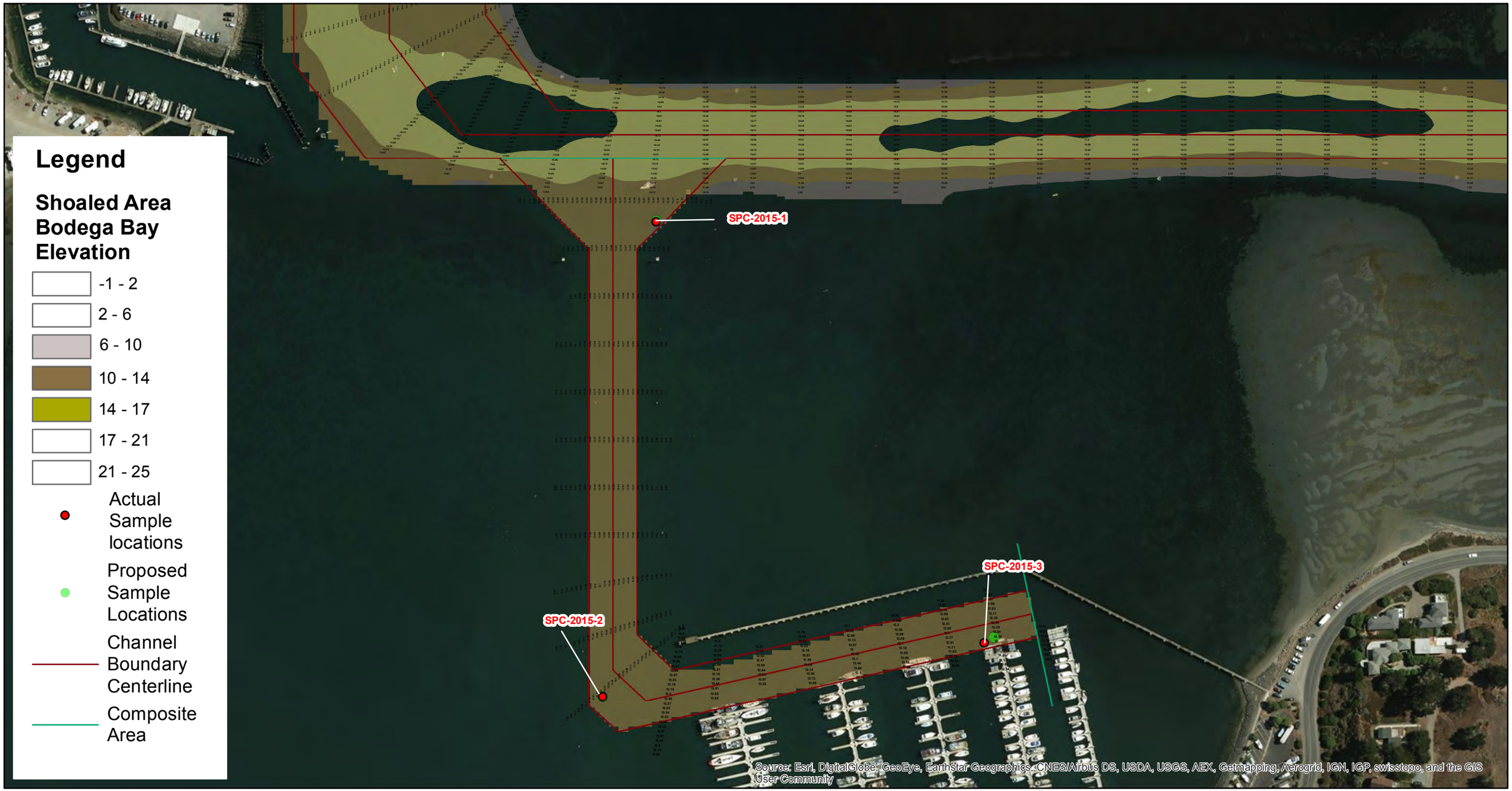
Bodega Bay Channel

Bodega Bay Harbor
Federal Channel, Operations and
Maintenance Dredging, Bodega Bay, CA

Figure 2f



N

Feet
0 200

Note

Survey Data Collected August 27- 29, 2014

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Bodega Bay Channel

Bodega Bay Harbor
Federal Channel, Operations and Maintenance Dredging, Bodega Bay, CA

Figure 2g

Table 2-1 Locations of Sampling Stations and Core Depths Achieved

Sample ID	Latitude (decimal-degrees)	Longitude (decimal-degrees)	Mudline Elevation (ft MLLW)	Project Elevation with Overdepth plus Z-Layer (ft MLLW)	Core Recovery for Lab Analysis (ft)	Core Intervals Sampled (ft MLLW)
BB1-2015-1	38°18.3247	123°03.0934	-13.7	-14.5	0.8	-13.7 to -14.0, -14.0 to -14.5
BB1-2015-2	38°18.3428	123°03.3322	-7.2	-14.5	7.3	-7.2 to -14.0, -14.0 to -14.5
BB1-2015-3	38°18.3937	123°03.3721	-7.8	-14.5	6.7	-7.8 to -14.0, -14.0 to -14.5
BB1-2015-4	38°18.5332	123°03.3421	-12.3	-14.5	2.2	-12.3 to -14.0, -14.0 to -14.5
BB2-2015-1	38°18.7090	123°03.2354	-11.2	-14.5	3.3	-11.2 to -14.0, -14.0 to -14.5
BB2-2015-2	38°18.7792	123°03.1721	-8.6	-14.5	5.9	-8.6 to -14.0, -14.0 to -14.5
BB2-2015-3	38°18.8546	123°03.1317	-13.6	-14.5	0.9	-13.6 to 14.0, -14.0 to -14.5
BB2-2015-4	38°18.9684	123°03.1275	-13.5	-14.5	1.0	-13.5 to -14.0, -14.0 to -14.5
BB3-2015-1	38°19.1588	123°03.1398	-13.3	-14.5	1.2	-13.3 to -14.0, -14.0 to -14.5
BB3-2015-2	38°19.3321	123°03.1314	-10.7	-14.5	3.8	-10.7 to -14.0, -14.0 to -14.5
BB3-2015-3	38°19.9233	123°03.0424	-11.6	-14.5	2.9	-11.6 to -14.0, -14.0 to -14.5
BB3-2015-4	38°19.9629	123°03.0337	-9.9	-14.5	4.6	-9.9 to -14.0, -14.0 to -14.5
BB3-2015-5	38°19.9195	123°03.0166	-11.2	-14.5	3.3	-11.2 to -14.0, -14.0 to -14.5
BB4-2015-1	38°19.6465	123°02.6424	-12.3	-14.5	2.2	-12.3 to -14.0, -14.0 to -14.5
BB4-2015-2	38°19.5542	123°02.5002	-11.0	-14.5	3.5	-11.0 to -14.0, -14.0 to -14.5
BB4-2015-3*	38°19.5228	123°02.4612	-9.0	-14.5	4.5	-9.0 to -14.0, -14.0 to -13.5
BB4-2015-4	38°19.4832	123°02.4702	-10.3	-14.5	4.2	-10.3 to -14.0, -14.0 to -14.5
BB4-2015-5*	38°19.4778	123°02.4276	-6.7	-14.5	5.5	-6.7 to -14.0, -14.0 to -12.2
SPC-2015-1	38°19.8406	123°03.1857	-13.0	-14.5	1.5	-13.0 to -14.0, -14.0 to -14.5
SPC-2015-2	38°19.8571	123°03.3939	-12.4	-14.5	2.1	-12.4 to -14.0, -14.0 to -14.5
SPC-2015-3	38°19.7257	123°03.3683	-11.9	-14.5	2.6	-11.9 to -14.0, -14.0 to -14.5

*Did not recover the full amount for laboratory analysis (down to 14.5 ft MLLW).

3 SAMPLE PROCESSING

3.1 HOMOGENIZATION AND COMPOSITING OF SEDIMENTS

Previous testing has revealed that shoaled material in Bodega Bay Harbor consists of two types of sediment: “Sandy Material” (composed of greater than 80 percent sand) and “Less Sandy Material” (composed of less than 80 percent sand). Typically, composite areas BB1, BB2, and the southern part of area BB3 consist of sandy material, while composite areas BB4, Spud Point Marina Channel (SPC), and the northern part of BB3 consist of less sandy material.

Sediment from the portions of Bodega Bay Harbor proposed for dredging were characterized by collecting 10 individual/discrete samples in the area of the channel with “Sandy Material” and three composite samples in the area of the channel with “Less Sandy Material.” The discrete samples were collected and analyzed (physical testing) within the Sandy Channels (BB1, BB2, and individual samples BB3-2015-1 and BB3-2015-2). The composite samples consisted of sediment from three or more sample locations. Material from a total of 21 representative sample locations in Bodega Bay Harbor were collected.

Based on the results of physical testing, individual samples did not require further analysis (full Tier III evaluation) since concentrations of sand were greater than 80%.

Homogenization and compositing of individual sediment cores was performed on the sampling vessel during the field event. The maintenance depth sections from each individual core were individually homogenized in clean stainless-steel pots using an electric drill fitted with a clean stainless-steel stirring paddle. Sub-samples of the homogenized sediment from the individual sediment cores were archived at the chemistry lab to allow for additional chemical analyses, if necessary. Archived samples are being stored frozen at -20 ± 10˚C until December 1, 2016.

Equal amounts of the homogenized sediment from each of the BB3-2015 individual sediment cores (BB3-2015-3, BB3-2015-4, and BB3-2015-5) were composited and homogenized in clean stainless-steel pots to form the BB3-2015 composite sediment sample. The BB4-2015 and SPC-2015 sediment cores were similarly processed to form the BB4-2015 and SPC-2015 composite sediment samples. The composite samples were submitted for chemical and conventional analyses and toxicity testing. Sub-samples of each composite sample are archived frozen as described above. The Z-layer sediments were processed and archived in similar fashion. As per the approved SAP, Z layer samples were not analyzed.

All sediment was processed following procedures outlined in the SAP (USACE 2015), with no deviations. Sediment and water samples were maintained on ice within insulated coolers until transported to the bioassay and chemistry labs for processing.

3.2 SHIPPING OF SAMPLES TO ANALYTICAL LABORATORY

Prior to shipping to the analytical laboratories, sample containers were labeled and secured on ice. Samples analyzed at PER were delivered to the laboratory by ECM under chain-of-custody (COC) protocol. Samples analyzed at ALS were shipped to the laboratory in Kelso, WA via overnight delivery. Prior to shipping, the samples were labeled, wrapped in bubble wrap and securely packed inside the coolers with ice along with temperature blanks. Each cooler was then sealed with custody seals on the front lid seam.

3.2.1 Chain-of-Custody (COC) Protocol

COC procedures were followed for all samples throughout the collection, handling, and analyses activities. The Project Manager, or a designee, was responsible for all sample tracking and COC procedures. This person was responsible for final sample inventory, maintenance of sample custody documentation, and completion of COC forms prior to transferring samples to the analytical laboratory. A COC form accompanied each cooler of samples to the respective analytical laboratories. Each custodian of the samples signed the COC form; copies of the COC forms are retained in the project file.

4 RESULTS OF PHYSICAL AND CHEMICAL ANALYSES

The Bodega Bay Harbor sediments were analyzed by PER and ALS for the conventional and chemical parameters specified in the SAP (USACE 2015). Conventional parameters included total organic carbon (TOC), total solids, and grain size. Chemical analyses included trace metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), organochlorine (OCl) pesticides, butyltins (also referred to as organotins), and dioxins. The results of these analyses are presented in Tables 4-1 and 4-2 and in Sections 4.1- 4.5. The complete Data Reports prepared by ALS are provided in Appendix B. Analytes detected below the reporting limit (RL) and above the laboratory method detection limit (MDL) were denoted using a J in the tables to indicate that the value is an estimate.

The results of the physical and chemical analyses of the sediments were compared to:

- The SF-DODS reference site database (USEPA 2015);
- The Ecological Screening Levels are used as secondary criteria, if data exceed the SF-DODS Reference Database. Threshold Effects Levels (TELs) and Probable Effects Levels (PELs) were used when Effects Range Low (ERLs) and Effects Range Median (ERMs) were not available.
    - ERL and ERM sediment quality objectives from Long *et al*. (1995).
    - TEL and PEL sediment quality Objectives from MacDonald (1994).

4.1 BB1-2015 DISCRETE SAMPLE RESULTS

Four discrete samples were collected from BB1 and tested for total solids, total sulfide, and total organic carbon.

- BB1-2015-1 site sediment was 83.7% total solids with 0.31% fines (silts and clays). The TOC concentration was 0.029% (J-flagged value), and sulfide content was <0.24 mg/kg.

- BB1-2015-2 site sediment was 80.2% total solids with 2.73% fines (silts and clays). The TOC concentration was 0.11% and sulfide content was 2.69 mg/kg.

- BB1-2015-3 site sediment was 68.1% total solids with 8.71% fines (silts and clays). The TOC concentration was 2.13% and above the SF-DODS (EPA 2015) reference database upper range of 1.45%. Sulfide concentrations was 202 mg/kg.

- BB1-2015-4 site sediment was 80.3% total solids with 1.54% fines (silts and clays). The TOC concentration was 0.091% (J-flagged value) and sulfide content was 4.29 mg/kg.

4.2 BB2-2015 DISCRETE SAMPLE RESULTS

Four samples were collected and tested for total solids, total sulfide, and total organic carbon from BB2.

- BB2-2015-1 site sediment was 72.5% total solids with 2.13% fines (silts and clays). The TOC concentration was 0.13% and sulfide content was 6.29 mg/kg.

- BB2-2015-2 site sediment was 79.1% total solids with 1.42% fines (silts and clays). The TOC concentration was 0.11% and sulfide content was 0.51 (J-flagged value).

- BB2-2015-3 site sediment was 81.5% total solids with 1.17% fines (silts and clays). The TOC concentration was 0.069% (J-flagged value) and sulfide was 0.34 mg/kg (J-flagged value).
- BB2-2015-4 site sediment was 81.9% total solids with 0.93% fines (silts and clays). The TOC concentration was 0.077% (J-flagged value) and sulfide was <0.25 mg/kg.

4.3 BB3-2015 DISCRETE SAMPLE RESULTS

Five discrete samples were collected. BB3-2015-1 and BB3-2015-2 were tested for total solids, total sulfide, and total organic carbon. BB3-2015-3, BB3-2015-4, and BB3-2015-5 were composited into BB3-2015 and analyzed for total solids, total sulfide, total organic carbon, and Tier III analytes.

- BB3-2015-1 site sediment was 83.2% total solids with 1.77% fines (silts and clays). The TOC concentration was 0.14% and the sulfide content was 3.57 mg/kg.

- BB3-2015-2 site sediment was 73.8% total solids with 5.31% fines (silts and clays). The TOC concentration was 0.23% and sulfide content was 2.16 mg/kg.

4.3.1 BB3-2015 Composite Sample Results

BB3-2015 site sediment was 53.1% total solids with 55.06% fines (silts and clays). The TOC level was above the SF-DODS (EPA 2015) upper range of 1.45% with an observed value of 2.00%. Sulfide concentration was 874 mg/kg.

- Arsenic (5.64 mg/kg) and cadmium (0.61 mg/kg) concentrations slightly exceeded the upper value range of the SF-DODS (USEPA 2015) reference site database, but did not exceed the lower effects based screening levels (Effects Range Median – ERM) sediment quality objectives from Long et al (1995). Nickel was 54.7 mg/kg, which is above the ERM but is close to the lower range value of the SF-DODS reference database (50.9 mg/Kg).

- Total butylins were detected at 1.57 µg/kg and were also above SF-DODS levels (ND – 1.3 µg/kg). There are no ERL or ERM values for total butyltins.

- Dioxins (as Total TCDD TEQ) were 1.83 ng/kg. There are no SF-DODS, ERL, or ERM values for dioxin.

- Total DDT was 0.19 µg/kg, which is below the SF-DODS reference site database screening levels.

- PCBs were not detected in sample BB3-2015.

- Total PAHs were 235.7 µg/kg, which is above the SF-DODS reference site database upper value, but below the ERL (4,022 µg/kg).

4.4 BB4-2015 COMPOSITE SAMPLE RESULTS

BB4-2015 site sediment was 45.4% total solids with 97.2% fines (silts and clays). The TOC level was 2.75% and above the SF-DODS (EPA 2015) upper range of 1.45%. Sulfide concentration was 965 mg/kg.

- Arsenic (8.14 mg/kg) and cadmium (0.817 mg/kg) concentrations were both above the SF-DODS (USEPA 2015) reference site database screening levels, but both below the arsenic and cadmium ERLs (8.2 mg/kg and 1.2 mg/kg, respectively). Mercury (0.179 mg/kg) concentration was slightly above the ERL (0.15 mg/kg) but below the ERM (0.71 mg/kg). Nickel concentration was 72.5 mg/kg, which is above the ERL but below the upper SF-DODS value (238 mg/kg).

- Total butylins were detected at 1.5 µg/kg and were also above SF-DODS levels (ND – 1.3 µg/Kg). There are no ERL or ERM values for total butyltins.

- Dioxins (as Total TCDD TEQ) were 4.35 ng/kg. There are no SF-DODS, ERL, or ERM values for dioxin.

- Total DDT was 1.69 µg/kg, which is below the SF-DODS reference site database screening levels, but slightly above the ERL (1.58 µg/kg).

- PCBs were not detected in sample BB4-2015.

- Total PAHs were 402.9 µg/kg, which is above the SF-DODS reference site database upper screening level, but below the ERL (4,022 µg/kg).

4.5 SPC COMPOSITE ANALYTICAL CHEMISTRY RESULTS

SPC-2015 site sediment was 54.8% total solids with 52.0% fines (silts and clays). The TOC level was 1.69% and above the SF-DODS (EPA 2015) upper range of 1.45%. Sulfide concentration was 328 mg/Kg.

- Arsenic (6.21 mg/kg) and cadmium (0.79 mg/kg) concentrations were both above the SF-DODS reference site database upper screening levels, but both below the arsenic and cadmium ERLs (8.2 mg/kg and 1.2 mg/kg, respectively). Nickel concentration was 61.4 mg/Kg above the ERM (51.6 mg/Kg).

- Total butylins were 7.7 µg/kg, above SF-DODS levels. There are no ERL or ERM values for total butyltins.

- Dioxins (as Total TCDD TEQ) were 3.48 ng/kg. There are no SF-DODS, ERL, or ERM values for dioxin.

- Total DDT was 1.18 µg/kg, which is below the SF-DODS reference site database upper screening level and below the ERL.

- PCBs were not detected in sample SPC-2015.

- Total PAHs were reported at 260 µg/kg, which is above the SF-DODS reference site database upper screening level but below the ERL.

Table 4-1 Bodega Bay Harbor Sediment Sample Results – Physical Testing

Sample ID	**BB1-2015-1**	**BB1-2015-2**	**BB1-2015-3**	**BB1-2015-4**	**BB2-2015-1**	**BB2-2015-2**	**BB2-2015-3**	**BB2-2015-4**	**BB3-2015-1**	**BB3-2015-2**	**BB3-2015[1]**	**BB4-2015[1]**	**SPC-2015[1]**	**SF-DODS Ref. Database[2]**	**Units**
Total Solids (SM 2540 G)	83.7	80.2	68.1	80.3	72.5	79.1	81.5	81.9	83.2	73.8	53.1	45.4	54.8	--	%, wet wt
Total Sulfide (9030M)	<0.24	2.69	202	4.29	6.29	0.51J	0.34J	<0.25	3.57	2.16	874	965	328	--	mg/Kg dw
Total Organic Carbon (EPA 9060)	0.029J	0.11	2.13	0.091J	0.13	0.11	0.069J	0.077J	0.14	0.23	2.00	2.75	1.69	0.63 - 1.45	%, dry wt
Grain Size (ASTM D422)															
Gravel M (4.75 mm)	0	0.04	0	0	0	0	0	0	0.05	0	0	0	0		%, dry wt
Gravel F (2.00 mm)	2.43	0.11	0.06	0.58	0.01	0	0.83	0.12	0.04	0	0.48	0	0		%, dry wt
Sand VC (0.85 mm)	30.75	1.82	0.52	12.97	0.08	0.04	13.71	5.93	2.37	0.10	0.76	0.15	0.23		%, dry wt
Sand C (0.425 mm)	62.06	5.76	2.86	35.65	1.33	1.06	48.14	51.65	14.65	1.01	2.96	0.59	1.00	16 - 60	%, dry wt
Sand M (0.25 mm)	6.32	15.45	6.20	24.80	17.26	11.06	26.60	33.39	37.32	2.72	11.37	0.53	3.45		%, dry wt
Sand F (0.106 mm)	1.21	73.20	83.21	26.37	83.37	87.70	11.71	9.92	40.69	93.33	25.50	5.71	38.52		%, dry wt
Sand VF (0.075 mm)	0.05	0.42	2.96	0.09	0.12	0.15	0.04	0.02	0.14	2.29	4.88	1.37	2.19		%, dry wt
Silt	0.00	1.29	5.47	0.36	0.42	0.28	0.26	0.15	0.49	2.99	33.99	57.13	29.32	25 - 62	%, dry wt
Clay	0.31	1.44	3.24	1.18	1.71	1.14	0.91	0.78	1.28	2.32	21.07	40.07	22.70	--	%, dry wt

Notes:

[1] – Indicates a Composite Sample

[2] – SF– DODS Reference Database (USEPA 2015).

Highlighted values exceed SF-DODS Reference Database values

Values preceded by a less than symbol (<) were not detected above the method reporting limit

Table 4-2. Bodega Bay Harbor Composite Sediment Sample Results

Sample ID	BB3-2015[1]	BB4-2015[1]	SPC-2015[1]	SF-DODS Ref. Database[2]	Ecological Screening Levels[3]		Units
					Salt ERL[4]/*TEL*[5]	Salt ERM[4]/*PEL*[5]	
Total Solids (SM 2540 G)	53.2	45.4	54.8	--	--	--	%, wet wt
Total Sulfide (9030M)	874	965	328	--	--	--	mg/Kg dw
Total Organic Carbon (EPA 9060)	2.00	2.75	1.69	0.63 - 1.45	--	--	%, dry wt
Grain Size (ASTM D422)							
Gravel M (4.75 mm)	0	0	0	16 - 60	--	--	%, dry wt
Gravel F (2.00 mm)	0.48	0	0		--	--	%, dry wt
Sand VC (0.85 mm)	0.76	0.15	0.23		--	--	%, dry wt
Sand C (0.425 mm)	2.96	0.59	1.00		--	--	%, dry wt
Sand M (0.25 mm)	11.37	0.53	3.45		--	--	%, dry wt
Sand F (0.106 mm)	25.50	5.71	38.52		--	--	%, dry wt
Sand VF (0.075 mm)	4.88	1.37	2.19		--	--	%, dry wt
Silt	33.99	57.13	29.32	25 - 62	--	--	%, dry wt
Clay	21.07	40.07	22.70	--	--	--	%, dry wt
Metals (EPA 6020/7471B/7742)							
Arsenic	5.64	8.14	6.21	2.2-5.3	8.2	70	mg/Kg dw
Cadmium	0.61	0.817	0.79	0.3-0.6	1.2	9.6	mg/Kg dw
Chromium	53.1	67.2	56.2	69.2-283	81	370	mg/Kg dw
Copper	18.2	27.3	24.2	18.3-86.3	34	270	mg/kg dw
Lead	8.12	11.9	7.38	5.1-26	46.7	218	mg/kg dw
Mercury	0.118	0.179	0.135	0.1-0.2	0.15	0.71	mg/kg dw
Nickel	54.7	72.5	61.4	50.9-238	20.9	51.6	mg/kg dw
Selenium	0.33	0.5	0.4	0.6-2.6	--	--	mg/kg dw
Silver	0.054	0.086	0.06	0.2-1.0	1	3.7	mg/kg dw
Zinc	57.4	81	66.2	60.8-288	150	410	mg/kg dw
Butylin (Krone)							
Tetrabutyltin	<0.82	<0.95	<0.79	--	--	--	µg/Kg
Tributyltin as Sn	1.1J	<0.93	1.8	--	--	--	µg/Kg
Dibutyltin as Sn	0.47J	1.5J	4	--	--	--	µg/Kg
Monobutyltin as Sn	<0.49	<0.56	1.9	--	--	--	µg/Kg
Total Butylins	**1.57**	**1.5**	**7.7**	**ND - 1.3**	**--**	**--**	**µg/Kg**

Table 4-2. Bodega Bay Harbor Composite Sediment Sample Results (continued)

Sample ID	BB3-2015[1]	BB4-2015[1]	SPC-2015[1]	SF-DODS Ref. Database[2]	Ecological Screening Levels[3]		Units
					Salt ERL[4]/*TEL*[5]	Salt ERM[4]/*PEL*[5]	
Dioxins and Furans (8290)							
TCDD, 2,3,7,8-	<0.194	<0.202	<0.181	--	--	--	ng/kg
PeCDD, 1,2,3,7,8-	0.417J	0.636J	0.529J	--	--	--	ng/kg
HxCDD, 1,2,3,6,7,8-	0.913J	2.08J	2.13J	--	--	--	ng/kg
HxCDD, 1,2,3,4,7,8-	0.469J	0.609J	0.683J	--	--	--	ng/kg
HxCDD, 1,2,3,7,8,9-	0.623J	1.36J	1.48J	--	--	--	ng/kg
HpCDD, 1,2,3,4,6,7,8-	13.7	33.3	33.6	--	--	--	ng/kg
OCDD, 1,2,3,4,6,7,8,9-	128	264	263	--	--	--	ng/kg
TCDF, 2,3,7,8-	0.634J	0.78J	0.537J	--	--	--	ng/kg
PeCDF, 1,2,3,7,8-	1.06J	2.09J	1.56J	--	--	--	ng/kg
PeCDF, 2,3,4,7,8-	0.658J	1.47J	1.04J	--	--	--	ng/kg
HxCDF, 1,2,3,6,7,8-	1.33J	4.6J	3.51J	--	--	--	ng/kg
HxCDF, 1,2,3,7,8,9-	0.869J	2J	1.47J	--	--	--	ng/kg
HxCDF, 1,2,3,4,7,8-	2.03J	6.32	4.73	--	--	--	ng/kg
HxCDF, 2,3,4,6,7,8-	1.02J	2.7J	1.85J	--	--	--	ng/kg
HpCDF, 1,2,3,4,6,7,8-	14.3	50.1	35.1	--	--	--	ng/kg
HpCDF, 1,2,3,4,7,8,9-	4.28J	14	10.3	--	--	--	ng/kg
OCDF, 1,2,3,4,6,7,8,9-	107	389	275	--	--	--	ng/kg
Total Tetra-Dioxins	<0.194	<0.202	<0.181	--	--	--	ng/kg
Total Penta-Dioxins	0.642J	3.05J	1.7J	--	--	--	ng/kg
Total Hexa-Dioxins	6.05	16.5	15.8	--	--	--	ng/kg
Total Hepta-Dioxins	36.6	86	78.2	--	--	--	ng/kg
Total Tetra-Furans	0.97	6.39	2.34	--	--	--	ng/kg
Total Penta-Furans	4.27J	16.8	11	--	--	--	ng/kg
Total Hexa-Furans	12	36.9	27.9	--	--	--	ng/kg
Total Hepta-Furans	30.4	97.6	66.2	--	--	--	ng/kg
Total TEQ	**1.83**	**4.35**	**3.48**	**--**	**--**	**--**	**ng/kg**

Table 4-2. Bodega Bay Harbor Composite Sediment Sample Results (continued)

Sample ID	BB3-2015[1]	BB4-2015[1]	SPC-2015[1]	SF-DODS Ref. Database[2]	Ecological Screening Levels[3]		Units
					Salt ERL[4]/*TEL*[5]	Salt ERM[4]/*PEL*[5]	
Organochlorine Pesticides (8081)							
HCH, alpha	<0.064	<0.071	<0.07	ND	--	--	µg/Kg
HCH, beta	<0.18	<0.2	<0.18	ND	--	--	µg/Kg
HCH, gamma	0.33J	<0.12	<0.051	ND	--	--	µg/Kg
HCH, delta	<0.07	<0.077	<0.07	ND	--	--	µg/Kg
Aldrin	<0.056	<0.062	<0.056	ND	--	--	µg/Kg
Chlordane	<3.1	<3.5	<3.1	ND	*0.32*	*0.99*	µg/Kg
Chlordane, cis-	<0.063	<0.07	<0.063	ND	--	--	µg/Kg
Chlordane, trans-	<0.087	<0.08	<0.094	ND	--	--	µg/Kg
Total Chlordane	**0**	**0**	**0**	**ND**	**0.5**	**6**	**µg/Kg**
DDD(o,p')	<0.11	<0.13	<0.11	ND - 2.1	--	--	µg/Kg
DDD(p,p')	<0.1	<0.11	<0.1	ND - 2.1	2	20	µg/Kg
DDE(o,p')	<0.11	<0.13	<0.11	ND - 2.1	--	--	µg/Kg
DDE(p,p')	0.19J	0.5J	0.41J	ND - 2.1	2.2	27	µg/Kg
DDT(o,p')	<0.14	0.32J	0.33J	ND - 2.1	--	--	µg/Kg
DDT(p,p')	<0.078	0.87J	0.44J	ND - 2.1	1	7	µg/Kg
Total DDT	**0.19**	**1.69**	**1.18**	**ND - 2.1**	**1.58**	**46.1**	**µg/Kg**
Dieldrin	<0.083	<0.092	<0.083	ND	--	--	µg/Kg
Endosulfan I	<0.06	<0.066	0.11J	ND	--	--	µg/Kg
Endosulfan II	<0.091	<0.1	<0.14	ND	--	--	µg/Kg
Endosulfan sulfate	<0.051	<0.057	<0.051	ND	0.02	8	µg/Kg
Endrin	<0.057	<0.063	<0.057	ND	--	--	µg/Kg
Endrin Aldehyde	<0.061	<0.067	<0.061	--	--	--	µg/Kg
Endrin Ketone	<0.076	<0.084	<0.076	--	--	--	µg/Kg
Heptachlor	<0.055	<0.061	<0.055	ND	--	--	µg/Kg
Heptachlor epoxide	<0.23	<0.26	<0.23	ND	--	--	µg/Kg
Methoxychlor	<0.15	<0.17	<0.15	--	--	--	µg/Kg
Nonachlor, cis-	<0.49	<0.54	<0.49	--	--	--	µg/Kg
Nonachlor, trans-	<0.53	<0.59	<0.53	--	--	--	µg/Kg
Toxaphene	<14	<16	<14	ND	--	--	µg/Kg

Table 4-2. Bodega Bay Harbor Composite Sediment Sample Results (continued)

Sample ID	BB3-2015[1]	BB4-2015[1]	SPC-2015[1]	SF-DODS Ref. Database[2]	Ecological Screening Levels[3]		Units
					Salt ERL[4]/*TEL*[5]	Salt ERM[4]/*PEL*[5]	
PCBs (8082)							
PCB 008	<0.21	<0.21	<0.21	--			µg/Kg
PCB 018	<0.096	<0.096	<0.096	--			µg/Kg
PCB 028	<0.064	<0.064	<0.064	--			µg/Kg
PCB 033	<0.11	<0.11	<0.11	--			µg/Kg
PCB 044	<0.065	<0.065	<0.065	--			µg/Kg
PCB 052	<0.059	<0.059	<0.059	--			µg/Kg
PCB 056	<0.046	<0.046	<0.046	--			µg/Kg
PCB 066	<0.035	<0.035	<0.035	--			µg/Kg
PCB 070	<0.051	<0.051	<0.051	--			µg/Kg
PCB 074	<0.044	<0.044	<0.044	--			µg/Kg
PCB 087	<0.038	<0.038	<0.038	--			µg/Kg
PCB 097	<0.053	<0.053	<0.053	--			µg/Kg
PCB 099	<0.045	<0.045	<0.045	--			µg/Kg
PCB 101	<0.049	<0.049	<0.049	--			µg/Kg
PCB 110	<0.035	<0.035	<0.035	--			µg/Kg
PCB 132	<0.075	<0.075	<0.075	--			µg/Kg
PCB 138	<0.064	<0.064	<0.064	--			µg/Kg
PCB 141	<0.035	<0.035	<0.035	--			µg/Kg
PCB 151	<0.043	<0.043	<0.043	--			µg/Kg
PCB 156	<0.042	<0.042	<0.042	--			µg/Kg
PCB 177	<0.052	<0.052	<0.052	--			µg/Kg
PCB 180	<0.095	<0.095	<0.095	--			µg/Kg
PCB 183	<0.081	<0.081	<0.081	--			µg/Kg
PCB 187	<0.047	<0.047	<0.047	--			µg/Kg
PCB 194	<0.043	<0.043	<0.043	--			µg/Kg
PCB 195	<0.031	<0.031	<0.031	--			µg/Kg
PCB 201	<0.041	<0.041	<0.041	--			µg/Kg
PCB 203	<0.039	<0.039	<0.039	--			µg/Kg
PCB 031	<0.056	<0.056	<0.056	--			µg/Kg
PCB 049	<0.058	<0.058	<0.058	--			µg/Kg
PCB 060	<0.039	<0.039	<0.039	--			µg/Kg
PCB 095	<0.049	<0.049	<0.049	--			µg/Kg
PCB 105	<0.033	<0.033	<0.033	--			µg/Kg
PCB 118	<0.031	<0.031	<0.031	--			µg/Kg
PCB 128	<0.031	<0.031	<0.031	--			µg/Kg
PCB 149	<0.067	<0.067	<0.067	--			µg/Kg
PCB 153	<0.038	<0.038	<0.038	--			µg/Kg
PCB 170	<0.026	<0.026	<0.026	--			µg/Kg
PCB 174	<0.03	<0.03	<0.03	--			µg/Kg
Total PCB's	**0**	**0**	**0**	**ND**	**22.7**	**180**	**µg/Kg**

Table 4-2. Bodega Bay Harbor Composite Sediment Sample Results (continued)

Sample ID	BB3-2015[1]	BB4-2015[1]	SPC-2015[1]	SF-DODS Ref. Database[2]	Ecological Screening Levels[3]		Units
					Salt ERL[4]/*TEL*[5]	Salt ERM[4]/*PEL*[5]	
PAHs (8270SIM)							
Naphthalene	7	9.6	10	--	160	2100	µg/Kg
Methylnaphthalene, 2-	12	15	17	--	70	670	µg/Kg
Methylnaphthalene, 1-	8.7	11	12	--	--	--	µg/Kg
Biphenyl	4.6J	5.7	6	--	--	--	µg/Kg
Dimethylnaphthalene, 2,6-	13	12	13	--	--	--	µg/Kg
Acenaphthylene	1.1J	1.1J	0.96J	--	44	640	µg/Kg
Acenaphthene	1.1J	1.1J	0.86J	--	16	500	µg/Kg
Trimethylnaphthalene, 2,3,5-	4.0J	5.8	5.4	--	--	--	µg/Kg
Fluorene	3.9J	6.3	5.5	--	19	540	µg/Kg
Dibenzothiophene	1.5J	2.1J	1.8J	--	--	--	µg/Kg
Phenanthrene	21	31	27	--	240	1500	µg/Kg
Anthracene	2.7J	6.1	2.7J	--	85.3	1100	µg/Kg
Methylphenanthrene, 1-	6.3	15	8.7	--	--	--	µg/Kg
Fluoranthene	22	45	24	--	600	5100	µg/Kg
Pyrene	23	47	27	--	665	2600	µg/Kg
Benz(a)anthracene	7.3	14	7.4	--	261	1600	µg/Kg
Chrysene	14	33	22	--	384	2800	µg/Kg
Benzo(b)fluoranthene	16	33	15	--	--	--	µg/Kg
Benzo(k)fluoranthene	4.6J	12	5.2	--	--	--	µg/Kg
Benzo(e)pyrene	9.3	17	9.5	--	--	--	µg/Kg
Benzo(a)pyrene	13	15	7.8	--	430	1600	µg/Kg
Perylene	19	29	11	--	--	--	µg/Kg
Indeno(1,2,3-c,d)pyrene	9	16	8.5	--	--	--	µg/Kg
Dibenz(a,h)anthracene	1.6J	3.1J	1.9J	--	63.4	260	µg/Kg
Benzo(g,h,i)perylene	10	17	9.8	--	--	--	µg/Kg
Total PAHs	**235.7**	**402.9**	**260.0**	**ND - 192**	**4022**	**44792**	**µg/Kg**

Notes: Exceeds SF-DODS Reference Database Exceeds Ecological Screening Levels

Values preceded by a less than symbol (<) were not detected above the method detection limit (MDL)
J - Values detected below the method reporting limit (MRL) and above the MDL are reported as estimated values
[1] – Indicates a Composite Sample
[2] – SF– DODS Reference Database (USEPA 2015).
[3] – The Ecological Screening Levels are used as secondary criteria, if data exceed the SF-DODS Reference Database. TELs and PELs are used when ERLs and ERMs are not available.

[4] – Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality objectives from Long *et al.* (1995).
[5] – Threshold Effects Level (TEL) and Probable Effects Level (PEL) sediment quality objectives from MacDonald (1994).

5 RESULTS OF BIOLOGICAL TESTING

The following biological tests were performed for each composite sample.

1. 10-day sediment amphipod survival test with *Ampelisca abdita*;
2. 10-day sediment juvenile polychaete survival test with *Neanthes arenaceodentata*;
3. 48-hour standard elutriate bivalve embryo survival and development test with *Mytilus galloprovincialis*;
4. 96-hour standard elutriate mysid survival test with *Americamysis bahia*;
5. 96-hour standard elutriate larval fish survival test with *Menidia beryllina*;
6. 28-day bioaccumulation test with the clam *Macoma nasuta*; and
7. 28-day bioaccumulation test with the polychaete *Nereis virens*.

All biological testing was performed by Pacific Eco Risk in accordance with the testing procedures and testing standards outlined in the SAP. Test data and summaries of the statistical analyses for the bioassay results, as well as summaries of the test conditions and acceptability of the test criteria, are provided in Appendix C. The results of the respective biological tests are presented in the following sections.

5.1 BENTHIC TOXICITY TESTING

Solid-phase bioassays were conducted with the amphipod *A. abdita* and the polychaete *N. arenaceodentata*. A summary of the measured concentrations of total ammonia and total sulfides in the sediment pore waters and summary tables of the total ammonia concentrations measured in the overlying test waters are presented in Appendix C.

Positive and negative Control treatments were tested concurrently with the bioassays. The positive Control for both species consisted of a 96-hr waterborne reference toxicant test. The results of these tests were compared to PER's in-house reference toxicant test response databases to determine whether these test organisms were responding to toxic stress in a typical fashion. The negative Control for *A. abdita* consisted of the "home" sediment from which the organisms were collected. The negative Control for *N. arenaceodentata* consisted of a homogenized mixture of previously collected clean reference site sediments that has been maintained at the PER Lab.

Inland Testing Manual (ITM [1998])/Ocean Testing Manual (OTM [1991]) guidance requires that site sediment results be compared with disposal site and/or reference site sediment results or a reference site database (if available) to determine the potential impact of whole sediment on benthic organisms at and beyond the boundaries of the disposal site (USEPA/USACE 1998). As detailed in the ITM/OTM, comparative guidelines for acceptance were followed as listed below:

1. If survival is greater in the proposed dredged sediments than in reference site sediment(s) or the reference site sediment database, the proposed dredged sediments are ***not*** acutely toxic to benthic organisms.

2. If a reduction in the survival response between the site sediment and in the reference sediment (or the reference site database survival') is ≤20% for amphipods or ≤10% for polychaetes, the test sediments are ***not*** acutely toxic to benthic organisms.

3. If a reduction in the survival response between the site sediment and the reference sediment (or the 'reference site database survival') is >20% for amphipods or >10% for polychaetes, then the respective survival responses must be statistically compared. If a statistically significant reduction in survival is observed for the site sediment, then the site sediment is considered to be acutely toxic to benthic organisms. Statistical analyses are not performed when reference site database values are used.

5.1.1 Sediment Pore water Characterization

Upon receipt, each sediment sample was homogenized in a large stainless steel bowl. Aliquots of the homogenized site composite samples were centrifuged at 2,500 g for 15 minutes; the porewaters were carefully collected and analyzed for routine water quality characteristics (Table 5-1).

Table 5-1. Sediment Porewater Initial Water Quality Characteristics

Sample ID	pH	Salinity (ppt)	Total Ammonia (mg/L N)	Total Sulfide (mg/L)
BB3-2015	7.76	33.5	29.1	0.288
BB4-2015	7.85	33.5	55.4	0.246
SPC-2015	7.78	33.4	11.8	0.170

5.1.2 Purging of Sediment Porewater Ammonia for the Amphipod and Polychaete Tests

The porewater ammonia concentrations in the BB3-2015 and BB4-2015 samples (Table 5-1) exceeded the USACE recommended threshold of 15 mg/L. Accordingly, the sediments were purged of ammonia by daily replacement of the overlying water with fresh 28 ppt seawater, coupled with aeration, until the porewater total ammonia levels were below 15 mg/L, after which the tests were initiated.

5.1.3 Effects of the Bodega Bay Harbor Sediments on *Ampelisca abdita*

The results of these tests are summarized in Table 5-2. There was 97% survival in the Lab Control sediment, indicating an acceptable survival response by the test organisms. There was 90% survival in the sediment sample SPC-2015. The survival rate was 87% for BB3-2015 and 84% for BB4-2015, indicating a significant reduction in survival rates in comparison to the Lab Control samples. There were no significant reductions in amphipod survival for the SPC-2015 sample.

The survival responses in the three samples were within 20% of the SF-DODS Reference Site Database survival response (90.5%), therefore, these results indicate that these sediments were ***not*** toxic to amphipods.

Table 5-2. *Ampelisca abdita* Survival in the Bodega Bay Harbor Sediments

Sediment Site	% Survival in Test Replicates					Mean % Survival
	Rep A	Rep B	Rep C	Rep D	Rep E	
Lab Control	100	95	100	90	100	97
BB3-2015	100	70	90	90	85	**87***
BB4-2015	85	75	95	90	75	**84***
SPC-2015	75	85	90	100	100	90

* The response at this treatment was significantly less than the Lab Control response at p<0.05

5.1.3.1 Potassium Chloride Reference Toxicant Toxicity to *Ampelisca abdita*

The results of this reference toxicity test are presented in Table 5-3. The reference toxicant test LC50 was consistent with the "typical response" range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

Table 5-3. Reference Toxicant Testing: Effects of KCl on *Ampelisca abdita*

KCl Treament (g/L)	Mean % Survival
Lab Control	100
0.25	95
0.5	100
1	90
2	0*
4	0*
LC_{50} =	1.33 g/L KCl
Typical Response Range (mean ±2 SD) =	0.038 - 2.04 g/L KCl[A]

* The response at this treatment was significantly less than the Lab Control response at p<0.05

[A] - The reference toxicant test LC50 for this test was consistent with the "typical response" range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

5.1.3.2 Ammonia Reference Toxicant Toxicity to *Ampelisca abdita*

The results of this test are presented in Table 5-4. The test is used to assess the sensitivity of the test organisms to ammonia. The test results indicate a no-observed-effect concentration (NOEC) for ammonia of 30 mg/L. Per DMMO guidance for testing dredged materials, solid phase toxicity tests are not initiated until porewater ammonia concentrations are less than 15 mg/l, which is below the NOEC. These test results indicate that ammonia would not contribute significantly to solid phase toxicity.

Table 5-4. Reference Toxicant Testing: Effects of NH_3 on *Ampelisca abdita*

NH_3 Treatment (mg/L)	Mean % Survival
Lab Control	100
7.5	95
15	100
30	90
60	70*
120	0*
LC_{50} =	65.2 mg/L NH_3

* The response at this treatment was significantly less than the Lab Control response at $p<0.05$

5.1.4 Effects of the Bodega Bay Harbor Sediments on *Neanthes arenaceodentata*

The results of these tests are summarized in Table 5-5. There was 100% survival in the Lab Control treatment, indicating acceptable survival responses by the test organisms. There were no significant reductions in survival in any of the composite samples in comparison to the Lab Control. There was ≥96% mean survival in all three of the sediment samples, which represents <10% deviation from the SF-DODS Reference Site Database survival rate of 98%, indicating that the sediments are ***not*** toxic to polychaetes.

Table 5-5. Neanthes arenaceodentata Survival in the Bodega Bay Harbor Federal Channel Sediments

Sediment Site	% Survival in Test Replicates					Mean % Survival
	Rep A	Rep B	Rep C	Rep D	Rep E	
Lab Control	100	100	100	100	100	100
BB3-2015	100	100	90	90	100	96
BB4-2015	100	100	90	100	100	98
SPC-2015	100	100	100	100	90	98

5.1.4.1 Potassium Chloride Reference Toxicant Toxicity to *Neanthes arenaceodentata*

The results of this test are summarized in Table 5-6. The reference toxicant test LC50 value was consistent with the "typical response" range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

Table 5-6. Reference Toxicant Testing: Effects on KCl on *Neanthes arenaceodentata*

KCl Treatment (g/L)	Mean % Survival
Lab Control	100
0.5	100
1	100
2	10*
3	0*
4	0*
LC_{50} =	1.49 g/L KCl
Typical Response Range (mean ±2 SD) =	1.07 - 2.74 g/L KCl[A]

* The response at this treatment was significantly less than the Lab Control response at p<0.05

[A] - The reference toxicant test LC50 for this test was consistent with the "typical response" range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

5.1.4.2 Ammonia Reference Toxicant Toxicity to *Neanthes arenaceodentata*

The results of this test are presented in Table 5-7. The test is used to assess the sensitivity of the test organisms to ammonia. The test results indicate a NOEC for ammonia of 120 mg/L. Per DMMO guidance for testing dredged materials, solid phase toxicity tests are not initiated until porewater ammonia concentrations are less than 15 mg/l, which is below the NOEC. These test results indicate that ammonia would not contribute significantly to solid phase toxicity.

Table 5-7. Reference Toxicant Testing: Effects on NH_3 on *Neanthes arenaceodentata*

NH_3 Treatment (mg/L)	Mean % Survival
Lab Control	100
15	100
30	100
60	100
120	100
240	0*
LC_{50} =	170 mg/L NH_3

* The response at this treatment was significantly less than the Lab Control response at p<0.05

5.2 WATER COLUMN (SEDIMENT ELUTRIATE) TOXICITY TESTING

The 48-hr bivalve embryo development test with *M. galloprovincialis* and 96-hr survival tests with *A. bahia* and *M. beryllina* were performed on sediment elutriates to assess the effects of dredged material disposal in the water column.

Positive and negative Lab Control treatments were tested concurrently with the site sediment elutriates. The positive Lab Control consisted of a ‘waterborne’ reference toxicant testing; the results of these tests were compared to PER’s reference toxicant test response databases to determine whether the test organisms were responding to toxic stress in a typical fashion. The negative Lab Control (and dilution media) consisted of 1µm-filtered natural seawater (obtained

from the U.C. Santa Cruz Granite Canyon Marine Laboratory, Carmel, CA), diluted to a test salinity of 30 ppt via addition of Type 1 lab water (reverse-osmosis de-ionized water). As an additional QA measure, the site water that was collected from the same area as the sediment cores (and mixed with the sediments to prepare the 100% elutriates) was also tested.

The test results for the sediment composite elutriates were compared with the test organism responses at the negative Lab Control treatment to determine the potential impact of the proposed dredged materials on pelagic organisms at and beyond the boundaries of the disposal site (USEPA/USACE 1991, 1998). The following criteria were used for suitability determinations:

1. If the survival response and/or normal embryo development response in the 100% sediment elutriate treatment is ≥ the Lab Control (clean seawater) treatment response(s), the dredged material is ***not*** predicted to be acutely toxic to water column organisms.

2. If the reduction in survival response and/or normal embryo development response in the 100% sediment elutriate treatment relative to the Lab Control treatment is ≤10%, there is no need for statistical analyses and no indication of water column toxicity attributable to the test sediments.

3. If the reduction in survival response and/or normal embryo development response in the 100% sediment elutriate treatment relative to the Lab Control treatment is >10%, then the data must be evaluated statistically to determine the significance of the difference. If there is >50% survival or normal embryo development in the 100% elutriate treatment, theLC50/EC50 is assumed to be ≥100%. If there is <50% survival or normal embryo development in at least one of the elutriate treatments, then an LC50/EC50 will be calculated and compared with existing acceptability standards [i.e., the elutriate suitability concentration or Elutriate Suitability Concentration (ESC)].

In order for the material to be determined suitable for disposal at SF-8 and SF-DODS, it must be in compliance with the federal narrative water quality standard. Compliance with the narrative water quality standard is determined by evaluating whether the dredged material concentration, after mixing, would exceed 1% of the LC50 or EC50 value calculated from the sediment elutriate test (whichever is most conservative), outside of the mixing zone. ESC calculations were performed using the lowest EC50/LC50 obtained for each site. The results are presented below in Table 5-8; detailed calculations are presented in Appendix D. Detailed toxicity test results are presented in Sections 5.2.1 – 5.2.3.

Table 5-8. Effects of the Bodega Bay Harbor Federal Channel Sediment Elutriate Samples

Elutriate Treatment	Test Species	Survival LC50	Development EC50	Pass ESC/LPC?
BB3-2015	*Mytilus galloprovincialis*	98% elutriate	99.1% elutriate	Y
	Americamysis bahia	>100% elutriate[a]	--	Y
	Menidia beryllina	>100% elutriate[a]	--	Y
BB4-2015	*Mytilus galloprovincialis*	63.1% elutriate	69% elutriate	Y
	Americamysis bahia	>100% elutriate[a]	--	Y
	Menidia beryllina	>100% elutriate[a]	--	Y
SPC-2015	*Mytilus galloprovincialis*	>100% elutriate[a]	>100% elutriate	Y
	Americamysis bahia	>100% elutriate[a]	--	Y
	Menidia beryllina	>100% elutriate[a]	--	Y

[a] - Due to the absence of significant impairment, the LC50 could not be calculated but can be determined by inspection to be >100% elutriate.

5.2.1 Toxicity of the Bodega Bay Harbor Federal Channel Sediment SET Elutriates to *Mytilus galloprovincialis*

The results of these tests are summarized below in Tables 5-9 through 5-11. For the three samples, there was ≥98.5% survival and ≥98.6% normal development in the Lab Control treatments, indicating acceptable responses by the test organisms. The LC50 was ≥63.1% embryo survival and ≥69.0% normal development elutriate for the three sediment elutriates.

Table 5-9. Effects of BB3-2015 Sediment Elutriate on *Mytilus galloprovincialis*

Elutriate Treatment	Mean % Survival	Mean % Normal Development
Lab Control	98.6	99.2
1%	97.9	99.3
10%	97.2	99.4
25%	100	98.8
50%	99.4	98.8
100%	47.9*	48.8*
Site Water	97.7	99.4
Salinity Control	100	99.2
Survival LC50 or Development EC50 =	98% elutriate	99.1% elutriate

* The response at this test treatment was significantly less than the Control treatment response at $p<0.05$

Table 5-10. Effects of BB4-2015 Sediment Elutriate on *Mytilus galloprovincialis*

Elutriate Treatment	Mean % Survival	Mean % Normal Development
Lab Control	99.6	98.9
1%	98.4	98.5
10%	99.8	99.1
25%	100	98.6
50%	83.2*	79.9*
100%	0*	0*
Site Water	97.7	99.4
Salinity Control	100	99.2
Survival LC50 or Development EC50 =	63.1% elutriate	69.0% elutriate

* The response at this test treatment was significantly less than the Control treatment response at p<0.05

Table 5-11. Effects of SPC-2015 Sediment Elutriate on *Mytilus galloprovincialis*

Elutriate Treatment	Mean % Survival	Mean % Normal Development
Lab Control	98.5	98.6
1%	99.4	98.5
10%	92.1	99.5
50%	97.1	99.1
100%	96*	99.5
Site Water	97.7	99.4
Salinity Control	100	99.2
Survival LC50 or Development EC50 =	>100% elutriate[a]	>100% elutriate

* The response at this test treatment was significantly less than the Control treatment response at p<0.05

[a] - Due to the absence of significant impairment, the LC50 could not be calculated but can be determined by inspection to be >100% elutriate

5.2.1.1 Reference Toxicant Toxicity to *Mytilus galloprovincialis* Embryos

The results of this test are presented in Table 5-12. The EC50 for this test was consistent with PER's reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

Table 5-12. Reference Toxicant Testing: Effects of KCl on *Mytilus galloprovincialis* Embryos

KCl Treatment (g/L)	Mean % Survival
Lab Control	98.9
0.5	99
1	98.9
2	95.3*
3	0*
4	0*
EC_{50} =	2.4 g/L KCl
Typical Response Range (mean ±2 SD) =	1.68 - 2.68 g/L KCl[A]

* The response at this treatment was significantly less than the Lab Control response at $p<0.05$

[A] - The reference toxicant test EC50 for this test was consistent with the "typical response" range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

5.2.2 Toxicity of the Bodega Bay Harbor Federal Channel Sediment Elutriates to *Americamysis bahia*

The results of these tests are summarized below in Tables 5-13 through 5-15. There was ≥90% survival in the Lab Control treatments, indicating acceptable survival response by the test organisms. The LC50 was >100% elutriate for each of the sediment elutriates.

Table 5-13. Effects of BB3-2015 Sediment Elutriate on *Americamysis bahia*

Test Treatment	Mean % Survival
Lab Control	90
1%	98
10%	94
25%	94
50%	94
100%	84
Site Water	96
Survival LC50 =	>100% elutriate[a]

[a] - Due to the absence of significant impairment, the LC50 could not be calculated but can be determined by inspection to be >100% elutriate

Table 5-14. Effects of BB4-2015 Sediment Elutriate on *Americamysis bahia*

Test Treatment	Mean % Survival
Lab Control	92
1%	90
10%	88
25%	88
50%	92
100%	92
Site Water	96
Survival LC50 =	>100% elutriate[a]

a - Due to the absence of significant impairment, the LC50 could not be calculated but can be determined by inspection to be >100% elutriate

Table 5-15. Effects of SPC-2015 Sediment Elutriate on *Americamysis bahia*

Test Treatment	Mean % Survival
Lab Control	94
1%	96
10%	96
50%	92
100%	90
Site Water	96
Survival LC50 =	>100% elutriate[a]

a - Due to the absence of significant impairment, the LC50 could not be calculated but can be determined by inspection to be >100% elutriate

5.2.2.1 Reference Toxicant Toxicity to *Americamysis bahia*

The results of this test are presented in Table 5-16. The LC50 for this test was within the typical response range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

Table 5-16. Reference Toxicant Toxicity to *Americamysis bahia*

KCl Treatment (g/L)	Mean % Survival
Lab Control	100
0.125	95
0.25	92.5
0.5	37.5*
1	0*
2	0*
LC_{50} =	0.45 g/L KCl
Typical Response Range (mean ±2 SD) =	0.37 - 0.79 g/L KCl[A]

* The response at this treatment was significantly less than the Lab Control response at p<0.05

[A] - The reference toxicant test LC50 for this test was consistent with the "typical response" range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

5.2.3 Toxicity of the Bodega Bay Harbor Federal Channel Sediment Elutriates to *Menidia beryllina*

The results of these tests are summarized below in Tables 5-17 through 5-19. There was ≥90% survival in the Lab Control treatments, indicating acceptable survival response by the test organisms. The LC50 was >100% elutriate for each of the sediment elutriates.

Table 5-17. Effects of BB3-2015 Sediment Elutriate on *Menidia beryllina*

Test Treatment	Mean % Survival
Lab Control	92
1%	100
10%	98
25%	96
50%	98
100%	96
Site Water	98
Survival LC50 =	>100% elutriate[a]

a - Due to the absence of significant impairment, the LC50 could not be calculated but can be determined by inspection to be >100% elutriate

Table 5-18. Effects of BB4-2015 Sediment Elutriate on *Menidia beryllina*

Test Treatment	Mean % Survival
Lab Control	98
1%	98
10%	94
25%	92
50%	94
100%	78*
Site Water	98
Survival LC50 =	>100% elutriate[a]

* The response at this treatment was significantly less than the Lab Control response at $p<0.05$

[a] - Due to the absence of significant impairment, the LC50 could not be calculated but can be determined by inspection to be >100% elutriate

Table 5-19. Effects of SPC-2015 Sediment Elutriate on *Menidia beryllina*

Test Treatment	Mean % Survival
Lab Control	90
1%	100
10%	98
50%	92
100%	94
Site Water	98
Survival LC50 =	>100% elutriate[a]

[a] - Due to the absence of significant impairment, the LC50 could not be calculated but can be determined by inspection to be >100% elutriate

5.2.3.1 Reference Toxicant Toxicity to *Menidia beryllina*

The results of this test are summarized in Table 5-20. The LC50 for this test was within the typical response range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

Table 5-20. Reference Toxicant Toxicity to *Menidia beryllina*

KCl Treatment (g/L)	Mean % Survival
Lab Control	90
0.125	95
0.25	95
0.5	95
1	50*
2	0*
LC_{50} =	1.02 g/L KCl
Typical Response Range (mean ±2 SD) =	1.00 - 1.53 g/L KCl[A]

* The response at this treatment was significantly less than the Lab Control response at p<0.05

[A] - The reference toxicant test LC50 for this test was consistent with the "typical response" range established by the reference toxicant test database for this species, indicating that these test organisms were responding to toxic stress in a typical fashion.

5.3 SEDIMENT BIOACCUMULATION TESTING

Sediment bioaccumulation testing was conducted using the bivalve *M. nasuta* and the polychaete *N. virens*. A summary table of the total ammonia concentrations measured in the test overlying waters during the performance of the testing is presented in Appendix C. Negative Lab Control treatments were tested concurrently with the bioassays and consisted of “clean” sediment collected from near the vicinity from which the *N. virens* was originally collected. The test organism survival results for the bioaccumulation test exposures are presented in Tables 5-21 and 5-22 for *M. nasuta* and *N. virens*, respectively. The results of chemical analyses of *M. nasuta* and *N. virens* tissues are presented in Section 6.

5.3.1 Sediment Bioaccumulation Test Data for *Macoma nasuta*

The percentage of bivales that survived in each of the test replicates is summarized below in Table 5-21.

Table 5-21. Sediment Bioaccumulation Tests with *Macoma nasuta*

Sediment Site	% Survival in Test Replicates					Mean % Survival
	Rep A	Rep B	Rep C	Rep D	Rep E	
Lab Control	100	100	95	100	95	98
BB3-2015	100	100	90	100	100	98
BB4-2015	100	95	100	90	95	96
SPC-2015	90	90	100	95	100	95

Note – All treatments were initiated with 20 clams per replicate.

5.3.2 Sediment Bioaccumulation Test Data for *Nereis virens*

The percentage of polychaetes that survived in each of the test replicates is summarized below in Table 5-22.

Table 5-22. Sediment Bioaccumulation Tests with *Nereis virens*

Sediment Site	% Survival in Test Replicates					Mean % Survival
	Rep A	Rep B	Rep C	Rep D	Rep E	
Lab Control	100	90	100	100	100	98
BB3-2015	100	100	100	100	90	98
BB4-2015	100	100	90	100	100	98
SPC-2015	100	100	100	100	100	100

Note - All treatments were initiated with 10 worms per replicate

6 CHEMICAL ANALYSES OF BIVALVE AND POLYCHAETE TISSUES

Tissues of *Macoma nasuta* and *Nereis virens* from the sediment bioaccumulation tests were analyzed for dioxins and furans, along with lipids. The results of the tissue analyses are presented in Tables 6-1 and 6-2. The full Data Reports for the tissue analyses that were prepared by ALS are provided in Appendices E and F.

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Table 6-1. Results of Chemical Analysis of *Macoma nasuta* tissue

Analyte	Units	SPC-2015-A-Macoma-Day 28	SPC-2015-B-Macoma-Day 28	SPC-2015-C-Macoma-Day 28	SPC-2015-D-Macoma-Day 28	SPC-2015-E-Macoma-Day 28	BB3-2015-A-Macoma-Day 28	BB3-2015-B-Macoma-Day 28	BB3-2015-C-Macoma-Day 28	BB3-2015-D-Macoma-Day 28	BB3-2015-E-Macoma-Day 28
Lipids, Total (NOAA Lipid)	%	1	0.90	1.40	1.10	0.80	1.00	1.00	0.90	0.90	1.10
Moisture	%	84.2	83.5	83.3	83.8	84.9	84.6	83.8	83.9	84	83.9
Total Solids	%	15.8	16.5	16.7	16.2	15.1	15.4	16.2	16.1	16.0	16.1
Dioxins and Furans (8290)											
TCDD, 2,3,7,8-	ng/Kg	<0.128	<0.146	<0.0917	<0.194	<0.152	<0.184	<0.178	<0.0972	<0.0383	<0.98
PeCDD, 1,2,3,7,8-	ng/Kg	<0.0858	<0.157	0.129 J	0.358 J	<0.106	<0.0919	<0.102	<0.0893	<0.0479	<0.672
HxCDD, 1,2,3,6,7,8-	ng/Kg	0.128 J	<0.0839	0.3 J	0.476 J	0.187 J	<0.0724	<0.0816	0.0716 J	0.0586 J	<0.383
HxCDD, 1,2,3,4,7,8-	ng/Kg	<0.0558	<0.084	0.14 J	0.424 J	<0.0741	<0.0693	<0.0833	<0.0556	<0.0274	<0.387
HxCDD, 1,2,3,7,8,9-	ng/Kg	<0.0501	<0.0758	0.259 J	0.416 J	<0.0676	<0.064	<0.0744	<0.0513	0.0418 J	<0.348
HpCDD, 1,2,3,4,6,7,8-	ng/Kg	1.5 J	1.34 J	1.7 J	1.83 J	1.15 J	0.465 J	0.507 J	0.599 J	0.643 J	1.22 J
OCDD, 1,2,3,4,6,7,8,9-	ng/Kg	10.20	8.59	11.70	9.85	7.68	2.82 J	3.26 J	3.9 J	5.40	6.88
TCDF, 2,3,7,8-	ng/Kg	<0.103	<0.128	<0.0833	<0.143	<0.159	<0.132	<0.152	<0.082	<0.0445	<1.03
PeCDF, 1,2,3,7,8-	ng/Kg	<0.088	<0.0887	0.119 J	0.383 J	<0.0854	<0.0972	<0.116	<0.369	<0.0379	<0.692
PeCDF, 2,3,4,7,8-	ng/Kg	<0.0848	<0.0875	0.152 J	0.401 J	<0.0811	<0.0887	<0.114	<0.123	<0.0377	<0.628
HxCDF, 1,2,3,6,7,8-	ng/Kg	<0.0596	<0.0923	0.133 J	0.337 J	<0.0497	<0.0583	<0.0731	<0.0417	<0.0234	<0.333
HxCDF, 1,2,3,7,8,9-	ng/Kg	<0.0696	<0.102	0.19 J	0.4 J	<0.0566	<0.0637	<0.0804	<0.0509	<0.028	<0.356
HxCDF, 1,2,3,4,7,8-	ng/Kg	<0.0629	<0.0962	0.176 J	0.418 J	<0.052	<0.0608	<0.0765	<0.0433	<0.0242	<0.361
HxCDF, 2,3,4,6,7,8-	ng/Kg	<0.0587	<0.0915	0.13 J	0.384 J	<0.0489	<0.056	<0.0692	<0.0425	<0.024	0.413 J
HpCDF, 1,2,3,4,6,7,8-	ng/Kg	0.242 J	0.234 J	0.432 J	0.76 J	0.204 J	0.166 J	0.152 J	0.2 J	0.168 J	0.809 J
HpCDF, 1,2,3,4,7,8,9-	ng/Kg	<0.0413	<0.0493	0.191 J	0.393 J	<0.0567	<0.0393	<0.0501	<0.0458	<0.0176	<0.233
OCDF, 1,2,3,4,6,7,8,9-	ng/Kg	0.462 J	0.412 J	0.968 J	1.63 J	0.441 J	0.358 J	0.38 J	0.52 J	0.502 J	2.48 J
Total Tetra-Dioxins	ng/Kg	<0.128	<0.146	<0.0917	<0.194	<0.152	<0.184	<0.178	<0.0972	<0.0383	<0.98
Total Penta-Dioxins	ng/Kg	<0.0858	<0.157	<0.0674	0.358 J	<0.106	<0.0919	<0.102	<0.0893	<0.0479	<0.672
Total Hexa-Dioxins	ng/Kg	0.656 J	<0.081	1.31 J	1.76 J	0.512 J	0.113 J	<0.0795	<0.0548	0.136 J	<0.372
Total Hepta-Dioxins	ng/Kg	3.47	3.20	3.95	3.79	2.74 J	1.11 J	1.23 J	1.49 J	1.85 J	1.36 J
Total Tetra-Furans	ng/Kg	<0.103	<0.128	<0.0833	<0.143	<0.159	<0.132	<0.152	0.60	0.273 J	2.16
Total Penta-Furans	ng/Kg	<0.0865	0.164 J	<0.0534	0.785 J	<0.0833	<0.0929	0.17 J	<0.168	0.0894 J	<0.659
Total Hexa-Furans	ng/Kg	0.141 J	0.32 J	0.681 J	1.37 J	0.269 J	<0.0596	<0.0745	0.0907 J	0.112 J	<0.342
Total Hepta-Furans	ng/Kg	0.361 J	0.234 J	0.623 J	1.15 J	0.276 J	0.166 J	<0.0489	0.2 J	0.484 J	<0.227
Total TEQ	ng/Kg	0.0334	0.0184	0.338	0.808	0.0347	0.00726	0.00768	0.0165	0.0199	0.0644

Notes:

J - Values detected below the method reporting limit (MRL) and above the method detection limit (MDL) are reported as estimated values
Values preceded by a less than symbol (<) were not detected above the MDL

Table 6-1. Results of Chemical Analysis of *Macoma nasuta* tissue (continued)

Analyte	Units	BB4-2015-A-Macoma-Day 28	BB4-2015-B-Macoma-Day 28	BB4-2015-C-Macoma-Day 28	BB4-2015-D-Macoma-Day 28	BB4-2015-E-Macoma-Day 28	Control-A-Macoma-Day 28	Control-B-Macoma-Day 28	Control-C-Macoma-Day 28	Control-D-Macoma-Day 28	Control-E-Macoma-Day 28
Lipids, Total (NOAA Lipid)	%	1.10	0.90	0.90	1.00	0.70	0.70	0.90	1.00	1.00	0.90
Moisture	%	82.8	84.4	85.1	84.2	84.4	84.5	84	83.3	83.7	84.4
Total Solids	%	17.2	15.6	14.9	15.8	15.6	15.5	16.0	16.7	16.3	15.6
Dioxins and Furans (8290)											
TCDD, 2,3,7,8-	ng/Kg	<0.0541	<0.0805	<0.136	<0.0869	<0.0552	<0.114	<0.157	<0.15	<0.153	<0.141
PeCDD, 1,2,3,7,8-	ng/Kg	0.183 J	<0.0716	<0.102	<0.0812	<0.0474	<0.0922	<0.0939	<0.114	<0.111	<0.115
HxCDD, 1,2,3,6,7,8-	ng/Kg	0.203 J	<0.0569	<0.112	<0.0502	<0.045	0.0928 J	0.117 J	0.178 J	0.115 J	<0.0821
HxCDD, 1,2,3,4,7,8-	ng/Kg	0.137 J	<0.0538	<0.1	<0.0452	<0.0401	<0.0767	<0.0867	<0.0778	<0.0658	<0.0809
HxCDD, 1,2,3,7,8,9-	ng/Kg	0.19 J	0.101 J	<0.0971	<0.0436	<0.039	<0.0727	0.105 J	<0.0694	0.0734 J	<0.0737
HpCDD, 1,2,3,4,6,7,8-	ng/Kg	1.06 J	0.694 J	0.531 J	0.695 J	0.707 J	0.548 J	0.646 J	5.18	0.791 J	0.475 J
OCDD, 1,2,3,4,6,7,8,9-	ng/Kg	4.08 J	5.55	3.27 J	4.04 J	4.46 J	4.25 J	4.25 J	32.9	5.15 J	3.1 J
TCDF, 2,3,7,8-	ng/Kg	0.262 J	<0.0785	<0.195	<0.116	<0.0831	<0.106	0.193 J	<0.13	0.254 J	<0.111
PeCDF, 1,2,3,7,8-	ng/Kg	0.154 J	<0.0615	<0.117	<0.0718	<0.0486	<0.0887	<0.0843	<0.0969	<0.0912	<0.0808
PeCDF, 2,3,4,7,8-	ng/Kg	0.159 J	<0.0602	<0.111	<0.0686	<0.0463	<0.0881	<0.0833	<0.0956	<0.0894	<0.0782
HxCDF, 1,2,3,6,7,8-	ng/Kg	0.182 J	0.089 J	<0.0684	<0.0551	<0.0385	<0.0358	<0.0561	<0.074	<0.0896	<0.0562
HxCDF, 1,2,3,7,8,9-	ng/Kg	0.265 J	0.109 J	<0.0734	<0.0647	<0.0418	<0.0395	<0.0723	<0.0865	<0.108	<0.0675
HxCDF, 1,2,3,4,7,8-	ng/Kg	0.19	0.0952 J	<0.0688	<0.0545	<0.0387	<0.0367	<0.0583	0.12 J	<0.0929	0.0936 J
HxCDF, 2,3,4,6,7,8-	ng/Kg	0.195 J	0.0506 J	<0.0697	<0.0534	<0.037	<0.0359	<0.057	<0.0744	<0.0912	<0.0558
HpCDF, 1,2,3,4,6,7,8-	ng/Kg	0.53 J	0.28 J	0.167 J	0.21 J	0.168 J	0.191 J	0.187 J	0.355 J	0.17 J	0.19 J
HpCDF, 1,2,3,4,7,8,9-	ng/Kg	0.347 J	0.104 J	0.134 J	0.0749 J	0.0385 J	<0.0495	<0.0949	<0.0665	<0.0748	<0.0443
OCDF, 1,2,3,4,6,7,8,9-	ng/Kg	0.735 J	0.591 J	0.438 J	0.497 J	0.478 J	0.492 J	0.768 J	0.605 J	0.461 J	0.352 J
Total Tetra-Dioxins	ng/Kg	<0.0541	<0.0805	<0.136	<0.0869	<0.0552	<0.114	<0.157	<0.15	0.231 J	<0.141
Total Penta-Dioxins	ng/Kg	0.353 J	<0.0716	<0.102	<0.0812	<0.0474	<0.0922	<0.0939	<0.114	<0.111	<0.115
Total Hexa-Dioxins	ng/Kg	0.687 J	0.336 J	<0.103	0.232 J	0.231 J	0.267 J	0.117 J	3.47	<0.0643	<0.0787
Total Hepta-Dioxins	ng/Kg	2.1 J	1.17 J	1.35 J	1.62 J	1.71 J	<0.0679	1.49 J	29.2	2.1 J	1.15 J
Total Tetra-Furans	ng/Kg	1.76	<0.0785	<0.195	<0.116	<0.0831	<0.106	<0.102	<0.13	0.254 J	<0.111
Total Penta-Furans	ng/Kg	0.692 J	0.117 J	<0.114	<0.0702	<0.0475	0.169 J	0.213 J	<0.0962	0.199 J	<0.0794
Total Hexa-Furans	ng/Kg	0.702 J	0.546 J	<0.07	<0.0567	<0.0389	<0.0369	<0.0604	0.699 J	<0.0949	<0.0593
Total Hepta-Furans	ng/Kg	0.803 J	0.583 J	0.399 J	<0.0454	<0.0294	<0.0501	0.21 J	1.03 J	0.276 J	0.19 J
Total TEQ	ng/Kg	0.418	0.0571	0.00943	0.0112	0.0106	0.0181	0.0513	0.0952	0.0555	0.0170

Notes:

J - Values detected below the method reporting limit (MRL) and above the method detection limit (MDL) are reported as estimated values

Values preceded by a less than symbol (<) were not detected above the MDL

Table 6-2. Results of Chemical Analysis of *Nereis virens* tissue

Analyte	Units	SPC-2015-1-A-Nereis-Day 28	SPC-2015-1-B-Nereis-Day 28	SPC-2015-1-C-Nereis-Day 28	SPC-2015-1-D-Nereis-Day 28	SPC-2015-1-E-Nereis-Day 28	BB3-2015-1-A-Nereis-Day 28	BB3-2015-1-B-Nereis-Day 28	BB3-2015-1-C-Nereis-Day 28	BB3-2015-1-D-Nereis-Day 28	BB3-2015-1-E-Nereis-Day 28
Lipids, Total (NOAA Lipid)	%	1.60	1.30	0.90	1.00	0.90	1.40	1.30	1.10	1.30	0.80
Moisture	%	83.7	84.1	85.4	85.2	84.7	85.2	84.5	84	84.8	84.7
Total Solids	%	16.3	16.0	15.9	14.6	14.8	15.3	14.8	15.5	16.0	15.2
Dioxins and Furans (8290)											
TCDD, 2,3,7,8-	ng/Kg	<0.455	<0.333	0.362 J	0.186 J	0.273 J	0.216 J	0.244 J	<0.0886	0.23 J	0.26 J
PeCDD, 1,2,3,7,8-	ng/Kg	<0.226	<0.469	0.118 J	0.122 J	0.0944 J	0.132 J	0.212 J	0.187 J	0.172 J	<0.0923
HxCDD, 1,2,3,6,7,8-	ng/Kg	<0.0541	<0.0743	0.163 J	0.134 J	0.179 J	0.16 J	0.216 J	0.215 J	0.133 J	0.122 J
HxCDD, 1,2,3,4,7,8-	ng/Kg	<0.0524	<0.0716	0.0975 J	<0.0588	<0.0622	0.0915 J	0.234 J	0.122 J	<0.0571	0.0742 J
HxCDD, 1,2,3,7,8,9-	ng/Kg	<0.0482	<0.0659	0.123 J	<0.0578	0.115 J	0.0876 J	0.234 J	0.151 J	<0.0545	0.101 J
HpCDD, 1,2,3,4,6,7,8-	ng/Kg	0.975 J	1.29 J	1.02 J	0.778 J	0.833 J	0.853 J	1.23 J	1.16 J	0.66 J	0.734 J
OCDD, 1,2,3,4,6,7,8,9-	ng/Kg	4.79 J	5.75 J	4.86 J	3.8 J	3.94 J	3.39 J	4.01 J	4.96 J	3.3 J	3.15 J
TCDF, 2,3,7,8-	ng/Kg	1.49	1.27	0.98	0.77	0.77	1.13	1.04	1.17	0.95	0.85
PeCDF, 1,2,3,7,8-	ng/Kg	<0.173	<0.361	0.104 J	0.087 J	0.0999 J	0.136 J	0.191 J	0.139 J	<0.0698	<0.062
PeCDF, 2,3,4,7,8-	ng/Kg	<0.174	<0.364	0.213 J	0.141 J	0.181 J	0.227 J	0.256 J	0.254 J	0.236 J	0.241 J
HxCDF, 1,2,3,6,7,8-	ng/Kg	<0.2	<0.204	<0.073	<0.0416	0.0896 J	0.0607 J	0.21 J	0.0972 J	0.107 J	0.106 J
HxCDF, 1,2,3,7,8,9-	ng/Kg	<0.223	<0.254	<0.0867	<0.0493	<0.0673	<0.051	0.26 J	0.136 J	0.0548 J	<0.0704
HxCDF, 1,2,3,4,7,8-	ng/Kg	<0.205	<0.213	0.146 J	0.134 J	0.103 J	0.121 J	0.252 J	0.183 J	0.156 J	0.165 J
HxCDF, 2,3,4,6,7,8-	ng/Kg	<0.194	<0.208	0.105 J	0.0798 J	<0.0562	0.0928 J	0.217 J	0.127 J	0.08 J	0.105 J
HpCDF, 1,2,3,4,6,7,8-	ng/Kg	0.598 J	0.558 J	0.325 J	0.302 J	0.306 J	0.359 J	0.549 J	0.417 J	0.322 J	0.333 J
HpCDF, 1,2,3,4,7,8,9-	ng/Kg	<0.163	<0.149	<0.0683	0.0746 J	<0.0464	0.0867 J	0.33 J	0.165 J	<0.0263	<0.0634
OCDF, 1,2,3,4,6,7,8,9-	ng/Kg	<0.621	<0.62	0.825 J	0.429 J	0.412 J	0.422 J	0.965 J	0.56 J	0.469 J	0.434 J
Total Tetra-Dioxins	ng/Kg	<0.455	<0.333	0.362 J	<0.0476	0.273 J	<0.0585	<0.0707	<0.0886	0.23 J	0.26 J
Total Penta-Dioxins	ng/Kg	<0.226	<0.469	<0.105	0.17 J	<0.0637	0.0775 J	0.212 J	0.187 J	<0.0743	<0.0923
Total Hexa-Dioxins	ng/Kg	<0.0515	<0.0704	0.539 J	0.746 J	0.115 J	0.434 J	1.04 J	0.658 J	<0.0577	0.586 J
Total Hepta-Dioxins	ng/Kg	<0.407	1.29 J	1.02 J	0.778 J	1.83 J	1.66 J	1.23 J	2.31 J	1.33 J	1.46 J
Total Tetra-Furans	ng/Kg	<0.407	1.27	0.98	1.03	0.99	1.78	1.04	1.47	1.41 J	0.65
Total Penta-Furans	ng/Kg	<0.174	<0.362	0.823 J	0.338 J	<0.0717	1.33 J	0.489 J	<0.0724	0.29 J	1.15 J
Total Hexa-Furans	ng/Kg	<0.205	<0.218	0.474 J	0.334 J	0.2 J	0.505 J	0.832 J	0.404 J	0.263 J	0.348 J
Total Hepta-Furans	ng/Kg	<0.152	<0.133	0.221 J	0.302 J	0.475 J	0.581 J	0.436 J	0.417 J	0.322 J	0.333 J
Total TEQ	ng/Kg	0.166	0.147	0.724	0.477	0.563	0.609	0.827	0.507	0.632	0.497

Notes:

J - Values detected below the method reporting limit (MRL) and above the method detection limit (MDL) are reported as estimated values

Values preceded by a less than symbol (<) were not detected above the MDL

Table 6-2. Results of Chemical Analysis of *Nereis virens* tissue (continued)

Analyte	Units	BB4-2015-1-A-Nereis-Day 28	BB4-2015-1-B-Nereis-Day 28	BB4-2015-1-C-Nereis-Day 28	BB4-2015-1-D-Nereis-Day 28	BB4-2015-1-E-Nereis-Day 28	Control-A-Nereis-Day 28	Control-B-Nereis-Day 28	Control-C-Nereis-Day 28	Control-D-Nereis-Day 28	Control-E-Nereis-Day 28
Lipids, Total (NOAA Lipid)	%	1.30	1.10	1.00	0.90	0.70	0.90	0.90	1.10	1.00	1.20
Moisture	%	83.7	83.8	84.2	84.8	85.3	85	85.9	85.1	85	84.3
Total Solids	%	15.2	16.3	16.2	15.2	14.7	15.0	14.1	14.9	15.0	15.7
Dioxins and Furans (8290)											
TCDD, 2,3,7,8-	ng/Kg	0.233 J	0.158 J	0.2 J	<0.0906	<0.147	<0.574	0.218 J	<0.378	<0.408	<0.638
PeCDD, 1,2,3,7,8-	ng/Kg	0.152 J	0.121 J	0.116 J	0.137 J	<0.137	<0.505	0.184 J	<0.388	<0.27	<0.298
HxCDD, 1,2,3,6,7,8-	ng/Kg	0.172 J	0.112 J	0.192 J	0.148 J	0.175 J	<0.242	0.212 J	<0.0823	<0.176	<0.144
HxCDD, 1,2,3,4,7,8-	ng/Kg	0.0836 J	0.0876 J	<0.0661	0.0684 J	0.128 J	<0.238	0.127 J	0.206 J	<0.171	<0.138
HxCDD, 1,2,3,7,8,9-	ng/Kg	0.116 J	0.0773 J	0.102 J	0.0986 J	0.163 J	0.471 J	0.147 J	<0.0723	<0.157	<0.127
HpCDD, 1,2,3,4,6,7,8-	ng/Kg	0.884 J	0.637 J	0.853 J	0.945 J	0.749 J	1.32 J	0.701 J	0.709 J	1.26 J	0.911 J
OCDD, 1,2,3,4,6,7,8,9-	ng/Kg	3.55 J	2.61 J	3.73 J	4.81 J	4.29 J	4.28 J	3.24 J	3.99 J	4.06 J	3.54 J
TCDF, 2,3,7,8-	ng/Kg	1.15	0.89	1.06	0.91	0.73	<0.776	0.778	1.26	<0.403	1.13
PeCDF, 1,2,3,7,8-	ng/Kg	0.166 J	0.0832 J	0.117 J	<0.0618	<0.0979	<0.351	0.178 J	<0.186	<0.165	<0.184
PeCDF, 2,3,4,7,8-	ng/Kg	0.214 J	0.153 J	0.192 J	0.17 J	0.211 J	<0.341	0.244 J	<0.192	<0.164	<0.18
HxCDF, 1,2,3,6,7,8-	ng/Kg	0.101 J	0.104 J	<0.0568	<0.0713	<0.0757	<0.295	0.128 J	<0.249	<0.167	<0.111
HxCDF, 1,2,3,7,8,9-	ng/Kg	<0.0722	<0.0395	<0.0648	<0.0805	<0.105	<0.363	0.169 J	<0.285	<0.178	<0.119
HxCDF, 1,2,3,4,7,8-	ng/Kg	0.139 J	0.107 J	0.125 J	0.147 J	0.167 J	<0.31	0.206 J	<0.26	<0.172	<0.112
HxCDF, 2,3,4,6,7,8-	ng/Kg	0.114 J	0.0692 J	0.102 J	<0.0737	<0.0774	<0.306	0.177 J	<0.244	<0.162	<0.109
HpCDF, 1,2,3,4,6,7,8-	ng/Kg	0.375 J	0.262 J	0.293 J	0.338 J	0.308 J	0.487 J	0.294 J	0.561 J	0.304 J	0.473 J
HpCDF, 1,2,3,4,7,8,9-	ng/Kg	0.0985 J	<0.0313	0.0712 J	0.0707 J	0.176 J	0.56 J	0.136 J	<0.176	<0.0592	<0.0694
OCDF, 1,2,3,4,6,7,8,9-	ng/Kg	0.488 J	0.325 J	0.357 J	0.458 J	0.518 J	<1.3	0.537 J	<0.457	<0.612	<0.357
Total Tetra-Dioxins	ng/Kg	0.233 J	<0.0595	<0.0596	<0.0906	<0.147	<0.574	<0.0603	<0.378	<0.408	<0.638
Total Penta-Dioxins	ng/Kg	0.152 J	<0.065	<0.0577	<0.0832	<0.137	<0.505	<0.0749	<0.388	<0.27	<0.298
Total Hexa-Dioxins	ng/Kg	0.288 J	0.0876 J	0.832 J	0.863 J	0.494 J	<0.232	0.516 J	<0.0773	<0.168	<0.136
Total Hepta-Dioxins	ng/Kg	1.85 J	0.637 J	1.92 J	2.12 J	1.78 J	<0.725	1.41 J	0.948 J	1.26 J	1.06 J
Total Tetra-Furans	ng/Kg	1.36	0.89	1.28	0.196 J	<0.119	<0.776	0.945	<0.491	<0.403	1.13
Total Penta-Furans	ng/Kg	0.166 J	0.642 J	0.742 J	0.648 J	1.12 J	<0.346	0.375 J	<0.189	0.39 J	<0.182
Total Hexa-Furans	ng/Kg	0.101 J	0.147 J	0.125 J	0.147 J	0.21 J	<0.317	0.914 J	<0.259	<0.169	<0.113
Total Hepta-Furans	ng/Kg	0.375 J	0.262 J	0.293 J	0.225 J	0.176 J	<0.113	0.262 J	0.561 J	<0.0546	<0.0658
Total TEQ	ng/Kg	0.657	0.482	0.549	0.340	0.213	0.0721	0.687	0.161	0.0169	0.128

Notes:
J - Values detected below the method reporting limit (MRL) and above the method detection limit (MDL) are reported as estimated values
Values preceded by a less than symbol (<) were not detected above the MDL

Total dioxin/furan concentrations (i.e., summed concentrations of the 17 dioxin and furan congeners) and toxic equivalency quotient or TEQ values are summarized in Tables 6-3 and 6-4, respectively. The total TEQ values are calculated by multiplying the measured concentration of each of the 17 dioxin and furan congeners by its corresponding toxic equivalency factor (TEF) and then summing the results for each sample. Non-detect results (i.e., below the method detection limit) for both the total dioxin/furan and TEQ calculations are treated as zero (0).

Table 6-3. Total Dioxin/Furan Concentrations (ng/kg ww) in *Macoma* and *Nereis* Tissues

	Macoma				*Nereis*			
Rep	SPC	BB3	BB4	Control	SPC	BB3	BB4	Control
1	12.5	3.81	8.87	5.57	7.85	7.56	8.04	7.12
2	10.6	4.30	7.66	6.27	8.87	10.6	5.79	4.44
3	16.7	5.29	4.54	39.3	9.44	10.0	7.51	6.73
4	18.4	6.81	5.52	7.01	7.03	6.87	8.30	5.62
5	9.66	11.8	5.85	4.21	7.40	6.68	7.61	6.05
mean	13.6	6.40	6.49	12.5	8.12	8.36	7.45	5.99
sd	3.44	2.89	1.56	13.5	0.904	1.66	0.876	0.934

sd = standard deviation

Table 6-4. Total TEQ Concentrations (ng/kg ww) in *Macoma* and *Nereis* Tissues

	Macoma				*Nereis*			
Rep	SPC	BB3	BB4	Control	SPC	BB3	BB4	Control
1	0.0334	0.00726	0.418	0.0181	0.166	0.609	0.657	0.0721
2	0.0184	0.00768	0.0571	0.0513	0.147	0.827	0.482	0.687
3	0.338	0.0165	0.00943	0.0952	0.724	0.507	0.549	0.161
4	0.808	0.0199	0.0112	0.0555	0.477	0.632	0.340	0.0169
5	0.0347	0.0644	0.0106	0.017	0.563	0.497	0.213	0.128
mean	0.246	0.0231	0.101	0.0474	0.415	0.614	0.448	0.213
sd	0.305	0.0212	0.159	0.0288	0.226	0.119	0.156	0.242

sd = standard deviation

The mean total dioxin/furan concentrations in *Macoma* tissue samples ranged from 6.4 to 13.6 ng/kg (ww) for the three composite sediment samples compared to 12.5 ng/kg for the control samples. The corresponding mean total TEQ concentrations ranged from 0.023 to 0.25 ng/kg for the three composite sediment samples compared to 0.047 ng/kg for the control samples. The mean total dioxin/furan concentrations in *Nereis* tissue samples ranged from 7.4 to 8.4 ng/kg (ww) for the three composite sediment samples compared to 6.0 ng/kg for the control samples. The corresponding mean total TEQ concentrations ranged from 0.42 to 0.61 ng/kg for the three composite sediment samples compared to 0.21 ng/kg for the control samples. Average lipid concentrations in the *Macoma* tissue samples ranged from 0.92% to 1.04% (ww) for the three composite sediment samples compared to 0.90% for the control samples. Average lipid concentrations in the *Nereis* tissue samples ranged from 1.0% to 1.18% (ww) for the three

composite sediment samples compared to 1.02% for the control samples. Results from a one-way analysis of variance (ANOVA) of the total TEQ values indicated that differences between the test and corresponding control samples were not statistically significant (i.e., $p > 0.05$) for both *Macoma* and *Nereis* tissue samples.

For comparison, the *Humboldt Harbor and Bay O&M Dredging Grain Size Verification and Tier III Evaluation Sampling and Analysis Results* report (Kinnetic Laboratories Inc. 2016) noted mean total TEQ values ranging from 0.471 – 0.769 ng/kg (ww) and from 0.540 to 1.00 ng/kg (ww) in tissues of *Macoma nasuta* and *Nereis virens*, respectively, subject to 28-day bioaccumulation exposures similar to those of the Bodega Bay bioaccumulation exposures. These results are generally comparable to those from bioaccumulation testing of the Bodega Bay sediments.

The SFDODS Reference Area database (https://www3.epa.gov/region9/water/dredging/sfdods/refarea-db.html) does not include values for dioxin/furan concentrations in tissues that can be used as a basis for comparison with these results. The SFEI Contaminant Data Download and Display (CD3) database (http://www.sfei.org/rmp/data#sthash.vGnhH4rd.dpbs) contains dioxin/furan concentration values for tissues of a number of aquatic species, including fish, birds, and mammals. However, the current data set for marine benthic invertebrate species is sparse. By contrast, the data sets for dioxins/furans in muscle tissues of the marine/estuarine fish species white croaker (*Genyonemus lineatus*) and shiner surfperch (*Cymatogaster aggregata*) are comparatively robust, representing 54 samples and 21 samples, respectively, collected within the San Francisco Bay. Fewer numbers of records for dioxins/furans in other fish species (less than 10 per species) are currently available from the CD3 database.

The mean (average of 54 samples) total dioxin/furan concentration (i.e., sum of detected dioxin and furan congeners) in white croaker muscle tissue samples included in the CD3 database is 4.88 ng/kg (ww), and the range in total dioxin/furan concentrations is 0.44 to 14.25 ng/kg. The average total dioxin/furan concentrations for *Macoma* and *Nereis* tissue samples are within this range. The mean total dioxin concentration for shiner surfperch is 5.31 ng/kg and the range is 1.44 to 10.85 ng/kg. The average total dioxin/furan concentrations for *Nereis* tissue samples are within this range, whereas the average concentrations for *Macoma* slightly exceed the corresponding range for shiner surfperch. The total TEQ concentrations for white croaker and shiner surfperch muscle tissue samples compiled by SFEI are provided in Table 6-5. The mean total TEQ concentrations for both white croaker and shiner surfperch, prepared as skin on, scales on, were approximately two fold higher than the average total TEQ concentrations for *Nereis* tissues and five to fifty fold higher than the average total TEQ concentrations for *Macoma* tissues.

Table 6-5. Total TEQ Concentrations (ng/kg ww) in Muscle Tissue (Fillet) of White Croaker and Shiner Surfperch from San Francisco Bay. Data from SFEI.

Preparation	Number of Samples	Mean	Standard Deviation	Minimum	Maximum
White Croaker (*Genyonemus lineatus*)					
Skin off	14	0.51	0.26	0.20	1.13
Skin on	4	2.01	0.20	1.71	2.17
Skin on, Scales Off	33	1.36	0.64	0.41	2.97
Skin on, Scales on	29	1.19	0.48	0.05	2.01
Shiner Surfperch (*Cymatogaster aggregata*)					
Skin on, Scales Off	26	0.82	0.46	0.22	2.07
Skin on, Scales on	11	1.07	0.75	0.14	2.30

Data provided by John Ross/SFEI on 9/20/16.

FDA does not identify an action level for dioxin/furan compounds that can be used as a basis for comparison of measured concentrations in these fish species, or in the *Macoma* and *Nereis* tissue bioaccumulation samples, to deleterious levels in human food. However, USEPA Region 9 identified a potential screening level concentration for TEQ of 0.3 ng/kg (https://www3.epa.gov/region9/water/dioxin/) based on a fish tissue advisory screening level established by the California Office of Environmental Health Hazard Assessment. A screening value is defined as a concentration of a target analyte in fish tissue that is of potential public health concern. Exceedance of screening value is an indication that more intensive site-specific monitoring and/or evaluation of human health risk should be conducted. The mean TEQ values for the *Macoma* tissues associated with the three test sediments are below this screening level, whereas the mean TEQ values for the *Nereis* tissues associated with the test sediments are up to two times above the screening level.

COMPARISON TO TISSUE RESIDUE EFFECTS DATA

Per EPA guidance, a toxicity reference value (TRV) represents the best estimate of the lowest concentration causing an observable adverse effect to a relevant organism. TRV values that can be used as a basis for comparison to total dioxin/furan concentrations (or total TEQ values) measured for the tissue bioaccumulation samples were obtained from the most recent version (November 2015) of the U.S. Army Corps of Engineers (USACE) Waterways Experiment Station Environmental Residue Effects Database (ERED) (http://www.wes.army.mil/el/ered/index.html). The ERED database contains 617 records for dioxin/furan compounds, of which 544 records are for 2,3,7,8 TCDD; these values are equivalent to TEQs since all dioxin/furan congeners are normalized to this compound via the TEFs. To obtain relevant TRV values, the ERED database was screened for data records per the following:

a. Marine or estuarine organisms;

b. Invertebrates (ideally but not necessarily including bivalves and polychaetes);

c. Sediment or sediment + water exposures (as opposed to water only, or injection, etc.); and

d. Whole-organism endpoints such as adverse effects on survival, growth, or reproduction.

The ERED database contains no records for dioxin/furan TRVs related to marine benthic invertebrate species and limited records for other aquatic species that would provide a relevant comparison to the tissue bioaccumulation samples. The ERED database contains a whole organism endpoint for Dover sole that would be a possible TRV in that it is the lowest value for any marine fish in the database, and it is a species that lives in intimate contact with bottom sediments. However, the lowest observed effects concentration (LOEC) is 1,000 ng/kg, which is still high relative to background concentrations in white croaker and shiner surfperch listed in the SFEI database. The two lowest true whole body effect entries in the ERED database are for freshwater salmonids: rainbow trout (30 ng/kg) and lake charr (34 ng/kg). Of these, the TEQ value for the rainbow trout growth LOEC at 30 ng/kg is recommended as the most relevant TRV for Bodega Bay tissue samples.

By comparison, all total TEQ values for the *Macoma* and *Nereis* tissue bioaccumulation samples are well below this TRV.

BENTHIC SEDIMENT ACCUMULATION FACTORS

Biota-sediment accumulation factor (BSAF) values were calculated using the dioxin/furan concentrations for the bioaccumulation tissue samples and corresponding sediment samples.

BSAF values are calculated per the following equation: $BSAF = [C_T/C_{lipid}]/[C_S/C_{TOC}]$;

Where:

- C_S and C_T = sediment and tissue dioxin/furan concentrations, respectively (ng/kg (dw); and
- C_{TOC} and C_{lipid} = sediment TOC and tissue lipid concentrations expressed as a decimal fraction (%*0.01), respectively.

Steady-state dioxin/furan concentrations for the tissue samples were calculated by multiplying measured concentrations by a factor of two per the USACE Engineer Research and Development Center (ERDC) guidance document. Values of one-half the method detection limit were substituted for non-detect results. BSAF values calculated for the tissue bioaccumulation samples are summarized in Table 6-6. Steady-state calculations are included as Appendix H.

Table 6-6. Biota-Sediment Accumulation Factors for Dioxin/Furan Congeners in *Macoma* and *Nereis* Tissues

Analyte	*Macoma*			*Nereis*		
	SPC-2015-1	BB3-2015-1	BB4-2015-1	SPC-2015-1	BB3-2015-1	BB4-2015-1
2,3,7,8 TCDD	2.697	5.787	2.480	8.678	7.292	7.386
1,2,3,7,8 PeCDD	0.785	0.918	0.583	0.778	1.184	1.026
1,2,3,6,7,8 HxCDD	0.335	0.347	0.177	0.178	0.640	0.445
1,2,3,4,7,8 HxCDD	0.600	0.509	0.472	0.214	0.803	0.787
1,2,3,7,8,9 HxCDD	0.307	0.388	0.314	0.152	0.677	0.488
1,2,3,4,6,7,8 HpCDD	0.147	0.202	0.133	0.089	0.236	0.140
1,2,3,4,6,7,8,9 OCDD	0.120	0.142	0.100	0.054	0.103	0.085
2,3,7,8 TCDF	0.399	0.859	0.716	5.825	5.639	6.766
1,2,3,7,8 PeCDF	0.251	0.488	0.163	0.219	0.329	0.223
2,3,4,7,8 PeCDF	0.400	0.579	0.230	0.503	1.304	0.738
1,2,3,6,7,8 HxCDF	0.099	0.152	0.085	0.058	0.306	0.070
1,2,3,7,8,9 HxCDF	0.288	0.256	0.256	0.128	0.394	0.109
1,2,3,4,7,8 HxCDF	0.089	0.106	0.064	0.080	0.305	0.127
2,3,4,6,7,8 HxCDF	0.202	0.373	0.133	0.135	0.425	0.142
1,2,3,4,6,7,8 HpCDF	0.034	0.082	0.031	0.035	0.096	0.036
1,2,3,4,7,8,9 HpCDF	0.038	0.035	0.056	0.016	0.096	0.039
1,2,3,4,6,7,8,9 OCDF	0.009	0.031	0.008	0.005	0.018	0.006
Total Dioxins/Furans	6.799	11.254	6.002	17.147	19.848	18.613

With the exception of 2,3,7,8 TCDD in all tissue samples, and 2,3,7,8 TCDF in *Nereis* tissue samples only, BSAF values for individual dioxin/furan congeners generally were less than one. These BSAF values are generally comparable to previously reported BSAF values for dioxins/furans (e.g., Oregon Department of Environmental Quality, 2007).

FOOD WEB TRANSFER AND BIOMAGNIFICATION

The potential for food web transfer and biomagnification of dioxins/furans was evaluated using the ERDC Trophic Trace model. The Trophic Trace Model Report is included as Appendix G. In the Trophic Trace model, ecological receptors are exposed to potential contaminants in dredged materials via ingestion of prey. The model estimates expected concentrations using a sediment-based food web that assumes organic compounds (e.g., dioxins/furans) partition from organic carbon in sediment to the lipid fraction of benthic invertebrates. However, when data are available from bioaccumulation tests, concentrations in receptor tissues are calculated based on concentrations measured in test organisms. For this simulation, concentrations in muscle tissue of the fish white croaker were estimated based on an assumed diet solely of the benthic worm *Nereis* and using the tissue bioaccumulation results for *Nereis* exposed to the composite sediment sample BB4-2015. White croaker was modeled since it is a relatively sedentary bottom dweller and indiscriminate substrate forager, as well as a sentinel species for monitoring programs, therefore it represents a suitable worst case species for the model. *Nereis* was selected over *Macoma* because it represents a more realistic food chain for trophic transfer to fish. BB4-2015 was selected because the sediment concentrations of dioxins/furans were the highest and it

represents a worst case exposure. The model also assumed that white croaker muscle tissue has a lipid content of 6.4 percent (ww), which is the value used by Gobas and Wilcockson (2003) for the *San Francisco Bay PCB Food-Web Model*. All other model input parameters are in accordance with the *Bioaccumulation Risk Assessment Modeling System (BRAMS)* Users Guide (Baker and Vogel, 2012). Model results showing predicted minimum (Min), mean, 95% upper confidence limit (95% UCL), and maximum (Max) values are presented in Table 6-7.

Table 6-7. Concentrations (ng/kg ww) of Dioxin/Furan Congeners in White Croaker Muscle Tissues Based on a Diet of *Nereis* Predicted by the Trophic Trace Model.

Analyte	Min	Mean	95% UCL	Max	TRV	SFEI Mean
2,3,7,8 TCDD	3.041E-4	9.53E-4	1.469E-3	1.564E-3	30	4.88
1,2,3,7,8 PeCDD	4.481E-4	7.779E-4	9.745E-4	9.944E-4	--	--
1,2,3,6,7,8 HxCDD	1.539E-4	2.196E-4	2.602E-4	2.638E-4	--	--
1,2,3,4,7,8 HxCDD	1.037E-4	2.514E-4	3.54E-4	4.015E-4	--	--
1,2,3,7,8,9 HxCDD	1.062E-4	1.531E-4	1.95E-4	2.24E-4	--	--
1,2,3,4,6,7,8 HpCDD	1.397E-3	1.784E-3	2.039E-3	2.072E-3	--	--
1,2,3,4,6,7,8,9 OCDD	3.67E-3	5.34E-3	6.454E-3	6.763E-3	--	--
2,3,7,8 TCDF	4.623E-3	6.009E-3	6.986E-3	7.303E-3	--	--
1,2,3,7,8 PeCDF	2.074E-4	5.988E-4	9.455E-4	1.114E-3	--	--
2,3,4,7,8 PeCDF	1.027E-3	1.262E-3	1.431E-3	1.437E-3	--	--
1,2,3,6,7,8 HxCDF	7.224E-5	1.562E-4	2.476E-4	2.645E-4	--	--
1,2,3,7,8,9 HxCDF	8.49E-5	1.556E-4	2.044E-4	2.257E-4	--	--
1,2,3,4,7,8 HxCDF	2.722E-4	3.485E-4	4.034E-4	4.248E-4	--	--
2,3,4,6,7,8 HxCDF	9.373E-5	1.835E-4	2.694E-4	2.9E-4	--	--
1,2,3,4,6,7,8 HpCDF	6.664E-4	8.017E-4	9.065E-4	9.539E-4	--	--
1,2,3,4,7,8,9 HpCDF	3.981E-5	2.198E-4	3.614E-4	4.477E-4	--	--
1,2,3,4,6,7,8,9 OCDF	1.697E-4	2.24E-4	2.662E-4	2.704E-4	--	--

The model-predicted dioxin/furan concentrations for 2,3,7,8 TCDD are orders of magnitude below the TRV value (30 ng/kg), as well as the TEQ values for the SFEI white croaker tissue samples from San Francisco Bay (mean value of 4.88 ng/kg and a range of 0.44 to 14.25 ng/kg). Therefore, the tissue bioaccumulation results do not indicate a significant potential for adverse effects to target aquatic organisms or food chain uptake of dioxins/furans from the proposed Bodega Bay dredged materials.

7 QUALITY CONTROL REVIEW

7.1 SEDIMENT CONVENTIONAL AND CHEMICAL ANALYTICAL QUALITY CONTROL SUMMARY

The QA/QC review entailed reviewing the contract lab data report(s) for sediment sample integrity, correct methodology, and compliance with all appropriate Lab QA/QC requirements. QC results that did not comply with the analytical laboratory QA/QC limits are presented below (also, see final analytical reports in Appendices B through F for full case narratives). A summary of targeted and achieved reporting limits are presented in Table 7-1. All sample analyses were performed using the appropriate methods as specified in the SAP. The overall data quality assessment found that all data were usable.

ALS Report K1512740

Total Organic Carbon – The method reporting limits (MRLs) for TOC were below the target reporting limit specified in the SAP. TOC was not detected in the method blank.

Grain Size – Communication from the analytical laboratory (ALS) indicates that very rarely will the percent of total weight recovered will add up to 100%. Grain size analysis takes a sample aliquot for analysis. To calculate the final results, a separate analysis for percent solids (on a second sample aliquot) is performed which is then applied to the grain size data. Any variation in aliquot collection for the two analyses would be reflected in the total weight recovered for grain size analysis. Further sources of potential error propagation during grain size analysis as a result of the multi-measurement technique is that grain size and percent analyses are performed by different analysts, and the potential for processing error for each sieve or pipette reading. Total weight recovered was within 5% for all samples which is considered an acceptable representation.

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

ALS Report K1512760

Total Organic Carbon – The MRLs for TOC were below the target reporting limit specified in the SAP. TOC was not detected in the method blank.

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

ALS Reports K1512817

Metals – The MRLs for metals were below target reporting limits specified in the SAP. None of the metals were detected in the method blanks.

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

Butylins – The MRLs for butlyins were below the target reporting limits specified in the SAP. None of the target analytes were detected in the method blanks.

- **Matrix Spike Recovery Exceptions:** Insufficient sample volume was received to perform a Matrix Spike/Matrix Spike Duplicate (MS/MSD). A Laboratory Control

Sample/Laboratory Control Sample Duplicate (LCS/LCSD) was analyzed and reported in lieu of the MS/MSD for these samples.

- **Sample Confirmation Notes:** The confirmation comparison criteria of 40% difference for n-Butyltin Cation was exceeded in sample SPC-2015. The lower of the two values was reported when no evidence of matrix interference was observed.

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

Dioxins – The MRLs for the dioxins ranged from 0.926 to 10.9 ng/kg, which were higher than the SAP target MRL of 2.0 ng/kg.

- **Method Blanks:** The Method Blank EQ1500690-01 contained low levels of various compounds below the MRL. One compound, OCDF, was above the MRL (CRQL). ALS/Houston follows the EPA National Functional Guidelines for CDDs and CDFs, September 2005, which states on page 31, "The concentration of OCDD/OCDF in the method blank must be <3x the CRQL (MRL.):" The associated compounds in the samples are flagged with 'B' flags where the sample result is less than ten times the level detected in the method blank.

- **MS/MSD:** EQ1500690: LCS/LCSD samples were analyzed and reported in lieu of an MS/MSD for this extraction batch. The matrix spike recoveries for several compounds are below the laboratory warning limits. Marginal exceedances are allowed as long as the values are within method control limits. Method 8290 control limits are from 70-130 ng/kg.

- **2378-TCDF:** Samples analyzed on the DB-5MSUI column were analyzed under conditions where sufficient separation between 2,3,7,8-TCDF and its closest eluter was achieved. Confirmation of this result was not required.

Organochlorine Pesticides – The MRLs for all pesticides were below the target reporting limits specified in the SAP, with the exception of toxaphene. However, the method detection limit (14 µg/kg) for toxaphene was below the SAP target reporting limit of (20 µg/kg).

- **Holding Time Exceptions:** Due to laboratory contamination the Method Blank KWG1511246-10 contained levels of 4,4'-DDT above the MRL. In accordance with ALS QA/QC policy, all sample results less than twenty times the level found in the Method Blank were flagged as estimated. Samples SPC-2015 and BB4-2015 were re-extracted and re-analyzed past sample hold time. Results for 4,4'-DDT only were reported from the re-analysis. No further corrective action was possible.

    - The BB3-2015 sample required a re-extraction for EPA 8081 due to a method blank contamination which resulted in detections in the sample. The sample re-extract confirmed that all analytes were non-detect. The initial sample result and the re-extraction results are included in the lab report (Appendix B). The re-extraction result was past the prescribed holding time, since it was taken from a refrigerated (not frozen) jar.

- **Second Source Exceptions:** The analysis of Chlorinated Pesticides by EPA 8081 requires the use of dual column confirmation. When the Initial Calibration Verification (ICV) criteria are met for both columns, the higher of the two sample results is generally reported. The primary evaluation criteria were not met on the confirmation column for 4,4'-DDD. The

ICV results are reported from the acceptable column. The data quality is not affected. No further corrective action was necessary.

- **Calibration Verification Exceptions:** The upper control criterion was exceeded for 2,4'-DDE in Continuing Calibration Verification (CCV) 1204F025. The field samples analyzed in this sequence did not contain the analyte in question. Since the apparent problem indicated a potential high bias, the data quality was not affected. No further corrective action was required.

- **Elevated Detection Limits:** The reporting limit is elevated for at least one analyte in all field samples. The chromatogram indicated the presence of non-target background components. The matrix interference prevented adequate resolution of the target compounds at the reporting limit. The results are flagged to indicate the matrix interference.

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

PCBs – The MRLs for all PCBs were below the target reporting limits specified in the SAP. None of the target PCB analytes were detected in the method blanks.

- **Matrix Spike Recovery Exceptions:** The recoveries of PCB 33 and PCB 95 in sample Batch QC (MS/MSD) were outside the control limits listed in the results summary. The limits are default values temporarily in use until sufficient data points are generated to calculate statistical control limits. Based on the method and historic data, the recoveries observed were in the range expected for this procedure. No further corrective action was taken.

- **Lab Control Sample Exceptions:** The recovery of PCB 74 in sample KWG1511214-3 was outside the control limits listed in the results summary. The limits are default values temporarily in use until sufficient data points are generated to calculate statistical control limits. Based on the method and historic data, the recoveries observed were in the range expected for this procedure. No further corrective action was taken.

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

PAHs –

- **Matrix Spike Recovery Exceptions:** The Matrix Spike (MS) KWG1511040-6 recovery of Perylene for sample Batch QC was outside control criteria. Recovery in the LCS KWG1511040-3 was acceptable, which indicated the analytical batch was in control. The matrix spike outlier suggested a potential low bias in this matrix. No further corrective action was appropriate.

- **Relative Percent Difference Exceptions:** The Relative Percent Difference (RPD) for Perylene in the replicate Matrix Spike (MS/DMS) KWG1511040-6 and KWG1511040-7 analyses of Batch QC was outside control criteria. The Relative Percent Differences for the compound in question in the associated Replicate Laboratory Control Samples (LCS/LCSD) KWG1511040-3 and KWG1511040-4 was within acceptance limits, indicating the analytical batch was in control. No further corrective action was appropriate.

- **Holding Time Exceptions:** The analysis of sample BB3-2015 was requested past the recommended holding time. The analysis was performed as soon as possible after requested by the client. The data were flagged to indicate the holding time violation.

- **Surrogate Exceptions:** The control criteria were exceeded for Terphenyl-d14 in the LCS KWG1511596-3. The associated matrix spike recoveries of target compounds were in control, indicating the analysis was in control. The surrogate outlier was flagged accordingly. No further corrective action was appropriate.

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

Table 7.1. Achieved Reporting Limits for Composited Sediments

Analyte	SAP Targeted	Achieved MRL	Achieved MRL	Achieved MRL	Units
Metals (EPA 6020/7471B/7742)					
Arsenic	1	0.3	0.36	0.3	mg/Kg dw
Cadmium	0.5	0.012	0.014	0.012	mg/Kg dw
Chromium	2	0.12	0.15	0.12	mg/Kg dw
Copper	3	0.06	0.07	0.06	mg/kg dw
Lead	3	0.03	0.04	0.03	mg/kg dw
Mercury	0.05	0.019	0.021	0.016	mg/kg dw
Nickel	5	0.12	0.15	0.12	mg/kg dw
Selenium	0.1	0.06	0.07	0.06	mg/kg dw
Silver	0.5	0.012	0.014	0.012	mg/kg dw
Zinc	3	0.3	0.4	0.3	mg/kg dw
Butylin (Krone)					
Tetrabutyltin	10	1.9	2.2	1.8	µg/Kg
Tributyltin as Sn	10	1.9	2.2	1.8	µg/Kg
Dibutyltin as Sn	10	1.9	2.2	1.8	µg/Kg
Monobutyltin as Sn	10	1.9	2.2	1.8	µg/Kg
Total Butylins					µg/Kg
Dioxins and Furans (8290)					
TCDD, 2,3,7,8-	2	0.926	1.09	0.91	ng/kg
PeCDD, 1,2,3,7,8-	2	4.63	5.45	4.55	ng/kg
HxCDD, 1,2,3,6,7,8-	2	4.63	5.45	4.55	ng/kg
HxCDD, 1,2,3,4,7,8-	2	4.63	5.45	4.55	ng/kg
HxCDD, 1,2,3,7,8,9-	2	4.63	5.45	4.55	ng/kg
HpCDD,	2	4.63	5.45	4.55	ng/kg
OCDD,	2	9.26	10.9	9.1	ng/kg
TCDF, 2,3,7,8-	2	0.926	1.09	0.91	ng/kg
PeCDF, 1,2,3,7,8-	2	4.63	5.45	4.55	ng/kg
PeCDF, 2,3,4,7,8-	2	4.63	5.45	4.55	ng/kg
HxCDF, 1,2,3,6,7,8-	2	4.63	5.45	4.55	ng/kg
HxCDF, 1,2,3,7,8,9-	2	4.63	5.45	4.55	ng/kg
HxCDF, 1,2,3,4,7,8-	2	4.63	5.45	4.55	ng/kg
HxCDF, 2,3,4,6,7,8-	2	4.63	5.45	4.55	ng/kg
HpCDF,	2	4.63	5.45	4.55	ng/kg
HpCDF,	2	4.63	5.45	4.55	ng/kg
OCDF,	2	9.26	10.9	9.1	ng/kg
Total Tetra-Dioxins	2	0.926	1.09	0.91	ng/kg
Total Penta-Dioxins	2	4.63	5.45	4.55	ng/kg
Total Hexa-Dioxins	2	4.63	5.45	4.55	ng/kg
Total Hepta-Dioxins	2	4.63	5.45	4.55	ng/kg
Total Tetra-Furans	2	0.926	1.09	0.91	ng/kg
Total Penta-Furans	2	4.63	5.45	4.55	ng/kg
Total Hexa-Furans	2	4.63	5.45	4.55	ng/kg
Total Hepta-Furans	2	4.63	5.45	4.55	ng/kg
Total TEQ					ng/kg

Note: Highlighted value indicates that Achieved MRL value is greater than SAP Target MRL value

Table 7.1. Achieved Reporting Limits for Composited Sediments (continued)

Analyte	SAP Targeted MRL	Achieved MRL BB3-2015	Achieved MRL BB4-2015	Achieved MRL SPC-2015	Units
Organochlorine Pesticides (8081)					
HCH, alpha	2	0.99	1.1	0.91	µg/Kg
HCH, beta	2	0.99	1.1	0.91	µg/Kg
HCH, gamma	2	0.99	1.1	0.91	µg/Kg
HCH, delta	2	0.99	1.1	0.91	µg/Kg
Aldrin	2	0.99	1.1	0.91	µg/Kg
Chlordane	20	9.9	11	9.1	µg/Kg
Chlordane, cis-	2	0.99	1.1	0.91	µg/Kg
Chlordane, trans-	2	0.99	1.1	0.91	µg/Kg
Total Chlordane	20	0.99	1.1	0.91	µg/Kg
DDD(o,p')	2	0.99	1.1	0.91	µg/Kg
DDD(p,p')	2	0.99	1.1	0.91	µg/Kg
DDE(o,p')	2	0.99	1.1	0.91	µg/Kg
DDE(p,p')	2	0.99	1.1	0.91	µg/Kg
DDT(o,p')	2	0.99	1.1	0.91	µg/Kg
DDT(p,p')	2	0.99	1.1	0.91	µg/Kg
Total DDT	2	0.99	1.1	0.91	µg/Kg
Dieldrin	2	0.99	1.1	0.91	µg/Kg
Endosulfan I	2	0.99	1.1	0.91	µg/Kg
Endosulfan II	2	0.99	1.1	0.91	µg/Kg
Endosulfan sulfate	2	0.99	1.1	0.91	µg/Kg
Endrin	2	0.99	1.1	0.91	µg/Kg
Endrin Aldehyde	2	0.99	1.1	0.91	µg/Kg
Endrin Ketone	2	0.99	1.1	0.91	µg/Kg
Heptachlor	2	0.99	1.1	0.91	µg/Kg
Heptachlor epoxide	2	0.99	1.1	0.91	µg/Kg
Methoxychlor	2	0.99	1.1	0.91	µg/Kg
Nonachlor, cis-	2	0.99	1.1	0.91	µg/Kg
Nonachlor, trans-	2	0.99	1.1	0.91	µg/Kg
Toxaphene	20	50	55	46	µg/Kg

Note: Highlighted value indicates that Achieved MRL value is greater than SAP Target MRL value

Table 7.1. Achieved Reporting Limits for Composited Sediments (continued)

Analyte	SAP Targeted MRL	Achieved MRL BB3-2015	Achieved MRL BB4-2015	Achieved MRL SPC-2015	Units
PCBs (8082)					
PCB 008	0.5	0.43	0.43	0.43	µg/Kg
PCB 018	0.5	0.25	0.28	0.23	µg/Kg
PCB 028	0.5	0.25	0.28	0.23	µg/Kg
PCB 033	0.5	0.43	0.43	0.43	µg/Kg
PCB 044	0.5	0.25	0.28	0.23	µg/Kg
PCB 052	0.5	0.25	0.28	0.23	µg/Kg
PCB 056	0.5	0.25	0.28	0.23	µg/Kg
PCB 066	0.5	0.25	0.28	0.23	µg/Kg
PCB 070	0.5	0.25	0.28	0.23	µg/Kg
PCB 074	0.5	0.25	0.28	0.23	µg/Kg
PCB 087	0.5	0.25	0.28	0.23	µg/Kg
PCB 097	0.5	0.25	0.28	0.23	µg/Kg
PCB 099	0.5	0.25	0.28	0.23	µg/Kg
PCB 101	0.5	0.25	0.28	0.23	µg/Kg
PCB 110	0.5	0.25	0.28	0.23	µg/Kg
PCB 132	0.5	0.25	0.28	0.23	µg/Kg
PCB 138	0.5	0.25	0.28	0.23	µg/Kg
PCB 141	0.5	0.25	0.28	0.23	µg/Kg
PCB 151	0.5	0.25	0.28	0.23	µg/Kg
PCB 156	0.5	0.25	0.28	0.23	µg/Kg
PCB 177	0.5	0.25	0.28	0.23	µg/Kg
PCB 180	0.5	0.25	0.28	0.23	µg/Kg
PCB 183	0.5	0.25	0.28	0.23	µg/Kg
PCB 187	0.5	0.25	0.28	0.23	µg/Kg
PCB 194	0.5	0.25	0.28	0.23	µg/Kg
PCB 195	0.5	0.25	0.28	0.23	µg/Kg
PCB 201	0.5	0.25	0.28	0.23	µg/Kg
PCB 203	0.5	0.25	0.28	0.23	µg/Kg
PCB 031	0.5	0.25	0.28	0.23	µg/Kg
PCB 049	0.5	0.25	0.28	0.23	µg/Kg
PCB 060	0.5	0.25	0.28	0.23	µg/Kg
PCB 095	0.5	0.25	0.28	0.23	µg/Kg
PCB 105	0.5	0.25	0.28	0.23	µg/Kg
PCB 118	0.5	0.25	0.28	0.23	µg/Kg
PCB 128	0.5	0.25	0.28	0.23	µg/Kg
PCB 149	0.5	0.27	0.28	0.27	µg/Kg
PCB 153	0.5	0.25	0.28	0.23	µg/Kg
PCB 170	0.5	0.25	0.28	0.23	µg/Kg
PCB 174	0.5	0.25	0.28	0.23	µg/Kg
Total PCB's					µg/Kg

Note: Highlighted value indicates that Achieved MRL value is greater than SAP Target MRL value

Table 7.1. Achieved Reporting Limits for Composited Sediments (continued)

Analyte	SAP Targeted MRL	Achieved MRL BB3-2015	Achieved MRL BB4-2015	Achieved MRL SPC-2015	Units
PAHs (8270SIM)					
Naphthalene	20	4.7	5.6	4.5	µg/Kg
Methylnaphthalene, 2-	20	4.7	5.6	4.5	µg/Kg
Methylnaphthalene, 1-	20	4.7	5.6	4.5	µg/Kg
Biphenyl	20	--	5.6	4.5	µg/Kg
Dimethylnaphthalene, 2,6-	20	4.7	5.6	4.5	µg/Kg
Acenaphthylene	20	--	5.6	4.5	µg/Kg
Acenaphthene	20	--	5.6	4.5	µg/Kg
Trimethylnaphthalene, 2,3,5-	20	--	5.6	4.5	µg/Kg
Fluorene	20	--	5.6	4.5	µg/Kg
Dibenzothiophene	20	--	5.6	4.5	µg/Kg
Phenanthrene	20	4.7	5.6	4.5	µg/Kg
Anthracene	20	--	5.6	4.5	µg/Kg
Methylphenanthrene, 1-	20	4.7	5.6	4.5	µg/Kg
Fluoranthene	20	4.7	5.6	4.5	µg/Kg
Pyrene	20	4.7	5.6	4.5	µg/Kg
Benz(a)anthracene	20	4.7	5.6	4.5	µg/Kg
Chrysene	20	4.7	5.6	4.5	µg/Kg
Benzo(b)fluoranthene	20	4.7	5.6	4.5	µg/Kg
Benzo(k)fluoranthene	20	--	5.6	4.5	µg/Kg
Benzo(e)pyrene	20	4.7	5.6	4.5	µg/Kg
Benzo(a)pyrene	20	4.7	5.6	4.5	µg/Kg
Perylene	20	4.7	5.6	4.5	µg/Kg
Indeno(1,2,3-c,d)pyrene	20	4.7	5.6	4.5	µg/Kg
Dibenz(a,h)anthracene	20	--	5.6	4.5	µg/Kg
Benzo(g,h,i)perylene	20	4.7	5.6	4.5	µg/Kg
Total PAHs					µg/Kg

Note: Highlighted value indicates that Achieved MRL value is greater than SAP Target MRL value

7.2 BIOLOGICAL TESTING QUALITY LAB CONTROL SUMMARY

The biological testing of the Bodega Bay Harbor Federal Channel sediments incorporated standard QA/QC procedures to ensure that the test results were valid, including the use of negative Lab Controls, positive Lab Controls, test replicates, and measurements of water quality during testing.

Quality assurance procedures that were used for sediment testing are consistent with methods described in the U.S.EPA/ACOE (1991) and U.S.EPA/ACOE (1998). Sediments for the bioassay testing were stored appropriately at ≤4°C and were used within the 8-week holding time period.

Sediment interstitial water characteristics were within test acceptability limits at the start of the tests.

All measurements of routine water quality characteristics were performed as described in the

PER Lab Standard Operating Procedures (SOPs). All biological testing water quality conditions were within the appropriate limits. Laboratory instruments were calibrated daily according to Lab SOPs, and calibration data were logged and initialed. All values in the report tables have been checked against the test data sheets and statistical reports where appropriate.

Negative Lab Control – The biological responses for the remaining test organisms at the negative Lab Control treatments were within acceptable limits for the sediment and sediment elutriate tests.

Positive Lab Control – The key test concentration-response LC and/or EC point estimates determined for each of the test species were within the respective typical response ranges for these species, indicating that these test organisms were responding to toxic stress in a typical fashion.

Concentration Response Relationships – The concentration-response relationships for the sediment elutriate tests and reference toxicant tests were evaluated as per EPA guidelines (EPA-821-B-00-004), and were determined to be acceptable.

7.3 TISSUE CHEMISTRY QA/QC SUMMARY

The QA/QC review entailed reviewing the contract lab data reports for tissue sample integrity, correct methodology, and compliance with all appropriate laboratory QA/QC requirements. QC results that did not comply with the analytical laboratory QA/QC limits are presented below (also, see final analytical reports in Appendices E and F for full case narratives). All sample analyses were performed using the appropriate methods as specified in the SAP. The overall data quality assessment found that all data were usable.

ALS Report K1600492

Lipids – The MRL for lipids was 0.01% wet weight; The SAP does not identify target MRLs for lipids in tissue samples. All sample results were above the MRL.

Dioxins/furans – Tissue samples were analyzed for polychlorinated dibenzodioxins and polychlorinated dibenzofurans using HRGC/HRMS according to EPA Method 8290A. Samples were received frozen on 1/27/16 and stored frozen until extraction on 1/29/16. Extracts were analyzed on 2/8/16. None of the samples or extracts were analyzed outside of method hold times.

The Method Reporting Limits (MRLs) for the dioxins/furans ranged from 0.385 to 5.86 µg/kg wet weight. The SAP does not identify target MRLs for dioxins in tissue samples. According to the case narrative provided by the analytical laboratory (ALS), detection limits were calculated for each analyte in each sample by measuring the height of the noise level for each quantitation ion for the associated labeled standard. The concentration equivalent to 2.5 times the height of the noise was then calculated using the appropriate response factor and the weight of the sample. The calculated concentration equaled the detection limit. All analytes detected in the tissue samples were at concentrations above the Estimated Detection Limit (EDL) but below the MRL and are J flagged.

- **Method Blank:** The Method Blank EQ160051-05 contained low levels of 1234678-HpCDD and OCDD above the EDL, but below the MRL. The associated compounds in the samples are flagged with ‘B’ flags where the sample result is less than ten times the level detected in the method blank.

- **LCS: EQ1600051-06**: A Laboratory Control Spike (LCS) sample was analyzed for this extraction batch. The batch quality control criteria for recovery were met.

- **MS/MSD: EQ1600051-01/EQ1600051-02**: A Matrix Spike/Matrix Spike Duplicate (MS/MSD) sample pair was analyzed for this extraction batch. The batch quality control criteria for recovery and relative percent difference were met.

- **K flags: Estimated Maximum Possible Concentration** - When the ion abundance ratios associated with a particular compound are outside the QC limits, samples are flagged with a 'K' flag. A 'K' flag indicates an estimated maximum possible concentration for the associated compound.

- **2378-TCDF:** Samples analyzed on the DB-5MSUI column were analyzed under conditions where sufficient separation between 2,3,7,8-TCDF and its closest eluter was achieved. Confirmation of this result was not required.

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

ALS Report K1600493

Lipids – The MRL for lipids was 0.01% wet weight; The SAP does not identify target MRLs for lipids in tissue samples. All sample results were above the laboratory MRL.

Dioxins/furans – Tissue samples were analyzed for polychlorinated dibenzodioxins and polychlorinated dibenzofurans using HRGC/HRMS according to EPA Method 8290A. Samples were received frozen on 1/27/16 and stored frozen until extraction on 2/1/16. Extracts were analyzed on 2/12/16. None of the samples or extracts were analyzed outside of method hold times.

The laboratory MRLs for the dioxins/furans ranged from 0.56 to 6.09 µg/kg wet weight. The SAP does not identify target MRLs for dioxins in tissue samples. According to the case narrative provided by the analytical laboratory (ALS), detection limits were calculated for each analyte in each sample by measuring the height of the noise level for each quantitation ion for the associated labeled standard. The concentration equivalent to 2.5 times the height of the noise was then calculated using the appropriate response factor and the weight of the sample. The calculated concentration equaled the detection limit.

- **Method Blank:** The Method Blank EQ1600055-03 contained low levels of 1,2,3,4,6,7,8-HpCDD and OCDD above the Estimated Detection Limit (EDL) but below the MRL. The associated compounds in the samples are flagged with 'B' flags where the sample result is less than ten times the level detected in the method blank.

- **LCS: EQ1600055-04**: A LCS sample was analyzed for this extraction batch. The batch quality control criteria for recovery were met.

- **MS/MSD: EQ1600055-01/EQ1600055-02**: A MS/MSD sample pair was analyzed for this extraction batch. The batch quality control criteria for recovery and relative percent difference were met.

- **Y flags – Labeled Standards:** Sample BB3-2015-C-Macoma-Day 28 had interference at 13C-12378 PeCDF, and the percent recovery of the labeled standard was 16.97%. Samples BB3-2015-D-Macoma-Day 28 and BB3-2015-E-Macoma-Day had recoveries of labeled standards for multiple analytes outside the respective limits. Samples that had recoveries of labeled standards outside the acceptance limits are flagged with 'Y' flags on the Labeled Compound summary pages. In all cases, the signal-to-noise ratios are greater than 10:1, making these data acceptable.

- **2378-TCDF:** All samples in service request K1600493 and the associated batch QC were not spiked with cleanup standard (37Cl-2378 TCDD) due to a laboratory miscommunication. The cleanup standard is not used for calculated results and does not affect the native and labeled results.

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

8 SUMMARY

The sediments proposed for dredging in support of the Bodega Bay Harbor Federal Channel maintenance dredging project were analyzed to determine the suitability for sediment placement in the ocean at the San Francisco Channel Bar Disposal Site (SF-8) near the Golden Gate Bridge or at the San Francisco Deep Ocean Disposal Site (SF-DODS). Again, please note that USACE will not place any material in the westernmost portion of SF-8 (outside of the 3-mile limit).

8.1 UNCONFINED AQUATIC DISPOSAL AT SF-8

Sediment containing greater than 80% sand is suitable for placement at SF-8 and SF-DODS. The ten discrete samples (BB1-2015-1, BB1-2015-2, BB1-2015-3, BB1-2015-4, BB2-2015-1, BB2-2015-2, BB2-2015-3, BB2-2015-4, BB3-2015-1, and BB3-2015-2) all contained greater than 80% sand; indicating that sediment in sampling areas BB1, BB2, BB3-1, and BB3-2 is suitable for placement at SF-8 and SF-DODS. The three composite samples (BB3-2015, BB4-2015, and SPC-2015) all contained less than 80% sand so material in sampling areas BB3-3, BB3-4, BB3-5, BB4, and SPC is not suitable for disposal at SF-8.

8.2 UNCONFINED AQUATIC DISPOSAL AT SF-DODS

Although each of the samples had various analytes with concentrations above the SF-DODS database values, the benthic test results indicated that sediment disposal would not result in significant toxicity. Sediment elutriate test results indicated that disposal would not exceed the LPC; thus, the narrative water quality objectives were met. Tables 8.1 and 8.2 summarize the results of the chemical and toxicological tests on composite samples BB3-2015, BB4-2015, and SPC-2015.

Based on these results, all of the sediments would be considered for SUAD at SF-DODS.

Table 8.1 Suitability Findings – Bulk Chemistry Suitability

	Bulk Sediment Chemistry Exceedances		
		Ecological Screening Levels	
Sample ID	**SF-DODS**	**Salt ERL/*TEL***	**Salt ERM/*PEL***
BB3-2015	Arsenic, Cadmium, Total Butylins, Total PAH	Nickel	Nickel
BB4-2015	Total Organic Carbon, Arsenic, Cadmium, Total Butylins, Total PAH	Mercury, Nickel, Total DDT	Nickel
SPC-2015	Total Organic Carbon, Arsenic, Cadmium, Total Butylins, Total PAH	Nickel	Nickel