REPORT ON
RESULTS OF CHEMICAL, PHYSICAL, AND BIOLOGICAL TESTING OF SEDIMENTS FROM THE MARIN COUNTY SERVICE AREA 29 AT PARADISE CAY MARIN COUNTY, CALIFORNIA

by

Haley & Aldrich, Inc.
Walnut Creek, California

for

Marin County
Department of Public Works
San Rafael, California

File No. 40636-002
18 February 2014

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18 February 2014
File No. 40636-002

U.S. Army Corps of Engineers
1455 Market Street
San Francisco, California 94105-2197

Attention: Mr. Rob Lawrence
Chief, Dredged Material Management Office

Subject: Results of Chemical, Physical, and Biological Testing of Sediments from
Marin County Service Area 29 at Paradise Cay
Marin County, California
USACE Permit #390201N
BCDC Permit #M94-68

Dear Mr. Lawrence:

Enclosed, please find the three copies of the report entitled *Results of Chemical, Physical and Biological Testing of Sediments from Marin County Service Area 29 at Paradise Cay* submitted on behalf of Marin County.

If you should have any questions during your review of this document, please do not hesitate to contact me via telephone at 415.748.2193 or email at sbodensteiner@HaleyAldrich.com.

Sincerely yours,
HALEY & ALDRICH, INC.

Scott Bodensteiner
Sediments Practice Client Leader

Enclosures

cc: Mr. Arn Aarreberg, CDF&W
Mr. Pat Balderama, Marin County
Ms. Elizabeth Christian, RWQCB
Ms. Leah Dreger, Weston Solutions
Ms. Brenda Goeden, BCDC
Mr. Don Oetzel, State Lands Commission
Ms. Melissa Scianni, USEPA
Ms. Korie Schaeffer, NMFS

EXECUTIVE SUMMARY

Sampling and analysis procedures were conducted in accordance with the *Sampling and Analysis Plan: Marin County Service Area 29 at Paradise Cay* (SAP) prepared by Haley & Aldrich, Inc. (Haley & Aldrich, 2013). Sediment samples were collected from the Paradise Cay (CSA 29) on 19 December 2013. Samples were subsequently analyzed for physical and chemical constituents and biological response following procedures described in the SAP to determine whether project area sediments are suitable for aquatic disposal at the in-Bay site at Alcatraz (SF-11).

After collection, samples were stored in a secured area at 4 ± 2°C. Samples were then processed and composited. Two sample composites were shipped to the analytical laboratories in coolers packed with ice. All chemical analyses and biological testing was performed within required holding times from sample collection. Table ES-I summarizes sample identifications and project participants. Analytical chemistry and bioassay data show that the CSA 29 sediments did not exhibit elevated contaminant concentrations relative to ambient San Francisco Bay concentrations, and did not elicit significantly toxic responses from any aquatic species tested.

TABLE ES-I.
Sample Collection and Analysis Summary

Sample Identification				Sampling and Analysis Delegation		
Individual Core IDs	Sample Composite IDs	*Calscience* Laboratory IDs	*Pacific EcoRisk Laboratory IDs*	Sample Collection and Grain Size	Chemistry	Bioassay
SC-1 SC-2 SC-3 SC-4 SC-5 SC-6 NC-1 NC-2 NC-3 NC-4 NC-5	SC-Comp NC-Comp	13-12-1800-2 13-12-1800-1	SC-Comp NC-Comp	*Haley & Aldrich Walnut Creek, CA* *Leviathan Environmental Services, Pleasant Hill, CA*	*Calscience Garden Grove, CA*	*Pacific EcoRisk, Fairfield, CA*

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ABBREVIATIONS AND ACRONYMS

ASC	ambient sediment concentration
BCDC	San Francisco Bay Conservation and Development Commission
BT	bioaccumulation trigger
C	Celsius
CEL	Calscience Environmental Laboratories
COC	chain-of-custody
CSA 29	County Service Area 29
CY	cubic yard
DMMO	Dredged Material Management Office
EC_{50}	effective concentration for 50 percent of population
EFH	Essential Fish Habitat
ELAP	Environmental Laboratory Accreditation Program
EPA	United States Environmental Protection Agency
g/L KCl	grams per liter potassium chloride
GPS	global positioning system
ITM	Inland Testing Manual
L	liter
LC_{50}	lethal concentration for 50 percent of population
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LMW	low molecular weight
LPC	Limiting Permissible Concentration
LSP	liquid suspended phase
LTMS	Long Term Management Strategy
MDLs	method detection limits
MET	modified elutriate test
mg/kg	milligrams per kilogram
µg/kg	micrograms per kilogram
MLLW	mean lower low water
MS	matrix spike
MSD	matrix spike duplicate
NAD	North American Datum
NMFS	National Marine Fisheries Service
OTM	Ocean Testing Manual
PAH	polyaromatic hydrocarbons
PCB	polychlorinated biphenyl
PCYH	Paradise Cay Yacht Harbor
PN	Public Notice
QA	quality assurance
QAPP	Quality Assurance Program Plan
QC	quality control
RL	reporting limit
RPD	relative percent difference
RWQCB	Regional Water Quality Control Board
SAP	sampling and analysis plan
TMDL	Total Maximum Daily Load

TOC	total organic carbon
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WAAS	Wide Angle Augmentation System

1. INTRODUCTION

1.1 Overview

Under U.S. Army Corps of Engineers (USACE) permit No. 390201N and San Francisco Bay Conservation and Development Commission (BCDC) permit No. M94-68, the County of Marin is planning to dredge shoaled sediments from the Paradise Cay navigation channels and fairways, and residential docks within County Service Area 29 (CSA 29). Paradise Cay is located in the western portion of San Francisco Bay on the north side of the Tiburon peninsula (Figure 1). As shown on Figure 2, it is occupied by CSA 29 to the south of the Cay's northern entrance channel, and the Paradise Cay Yacht Harbor (PCYH) to the north of this channel. The objective of the proposed dredging episode is to restore navigational depths for recreational watercraft by removing accumulated sediments from the navigation channels, fairways and docks of CSA 29. It should be noted that as shown in Figure 2, the County is not including the northern entrance channel in their current dredging plans. The proposed disposal site for the CSA 29 dredged material is the authorized aquatic disposal site near Alcatraz Island (SF-11).

The total volume of dredged material estimated for removal from the CSA 29 portion of Paradise Cay is 35,975 cubic yards (CY), which includes a 1-foot over dredge allowance. Estimated dredge volumes for the two distinct CSA 29 dredge areas are provided in Table I. These volumes were determined based on the bathymetric survey performed on 15 August 2013 by Sea Engineering Inc.

TABLE I
Estimated Dredge Material Volume (CY)

Dredge Area	Permitted Dredge Depth (feet MLLW)[a]	Acreage	Estimated Dredge Volumes		
			To Design Depth[a] (CY)	1-foot Over-depth (CY)	Total (CY)
CSA 29 North	-7	3.4	3,950	3,960	7,910
CSA 29 South	-7 and -8[b]	7.4	16,885	11,180	28,065
TOTAL	-	**10.8**	**20,835**	**15,140**	**35,975**

a Does not include a 1-foot over dredge tolerance.
b Permitted dredge depth in the Southern Entrance Channel is -8 feet. MLLW.

Haley & Aldrich conducted physical, chemical and biological analyses performed with samples collected on 19 December 2013 from the Paradise Cay (CSA 29). All procedures were performed in accordance with federal and regional guidance as outlined in:

1. *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual* (US Army Corps of Engineers/US Environmental Protection Agency [EPA], 1998), otherwise referred to as the Inland Testing Manual (ITM); and
2. Public Notice (PN) 01-01: *Guidelines for Implementing the Inland Testing Manual in the San Francisco Bay Region* (USACE/EPA, 2001).

Figure 1. Vicinity Map

Figure 2. Project Area Map

In addition to the requirements outlined in the documents cited in the previous page, sediment samples were collected and analyzed in compliance with the conservation measures recently promulgated by the National Marine Fisheries Service (NMFS) under the Long Term Management Strategy (LTMS) Essential Fish Habitat (EFH) Programmatic Consultation (USACE/EPA, 2012), as modified 6 March 2012. The following measures were taken in accordance with the EFH Programmatic Consultation:

1. In addition to the dredge-cut portion of the collected sediment cores, the 6-inch segment below the overdredge interval was kept and isolated for potential analysis should elevated contaminants be detected in the dredge-cut portion. This 6-inch interval is representative of the new, post-dredge sediment surface and is referred to as the "z-layer."
2. Polychlorinated biphenyl (PCB) congeners were analyzed instead of PCB aroclors, and additional polyaromatic hydrocarbon (PAH) analytes were analyzed as detailed in Section 2.

1.2 Organization

This report follows guidelines provided in the SAP and Public Notice (PN) 99-4: Sampling and Analysis Plan (Quality Assurance Project Plan) Guidance for Dredging Projects within the San Francisco District (EPA and USACE, 1999). This report is organized as follows:

- Section 1.0 – Introduction
- Section 2.0 – Sampling Program
- Section 3.0 – Methods
- Section 4.0 – Results
- Section 5.0 – Discussion
- Section 6.0 – References

2. SAMPLING PROGRAM

2.1 Test Area Designations

A total of 11 individual sediment core samples were collected from two distinct sample CSA 29 areas: North Cay and South Cay (Figures 3 and 4). Core samples were blended to form two composites for analysis as described in the following sections. A sufficient volume of sediment was collected at all stations to carry out all physical, chemical and biological analyses, while providing an adequate amount of archived material from which aliquots could be taken in case additional testing was necessary.

2.2 Sediment Collection

Haley & Aldrich field personnel collected 11 sediment core samples from the CSA 29 project area on 19 December 2013. The target and actual sampling locations along with recent bathymetric survey data are depicted on Figure 3 through Figure 4. Final sample location coordinates and sediment core lengths are presented in Table II. The target sample depths listed in Table II include the design dredge depth, a 1-foot overdepth tolerance, and a 6-inch z-layer. The authorized dredge depth in the CSA 29 south entrance channel is 1 foot deeper than rest of the project area. As such, the sample depth for the single sample location collected in that area (SC-6) is a foot deeper than the other 10 samples.

TABLE II.
Paradise Cay (CSA 29) Sediment Core Log

Station ID	Latitude	Longitude	Mudline Depth (-ft MLLW)	SAP Depth (-ft MLLW)[a]	Target Core Length (ft)	Retrieved Length (ft)	Segment Analyzed (ft)[b]
SC-1	37.91185	122.47949	6.6	8.5	1.9	2.8	1.4
SC-2	37.909933	122.47546	6.2	8.5	2.3	3.3	1.8
SC-3	37.91186	122.47568	6.4	8.5	2.1	2.0	1.6
SC-4	37.90942	122.47453	5.0	8.5	3.5	5.3	3.0
SC-5	37.90895	122.47314	4.3	8.5	4.2	5.3	3.7
SC-6	37.90889	122.47105	4.5	9.5	5.0	5.1	4.5
NC-1	37.91462	122.47811	5.7	8.5	2.8	2.7	2.3
NC-2	37.91303	122.47625	5.8	8.5	2.7	2.7	2.2
NC-3	37.91471	122.47681	6.7	8.5	1.8	2.5	1.3
NC-4	37.91476	122.47564	6.4	8.5	2.1	3.5	1.6
NC-5	37.91537	122.47495	4.8	8.5	3.7	3.8	3.2

a. All target depths included a 1-foot overdredge tolerance but does not include 0.5-foot z-layer collection.
b. Excess bottom material discarded for cores exceeding project specified target length.

Sediment samples were collected from a 19-foot sample vessel operated by Leviathan Environmental. All CSA 29 samples were collected with a push-core device consisting of an 8-foot long, 2-inch diameter lexan core barrel, brass flapper valve, and an 8-foot long PVC push handle. Prior to the initiation of field activities, GIS tools and USGS data were employed to determine sample location coordinates (NAD 83) for each sample location target specified in the SAP. During field operations, sample stations were located using visual aids and a Garmin™ Global Positioning System (GPS) that employs U.S. Government Wide Angle Augmentation System (WAAS) differential correction data.

DREDGE AREA

EXISTING RIP RAP (TYP.)

NC-5

NC-4

NC-3

NORTH WATERWAY

CHANNEL C

CHANNEL B

ST LUCIA PL

ST THOMAS WAY

JAMAICA ST

LEGEND

- SAMPLE, ACTUAL LOCATION
- SAMPLE, TARGET LOCATION
- STORM DRAIN OUTFALL
- DREDGE BOUNDARY
- RIP RAP

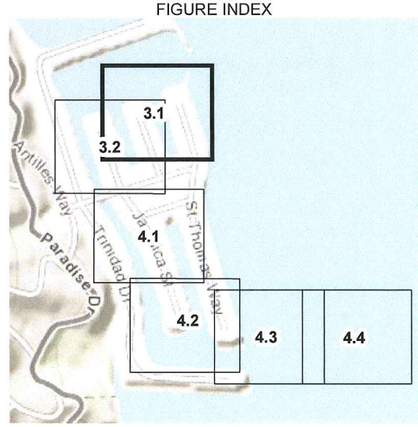
SOUNDING LABELS (MLLW)
SOUTH ENTRANCE CHANNEL: RED > -8' < BLACK
ALL OTHER CHANNELS: RED > -7' < BLACK

NOTE
BATHYMETRIC SURVEY PERFORMED BY
SEA ENGINEERING, INC. ON AUGUST 15, 2013

N
W E
S

0 80 160
SCALE IN FEET 1 INCH = 80 FEET

FIGURE INDEX



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PARADISE CAY, CALIFORNIA

CSA-29 NORTH CAY
PROPOSED SAMPLE LOCATIONS

SCALE: AS SHOWN
JANUARY 2014

FIGURE 3.1

G:\40536_Paradise_Cay\Global\GIS\MapProjects\40536-970-0000-ProposedSampleLocation_CSA-29_Mapbook.mxd -- 2/18/2014 2:20:44 PM -- crauimann

NC-1

NC-2

NC-3

NC-4

DREDGE BOUNDARY (TYP.)

SLOPE TOE (TYP.)

OVERDREDGE SLOPE TOE (TYP.)

CHANNEL A

CHANNEL B

TRINIDAD DR

JAMAICA ST

ST LUCIA PL

MARTINIQUE AVE

LEGEND

- SAMPLE, ACTUAL LOCATION
- SAMPLE, TARGET LOCATION
- STORM DRAIN OUTFALL
- DREDGE BOUNDARY
- RIP RAP

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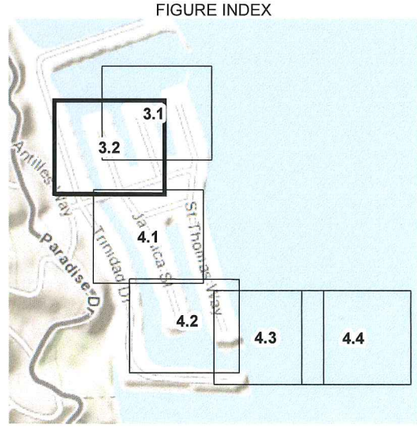

HALEY & ALDRICH

PARADISE CAY, CALIFORNIA

CSA-29 NORTH CAY
PROPOSED SAMPLE LOCATIONS

SCALE: AS SHOWN
JANUARY 2014

FIGURE 3.2

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LEGEND

- SAMPLE, ACTUAL LOCATION
- SAMPLE, TARGET LOCATION
- STORM DRAIN OUTFALL
- DREDGE BOUNDARY
- RIP RAP

SOUNDING LABELS (MLLW)
SOUTH ENTRANCE CHANNEL: RED > -8' < BLACK
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0 80 160
SCALE IN FEET 1 INCH = 80 FEET

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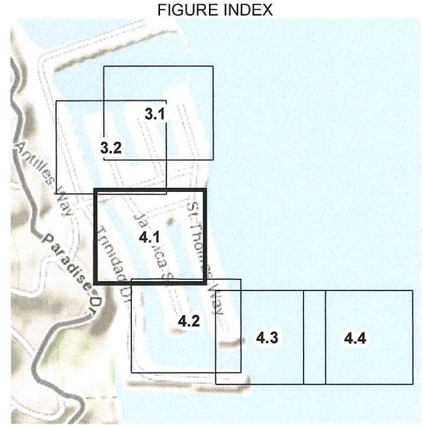

HALEY & ALDRICH

PARADISE CAY, CALIFORNIA

CSA-29 SOUTH CAY
PROPOSED SAMPLE LOCATIONS

SCALE: AS SHOWN
JANUARY 2014

FIGURE 4.1

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TRINIDAD DR

JAMAICA ST

ST THOMAS WAY

OVERDREDGE SLOPE TOE (TYP.)

SLOPE TOE (TYP.)

DREDGE BOUNDARY (TYP.)

SC-2

SC-4

SC-5

SOUTH WATERWAY

SOUTH WATERWAY

TRINIDAD DR

LEGEND

- SAMPLE, ACTUAL LOCATION
- SAMPLE, TARGET LOCATION
- STORM DRAIN OUTFALL
- DREDGE BOUNDARY
- RIP RAP

SOUNDING LABELS (MLLW)
SOUTH ENTRANCE CHANNEL: RED > -8' < BLACK
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NOTE
BATHYMETRIC SURVEY PERFORMED BY
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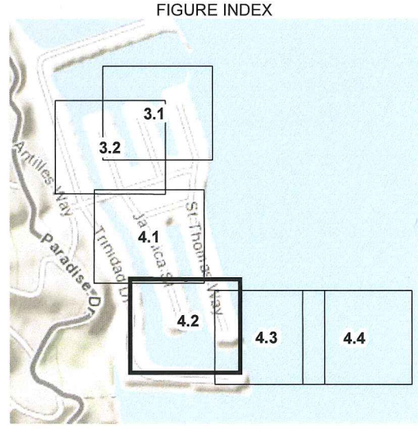

HALEY & ALDRICH

PARADISE CAY, CALIFORNIA

CSA-29 SOUTH CAY
PROPOSED SAMPLE LOCATIONS

SCALE: AS SHOWN
JANUARY 2014

FIGURE 4.2

G:\40636_Paradise_Cay\GlobalGIS\MapProjects\40636-970-0000-ProposedSampleLocation_CSA-29_Mapbook.mxd -- 2/19/2014 2:20:44 PM -- craumann

ST THOMAS WAY

DREDGE AREA

SOUTH WATERWAY

BEGIN -8.0 MLLW DREDGE DEPTH

SOUTH ENTRANCE CHANNEL

SC-5

SC-6

TOP OF SLOPE/DAYLIGHT
AT OVERDREDGE DEPTH (TYP.)
USED AS DREDGE AREA FOR
SOUTH ENTRANCE CHANNEL AREA

TOP OF SLOPE/DAYLIGHT (TYP.)

TRINIDAD DR

LEGEND

- SAMPLE, ACTUAL LOCATION
- SAMPLE, TARGET LOCATION
- STORM DRAIN OUTFALL
- DREDGE BOUNDARY
- RIP RAP

SOUNDING LABELS (MLLW)
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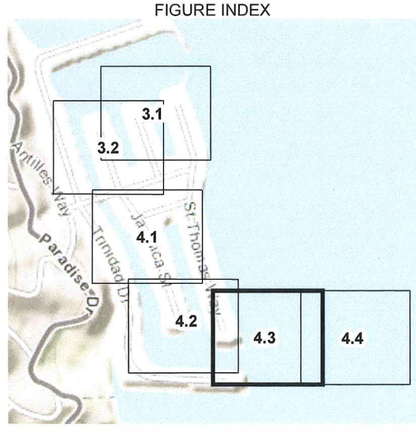

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PARADISE CAY, CALIFORNIA

CSA-29 SOUTH CAY
PROPOSED SAMPLE LOCATIONS

SCALE: AS SHOWN
JANUARY 2014

FIGURE 4.3

G:\40636_Paradise_Cay\Global\GIS\MapProjects\40636-970-0000-ProposedSampleLocation_CSA-29_Mapbook.mxd -- 2/18/2014 2:20:44 PM -- craumann

SC-6

LEGEND

- SAMPLE, ACTUAL LOCATION
- SAMPLE, TARGET LOCATION
- STORM DRAIN OUTFALL
- DREDGE BOUNDARY
- RIP RAP

SOUNDING LABELS (MLLW)
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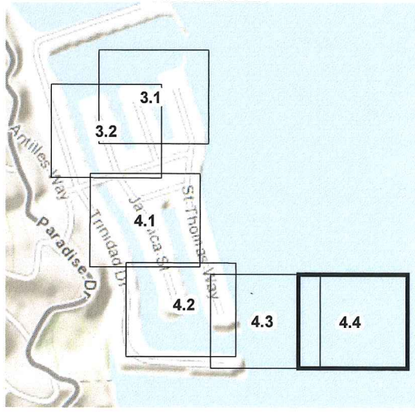

HALEY & ALDRICH

PARADISE CAY, CALIFORNIA

CSA-29 SOUTH CAY
PROPOSED SAMPLE LOCATIONS

SCALE: AS SHOWN
JANUARY 2014

FIGURE 4.4

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Once each sample station was located, the sampling vessel was maneuvered onto location and stabilized by deploying anchors or tying off to nearby docks. After the vessel was stabilized, station coordinates were recorded, and the push core system was deployed. Coordinates for each sample location were recorded on project log sheets as summarized in Table II. Once the push core device was retrieved, the cores were extruded onto PVC trays lined with a clean polyethylene sheathe, and penetration depth and sediment core retrieval lengths were measured and recorded. As shown in Table II, target core lengths were achieved within 0.1 foot at all sample locations. After measuring each core, they were characterized for color, texture and odor. These sensory observations are summarized in Table III. Copies of all coring logs are provided in Appendix A.

2.3 Sample Processing and Segmentation

After sensory characterization was performed with each core, the samples were segmented, homogenized and composited. Z-layer subsamples were first collected from all 11 sediment cores. The 0.4 to 0.5 foot of each core below the 1-foot overdepth was isolated using stainless steel utensils and placed in polyethylene sample containers that were sealed and stored on ice and later under refrigerated conditions. The dredge-cut portion of the sediment core was then homogenized in a 5-gallon bucket lined with a polyethylene bag using clean stainless steel utensils. A subsample of the homogenate was transferred to a 5-gallon container used for compositing (a separate container was used for each sample area), and the remainder of the sample homogenate was placed in a separate container, sealed and stored under refrigerated conditions with the z-layer subsamples. As each core homogenate was added to the compositing container, it was thoroughly blended with the sample area material already present in the container. After sampling was complete, composite subsamples from both sample area containers were placed in two 8 ounce glass jars with Teflon-lined lids, and the master composite containers were securely sealed with minimal headspace. Composite samples were then stored on ice until shipped at the end of the day.

2.4 Sample Shipping and Storage

All transport and shipping of samples was done under chain-of-custody (COC). Composite samples contained in the glass jars were wrapped in bubble wrap, and securely packed inside a cooler on ice to be shipped to CalScience for chemical analysis. The two master composite containers were packed on ice in separate coolers to be shipped to Pacific EcoRisk for bioassay testing. The COC forms were completed, and the original signed COC forms were inserted in a re-sealable plastic bag and placed inside each cooler. The cooler lids were then securely taped shut. Samples were maintained and stored in the dark at 4°C until used for testing.

2.5 Control Sediment and Site Water Collection

In lieu of collecting an SF-11 reference sample, the SF-11 reference database provided in PN 93-2: *Testing Guidelines for Dredged Material Disposal at San Francisco Bay Sites* (USEPA and USACE, 1993) will be used for data comparison. Control sediments used in the benthic bioassays were collected from the test organisms' native environment by test organism suppliers.

A site water sample (approximately 40 liters [L]) was collected from the sampling area for use in preparation of elutriates for water column bioassay testing. The site water sample was collected by submersing 20-L polyethylene cubitainers® below the water surface, allowing them to entirely fill without headspace.

TABLE III.
Physical Characterization of Sediment Cores – Paradise Cay (CSA 29)

Sample ID	Sediment Depth (feet)	Color	Odor	Sediment Type
SC-1	0 – 1.0	Olive	Slight organic decay	Silt
	1.0 – 1.4	Olive gray	None	Clayey silt
SC-1-Z	1.4– 1.9			Silty clay
SC-2	0 – 1.0	Olive	Slight organic decay	Silt
	1.0 – 1.8	Olive gray	None	Clayey silt
SC-2-Z	1.8 – 2.3			Silty clay
SC-3	0 – 1.0	Olive	None	Silt
	1.0 – 1.6	Olive gray		Clayey silt
SC-3-Z	1.6 – 2.0			
SC-4	0 – 1.0	Olive	None	Silt
	1.0 – 2.0	Olive gray		Clayey silt
	2.0 - 3.0			Silty clay
SC-4-Z	3.0 - 3.5			
SC-5	0 – 1.0	Olive	Slight organic decay	Silt
	1.0 – 2.0	Olive gray	None	Clayey silt
	2.0 - 3.7			Silty clay
SC-5-Z	3.7 – 4.2			
SC-6	0 – 1.0	Olive	None	Silt
	1.0 – 2.0	Olive gray		Silty clay
	2.0 – 4.5			
SC-6-Z	4.5 – 5.0			
NC-1	0 – 1.0	Olive	None	Silt
	1.0 – 2.3	Olive gray		Clayey silt
NC-1-Z	2.3 – 2.8			Silty clay
NC-2	0 – 1.0	Olive	Organic decay	Silt
	1.0 – 2.2	Olive gray	None	Clayey silt
NC-2-Z	2.2 – 2.7			Silty clay
NC-3	0 – 1.0	Olive	None	Silt
	1.0 – 1.3	Olive gray		Clayey silt
NC-3-Z	1.3 – 1.8			
NC-4	0 – 0.5	Olive	None	Silt
	0.5 – 1.6	Olive gray		Clayey silt
NC-4-Z	1.6 – 2.1			
NC-5	0 – 1.0	Olive	None	Silt
	1.0 – 3.2	Olive gray		Clayey silt
NC-5-Z	3.2 -3.7			

2.6 Decontamination of Field and Laboratory Equipment

All sampling equipment was cleaned prior to sampling. Between stations, the core barrel and deck of the vessel were rinsed thoroughly with site water. After the completion of sampling in the first sample area, all sampling equipment was cleaned with a mixture of Alconox® and site water then rinsed thoroughly with site water before initiating sample operations in the next sample area. Before creating each composite, all stainless steel utensils were cleaned with a mixture of Alconox® and water and then rinsed three times with deionized water.

2.7 Documentation and Chain-of-Custody

Samples were considered to be in custody if they were 1) in the custodian's possession or view, or 2) retained in a secured place (under lock) with restricted access. The principal documents used to identify samples and to document possession were COC records, field logbooks, and field tracking forms. COC procedures were used for all samples throughout the collection, transport, and analytical process and for all data and data documentation, whether in hard copy or electronic format.

COC procedures were initiated during sample collection. A COC record was provided with each sample or sample group. Each person who had custody of the samples signed the form and ensured that the samples were not left unattended unless properly secured. Documentation of sample handling and custody included the following:

- Sample identifier
- Sample collection date and time
- Any special notations on sample characteristics
- Initials of the person collecting the sample
- Date the sample was sent to the laboratory
- Shipping company and waybill information

Completed COC forms were placed in a plastic envelope that traveled inside the ice chest containing the listed samples. The COC form was signed by the person transferring custody of the samples. The condition of the samples was recorded by the receiver. COC records are included in the final analytical report prepared by the laboratory.

3. METHODS

3.1 Introduction

Results of the chemical, physical, and biological analyses of the dredge-cut sediment composites created with samples collected from CSA 29 were evaluated to determine the material's suitability for in-Bay aquatic disposal at SF-11. All sampling procedures were conducted in accordance with the SAP (Haley & Aldrich, 2013). The specific methods used for each chemical and biological analysis are summarized in the following tables.

Chemical analyses were performed by Calscience Environmental Laboratories, Inc. (CEL) in Garden Grove, California – a State of California accredited laboratory using USACE, EPA, or other Environmental Laboratory Accreditation Program (ELAP) approved test methods. Analytical chemistry methods and achieved detection limits are provided in Table IV. Acute toxicity bioassays (one water column and two benthic) were performed by Pacific EcoRisk Laboratories in accordance with the SAP (Haley & Aldrich, 2013). The bioassays performed are summarized in Table V and the bioassay methods utilized for each protocol are provided in Tables VI through VIII.

TABLE IV
Analytical Methods and Detection Limits for Sediment Analyses 2013 Paradise Cay (CSA 29) Sediment Evaluation

Analyte	SAP-Specified Method	Method Used	Target Detection Limits	Achieved MDLs	Achieved RLs
Physical/Conventional Tests					
Total solids (%)	SMEWW 2540G	SM2540 B	0.1	0.100	0.100
Total organic carbon (%)	EPA 415.1	EPA 9060A		0.019	0.079-0.80
Grain size (%)	Plumb (1981)	Plumb (1981)		0.01	0.01
Total sulfides (mg/kg)	Plumb (1981)	EPA 376.2 (M)		0.13-0.67	0.16-0.79
Dissolved sulfides (mg/kg)	SMEWW 4500	EPA 376.2 (M)		0.017	0.10
Metals (mg/kg)					
Arsenic	EPA 6020	EPA 6020	2.0	0.138-0.140	0.158-0.160
Cadmium			0.3	0.091-0.092	0.158-0.160
Chromium			5.0	0.098-0.100	0.158-0.160
Copper			5.0	0.066-0.067	0.158-0.160
Lead			5.0	0.104-0.106	0.158-0.160
Mercury	EPA 7471	EPA 7471A	0.02	0.0093-0.0094	0.0318-0.0321
Nickel	EPA 6020	EPA 6020	5.0	0.0802-0.0811	0.158-0.160
Selenium	EPA 7742		0.1	0.116-0.117	0.158-0.160
Silver	EPA 6020		0.2	0.0496-0.0502	0.158-0.160
Zinc			1.0	1.26-1.27	1.58-1.60
Organotins (µg/kg)					
Monobutyltin	Krone et al, 1996	Krone, 1989	10	1.0	4.8
Dibutyltin				1.0	4.8
Tributyltin				0.91-0.92	4.8
Tetrabutyltin				1.2	4.8

TABLE IV
Analytical Methods and Detection Limits for Sediment Analyses 2013 Paradise Cay (CSA 29)
Sediment Evaluation (Continued)

Analyte	SAP-Specified Method	Method Used	Target Detection Limits	Achieved MDLs	Achieved RLs
PAHs (µg/kg)					
1,6,7-Trimethylnaphthalene	EPA 8270C SIM	EPA 8270C SIM	20	2.2-2.3	16
1-Methylnaphthalene				2.6-3.2	16
1-Methylphenanthrene				2.6-2.7	16
2,3,5-Trimethylnaphthalene				2.9	16
2,6-Dimethylnaphthalene				2.9	16
2-Methylnaphthalene				2.4	16
Acenaphthene				1.3	16
Acenaphthylene				2.5	16
Anthracene				1.6	16
Benzo(a)anthracene				1.6	16
Benzo(a)pyrene				2.4	16
Benzo(b)floranthene				1.5	16
Benzo(e)pyrene				2.2	16
Benzo(g,h,i)perylene				2.2	16
Benzo(k)floranthene				1.9	16
Biphenyl				1.6	16
Chrysene				1.7	16
Dibenzo(a,h)anthracene				2.1-2.2	16
Dibenzothiophene				1.6	16
Floranthene				2.3-2.4	16
Fluorene				1.7	16
Indeno(1,2,3-cd)pyrene				4.8	16
Naphthalene				2.8	16
Phenanthrene				1.6	16
Perylene				1.6	16
Pyrene				2.2-2.3	16
Pesticides (µg/kg)					
Aldrin	EPA 8081A	EPA 8081A	2	0.50	1.6
Alpha-BHC				0.51-0.52	1.6
Beta-BHC				0.42	1.6
Delta-BHC				0.41	1.6
Gamma-BHC				0.55	1.6
Chlordane			20	5.2	16
2,4'-DDD			2	0.54	1.6
2,4'-DDE				0.48-0.49	1.6
2,4'-DDT				0.48	1.6
4,4'-DDD				0.50-0.51	1.6
4,4'-DDE				0.47-0.48	1.6
4,4'-DDT				0.53-0.54	1.6
Dieldrin				0.52-0.53	1.6
Endosulfan I				0.42	1.6
Endosulfan II				0.44-0.45	1.6
Endosulfan Sulfate				0.54	1.6
Endrin Aldehyde				0.39	1.6
Heptachlor				0.51-0.52	1.6
Heptachlor Epoxide				0.56-0.57	1.6
Methoxychlor				0.51-0.52	1.6
Toxaphene			20	10	32

TABLE IV
Analytical Methods and Detection Limits for Sediment Analyses 2013 Paradise Cay (CSA 29)
Sediment Evaluation (Continued)

Analyte	SAP-Specified Method	Method Used	Target Detection Limits	Achieved MDLs	Achieved RLs
Congener PCBs (µg/kg)					
PCB008	8270C SIM	8270C SIM	1	0.13-0.14	0.79-0.80
PCB018				0.25	0.79-0.80
PCB028				0.16	0.79-0.80
PCB031				0.18-0.19	0.79-0.80
PCB033				0.17	0.79-0.80
PCB044				0.21	0.79-0.80
PCB049				0.19	0.79-0.80
PCB052				0.15-0.16	0.79-0.80
PCB056				0.22	0.79-0.80
PCB060				0.17	0.79-0.80
PCB066				0.14-0.15	0.79-0.80
PCB070				0.13	0.79-0.80
PCB074				0.15	0.79-0.80
PCB087				0.16	0.79-0.80
PCB095				0.26-0.27	0.79-0.80
PCB097				0.22	0.79-0.80
PCB099				0.14	0.79-0.80
PCB101				0.13	0.79-0.80
PCB105				0.17	0.79-0.80
PCB110				0.16-0.17	0.79-0.80
PCB118				0.21	0.79-0.80
PCB128				0.16	0.79-0.80
PCB132				0.26-0.27	0.79-0.80
PCB138/158				0.32-0.33	1.6
PCB141				0.18	0.79-0.80
PCB149				0.14	0.79-0.80
PCB151				0.16-0.17	0.79-0.80
PCB153				0.16-0.17	0.79-0.80
PCB156				0.16	0.79-0.80
PCB170				0.15	0.79-0.80
PCB174				0.17	0.79-0.80
PCB177				0.20	0.79-0.80
PCB180				0.097-0.098	0.79-0.80
PCB183				0.18	0.79-0.80
PCB187				0.17	0.79-0.80
PCB194				0.15	0.79-0.80
PCB195				0.083-0.084	0.79-0.80
PCB201				0.090-0.091	0.79-0.80
PCB203				0.17	0.79-0.80

TABLE V
Biological Testing Summary

Type of Organism	Taxon	Water Column Toxicity Test	Benthic Toxicity Test	Control Media	Reference Toxicant Tests[a]
Bivalve larvae	*Mytilus galloprovincialis*	X	-	SW	X
Amphipod	*Ampelisca abdita*	-	X	N	X
Polychaete	*Neanthes arenaceodentata*	-	X	N	X

a. Standard toxicants to be used as a positive control.
SW = Site Water
N = Native sediments collected from areas in which the test organisms naturally reside.

TABLE VI
Procedure and Organism Data: 48-hour Water Column Bioassay Using *Mytilus galloprovincialis*

Sample Identification		
Sample identification(s)	NC-Comp and SC-Comp	
Date sampled	21 December 2013	
Date received	22 December 2013	
Volume received	Approximately 15 L per composite	
Sample storage conditions	4°C – dark	
Sample treatment	4:1 Site water to sediment mix and decant	
Test Species – *Mytilus galloprovincialis*		
Supplier	M-REP	
Date acquired	9 January 2014	
Acclimation time	48 hours	
Age group	Adult	
Test Procedures		
Test location	Pacific EcoRisk Laboratory	
Test type; duration	Static – Acute; 10 days	
Test dates	9 - 11 January 2014	
Control water source	Granite Canyon seawater, .45 µm filtered	
Test photoperiod	16-hours light, eight-hours dark	
Test chamber	20 mL scintillation vials	
Replicates/treatment	5	
Organisms/replicate	22–45 / mL	
Exposure volume	10 mL	
Feeding	None	
Water renewal	None	
Test temperature (°C)	Recommended: 16 ± 1	Actual: 15.1 – 15.7
Test salinity (ppt)	Recommended: 30 ± 1	Actual: 28.6 – 30.3
Test dissolved oxygen (mg/L)	Recommended: > 4.5	Actual: 6.1 – 9.3
Test pH	Recommended: 7.8 ± 0.5	Actual: 7.57 – 8.01
Deviations from procedures	No significant deviations observed	

TABLE VII
Procedure and Organism Data: 10-Day Benthic Toxicity Bioassay Using *Ampelisca abdita*

Sample Identification		
Sample identification(s)	NC-Comp and SC-Comp	
Dates sampled	21 December 2013	
Date received	22 December 2013	
Volume received	Approximately 15 L per composite	
Sample storage conditions	4°C, dark, minimal head space	
Test Species – Ampelisca abdita		
Supplier	Collected by Pacific EcoRisk	
Date acquired	21 December 2013	
Acclimation time	15 days	
Age group	Immature amphipods	
Test Procedures		
Test location	Pacific EcoRisk Laboratory	
Test type; duration	Static – acute; 10 days	
Test dates	4 January – 14 January 2014	
Control water source	Granite Canyon seawater, 0.45 µm filtered	
Test photoperiod	Continuous light	
Test chamber	1-L glass jars	
Replicates/treatment	5	
Organisms/replicate	20	
Exposure volume	4 cm sediment, 800 mL water	
Feeding	None	
Water renewal	None	
Test temperature (°C)	Recommended: 20 ± 1	Actual: 19.6 – 20.0
Test salinity (ppt)	Recommended: 28 ± 2	Actual: 27.4 – 29.8
Test dissolved oxygen (mg/L)	Recommended: > 6.0	Actual: 7.1 – 8.1
Test pH	Recommended: 7.8 ± 0.5	Actual: 7.57 – 8.37
Deviations from procedures	No significant deviations observed	

TABLE VIII
Procedure and Organism Data: 10-Day Benthic Toxicity Bioassay Using *Neanthes arenaceodentata*

Sample Identification		
Sample identification(s)	NC-Comp and SC-Comp	
Dates sampled	21 December 2013	
Date received	22 December 2013	
Volume received	Approximately 15 L per composite	
Sample storage conditions	4°C, dark, minimal head space	
Test Species – Neanthes arenaceodentata		
Supplier	Aquatic Toxicology Support	
Date acquired	5 January 2014	
Acclimation time	<1 day	
Age group	3 week post emergence	
Test Procedures		
Test location	Pacific EcoRisk Laboratory	
Test type; duration	Static – Acute; 10 days	
Test dates	5 January – 15 January 2014	
Control water source	Granite Canyon seawater, .45 µm filtered	
Test photoperiod	Continuous light	
Test chamber	2-L glass jars	
Replicates/treatment	5	
Organisms/replicate	10	
Exposure volume	2 cm sediment, 1500 mL water	
Feeding	None	
Water renewal	None	
Test temperature (°C)	Recommended: 20 ± 1	Actual: 19.5 – 20.0
Test salinity (ppt)	Recommended: 28 ± 2	Actual: 29.1 – 31.9
Test dissolved oxygen (mg/L)	Recommended: > 6.0	Actual: 7.5 – 8.9
Test pH	Recommended: 7.8 ± 0.5	Actual: 7.73 – 8.33
Deviations from procedures	No significant deviations observed	

4. RESULTS

4.1 Introduction

Results of the physical, chemical and biological analyses of the CSA 29 sediment samples are reported in this section to determine suitability for placement at SF-11. The analytical chemistry report is provided in Appendix B, and the bioassay laboratory report is provided in Appendix C.

4.2 Standard Chemical Analysis of Sediment Samples

Results of all analytical chemistry testing performed with the two CSA 29 composite samples (SC-Comp and NC-Comp) are provided in Table IX. Aquatic disposal reference values from the SF-11 database and established San Francisco Bay ambient sediment concentrations (ASCs), including bioaccumulation trigger (BT) and Total Maximum Daily Load (TMDL) thresholds for key contaminants are also provided in these tables.

4.2.1 Conventional and Metals Analyses

As shown in Table IX, the CSA 29 composite samples were predominantly comprised of fine-grained material (>98% silts and clays) making it difficult to compare composite chemical concentrations to the SF-11 database ranges, which are based on samples comprised of primarily sand. The total organic carbon (TOC) levels reported for the composites were both 1.2%.

With the exception of zinc, method detection limits (MDLs) for all metals were below SAP target detection limits. However, the reported MDLs for zinc exceeded the target by a nominal margin (0.26 and 0.27 milligrams per kilogram [mg/kg]), and zinc was detected in both composite samples at concentrations higher than the achieved reporting limit (RL) (Table IV). Therefore this SAP deviation is not considered significant.

Metals measured in the two CSA 29 composite samples were all lower than ASCs. The reported mercury concentrations were 0.30 and 0.31 mg/kg lower than the TMDL threshold concentration for San Francisco Bay.

4.2.2 Organic Sediment Analyses

The MDLs achieved for organic constituents were all below the targeted SAP detection limits (Table IV). As shown in Table IX, multiple PAH compounds were detected in the composite sample. The total PAH concentration reported for the NC-Comp and SC-Comp samples were 136 and 111 micrograms per kilogram (µg/kg), respectively, both well below ASCs and the San Francisco Bay BT. No other organic constituents were detected in the CSA 29 composite samples.

TABLE IX

Results of Chemical and Physical Analyses of 2013 CSA 29 Sediment Samples

Analyte		NC-COMP	SC-COMP	SF Bay Ambient Levels[a]	SF-11 Database Values
Conventionals					
Grain size (%)	Gravel	ND	ND	NA	0 – 17
	Sand	1.02	ND		81 – 98
	Silt	66.88	63.49		0 – 3
	Clay	32.10	36.51		0 – 6
Total organic carbon (%)		1.2	1.2		0.07 – 0.19
Total sulfide (mg/kg)		24	1.3		0.1
Dissolved Sulfide (mg/kg)		<0.017	<0.017		0.1
Total solids (%)		63.1	62.4		1.32 – 2.60
Metals (mg/kg)					
Arsenic		6.52	6.24	15.3	13.2
Cadmium		0.321	0.291	0.33	0.35
Chromium		49.5	50.3	112	121
Copper		36.1	38.8	68.1	12.4
Lead		14.1	15.1	43.2	14.4
Mercury		0.158	0.169	0.47[g]	0.156
Nickel		49.6	51.3	112	40.7
Selenium		0.246	<0.117	0.64	0.41
Silver		0.182	0.201	0.58	< 0.10
Zinc		73.3	85.6	158	106.8
Pesticides (µg/kg)					
Aldrin		<0.50	<0.50	NA	ND
alpha-BHC		<0.51	<0.52		
beta-BHC		<0.42	<0.42		
gamma-BHC		<0.55	<0.55		
delta-BHC (Lindane)		<0.41	<0.41		
Total BHC		<0.55	<0.55		
Total Chlordane		<5.2	<5.2	37[c]	
2,4'-DDD		<0.54	<0.54	NA	
4,4'-DDD		<0.50	<0.51		
2,4'-DDE		<0.48	<0.49		
4,4'-DDE		<0.47	<0.48		
2,4'-DDT		<0.48	<0.48		
4,4'-DDT		<0.53	1.1		
Total DDT		<0.54	1.1	7	
Dieldrin		<0.52	<0.53	1.9[c]	
Endosulfan I		<0.42	<0.42	NA	
Endosulfan II		<0.44	<0.45		
Endosulfan sulfate		<0.54	<0.54		
Endrin		<0.57	<0.57		
Endrin aldehyde		<0.39	<0.39		
Endrin Ketone		<0.55	<0.56		
Heptachlor		<0.51	<0.52		
Heptachlor epoxide		<0.56	<0.57		
Methoxychlor		<0.51	<0.52		
Toxaphene		<10	<10		

TABLE IX
Results of Chemical and Physical Analyses of 2013 CSA 29 Sediment Samples (Continued)

Analyte	NC-COMP	SC-COMP	SF Bay Ambient Levels[a]	SF-11 Database Values
PAHs (µg/kg)				
Acenaphthene	<2.9	<2.9	NA	NA
Acenaphthylene	<2.4	<2.4		
Anthracene	2.3	<1.3		
Benzo (a) Anthracene	6.5	5.5		
Benzo (a) Pyrene	8.9	7.1		
Benzo (b) Fluoranthene	8.8	6.0		
Benzo (e) Pyrene	6.8	5.4		
Benzo (g,h,i) Perylene	10	7.7		
Benzo (k) Fluoranthene	5.7	5.0		
Biphenyl	<2.2	<2.2		
Chrysene	6.2	5.2		
Dibenz (a,h) Anthracene	<1.6	<1.7		
2,6-Dimethylnaphthalene	<2.6	<2.7		
Fluoranthene	8.1	7.0		
Fluorene	<2.3	<2.4		
Indeno (1,2,3-c,d) Pyrene	8.3	6.1		
2-Methylnaphthalene	<2.9	<2.9		
1-Methylnaphthalene	<3.2	<3.2		
1-Methylphenanthrene	<2.6	<2.6		
Naphthalene	5.7	4.9		
Perylene	8.5	4.9		
Phenanthrene	6.8	4.7		
Pyrene	16	13		
1,6,7-Trimethylnaphthalene	<2.2	<2.3		
Dibenzothiophene	<2.1	<2.2		
Total Detected LMW PAHs	14.8	9.6	NA	NA
Total LMW PAHs[b]	22.4	18.6	464	374
Total Detected HMW PAHs	93.8	72.9	NA	NA
Total HMW PAHs[b]	113	92.7	3,478	1,246
Total Detected PAHs	109	82.5	NA	NA
Total PAH[b]	136	111	4,500[c]	1,620
Organotins (µg/kg)				
Monobutyltin	<4.8	<4.8	NA	NA
Dibutyltin	<4.8	<4.8	NA	NA
Tributyltin	<4.8	<4.8	NA	NA
Tetrabutyltin	<4.8	<4.8	NA	NA

TABLE IX

Results of Chemical and Physical Analyses of 2013 CSA 29 Sediment Samples (Continued)

Analyte	NC-COMP	SC-COMP	SF Bay Ambient Levels[a]	SF-11 Database Values
PCB008	<0.13	<0.14		
PCB018	<0.25	<0.25		
PCB028	<0.16	<0.16		
PCB031	<0.18	<0.19		
PCB033	<0.17	<0.17		
PCB044	<0.21	<0.21		
PCB049	<0.19	<0.19		
PCB052	<0.15	<0.16		
PCB056	<0.22	<0.22		
PCB060	<0.17	<0.17		
PCB066	<0.14	<0.15		
PCB070	<0.13	<0.13		
PCB074	<0.15	<0.15		
PCB087	<0.16	<0.16		
PCB095	<0.26	<0.27		
PCB097	<0.22	<0.22		
PCB099	<0.14	<0.14		
PCB101	<0.13	<0.13		
PCB105	<0.17	<0.17		
PCB110	<0.16	<0.17	NA	NA
PCB118	<0.21	<0.21		
PCB128	<0.16	<0.16		
PCB132	<0.26	<0.27		
PCB138/158	<0.32	<0.33		
PCB141	<0.18	<0.18		
PCB149	<0.14	<0.14		
PCB151	<0.16	<0.17		
PCB153	<0.16	<0.17		
PCB156	<0.16	<0.16		
PCB170	<0.15	<0.15		
PCB174	<0.17	<0.17		
PCB177	<0.20	<0.20		
PCB180	<0.097	<0.098		
PCB183	<0.18	<0.18		
PCB187	<0.17	<0.17		
PCB194	<0.15	<0.15		
PCB195	<0.083	<0.084		
PCB201	<0.090	<0.091		
PCB203	<0.17	<0.17		
Total PCB	<0.32	<0.33	18[c]	NA

***Notes:** Exceedance of a reference value does not equate to an expectation of adverse ecological impacts.

NA = Not Available

Italicized analytes indicate Low Molecular Weight PAHs

a. Ambient levels reported for fine grained sediment (RWQCB, 1998) or in-Bay BT or TMDL (SFEI, 2013)

b. Total PAH = detected plus sum of MDLs among undetected analytes

c. 2014 In-Bay BT for PCBs, PAHs, chlordane and dieldrin; and TMDL for Hg (PCB TMDL = 29.6 µg/kg) as reported by SFEI.

4.3 Bioassay Results

Bioassays were performed with CSA 29 sediment composite samples to support a suitability determination for aquatic disposal at SF-11. One water column toxicity bioassay and two benthic toxicity bioassays were conducted

4.3.1 Water Column Toxicity Bioassays

Water column toxicity testing was performed to ascertain whether CSA 29 dredged material will have an adverse impact within the water column environment at SF-11. Results were statistically evaluated against site water control data and were then used to calculate the Limiting Permissible Concentration (LPC) for SF-11.

4.3.1.1 *Mytilus galloprovincialis* Water Column Toxicity Bioassay

Results of the water column test with *M. galloprovincialis* are presented in Table X. There were no significant deviations from the acceptable ranges for the water quality parameters measured during this bioassay, and there were no other significant deviations from procedural protocol during testing.

Mean percentage of normally developed laboratory control embryos relative to the initial embryo density was 97.7%, exceeding the passing criteria for this test (>70%). The rate of normal development among site water control treatments was 85.9%. The site water control treatment results were used for calculating the EC_{50} values. Statistical analysis of the NC-Comp and SC-Comp samples resulted in EC_{50} values of 70.6% and >100%, respectively.

The mean *M. galloprovincialis* survival rate calculated for the laboratory control was 87.3% and the mean survival rate for the site water control was 99.2%. The calculation of LC_{50} values for the NC-Comp and SC-Comp samples resulted in EC_{50} values of 70.7% and >100%, respectively.

The potassium chloride reference toxicant was tested at nominal concentrations of 0.5, 1, 2, 3, and 4 g/L KCl. The calculated EC50 was 2.3 g/L KCl, which was within two standard deviations of the lab mean (2.1 – 2.5 g/L KCl), indicating normal sensitivity based on development. Reference toxicant results are summarized in Table XI.

4.3.1.2 Limiting Permissible Concentration

The calculation of the LPC shown in Table XII was modeled for the SF-11 disposal site using the mixing zone estimation model as described in the Ocean Testing Manual (OTM) (EPA and USACE, 1991).

For SF-11, the model projects the maximum concentration of liquid suspended phase (LSP) to be 0.154%. The toxicity threshold, calculated as 1% of the lowest EC_{50}, is 0.706% (from sample NC-Comp development endpoint), higher than the projected LSP concentration. Consequently, results of the water column test show that the CSA 29 sediment meets the LPC criteria for open water disposal at SF-11.

TABLE X
Water Column Toxicity Test Results Summary *Mytilus galloprovincialis* Development Endpoint

Sample Identification	Conc (%)	Mean % Normal	EC_{50} (%)	Mean % Survival	LC_{50} (%)
Lab Control	-	97.7	-	87.3	-
Site Control	-	85.9	-	99.2	-
NC-Comp	1	98.4	70.6	85.9	70.7
	10	98.3		88.2	
	50	97.9		87.3	
	100	0*		0*	
Lab Control	-	98.0	-	90.6	-
Site Control	-	99.2	-	85.9	-
SC-Comp	1	98.1	>100	86.6	>100
	10	99.0		84.6	
	50	98.7		84.8	
	100	97.7		80.3	

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

TABLE XI
Reference Toxicant Data Summary *Mytilus galloprovincialis*

KCl (g/L)	Mean % Normal Embryo Development	EC_{50} (g/L)
Control	98.7	2.3
0.5	99.1	
1	99.6	
2	87.9	
3	**0***	
4	**0***	

* The survival response at this treatment was significantly less than the Lab Control response at $p < 0.05$.
Typical Response Range (mean + 2SD): 2.1 – 2.5 g/L KCl
Sensitivity: Normal

TABLE XII
Calculation of the SF-11 Limiting Permissible Concentration

Project Site:	**Paradise Cay (CSA 29)**
Species:	***Mytilus galloprovincialis***
Disposal Site:	**SF-11**
Sample:	**NC-Comp (Development)**
Mixing Zone Estimation	
Depth of disposal site (m)	10.7
Pi	3.14159
Width of vessel (m)	10
Length of vessel(m)	40
Speed of vessel (m/sec)	0.5
Time of discharge (sec)	30
Depth of vessel (m)	5
Mixing zone volume(m^3)	481,135
Volume of Liquid Phase	
Bulk density (constant)	1.3
Particle density (constant)	2.6
Density of liquid phase (constant)	1
Volume of disposal vessel (m^3)	4,000
Liquid phase volume (m^3)	3,250
Concentration of Suspended Phase (SP)	
Percent silt	66.9
Percent clay	32.1
Volume of suspended phase (m^3)	743
Projected Concentration (% SP)	0.154
LC_{50} or EC_{50} from bioassay (%)	35.0
Factored LC_{50} or EC_{50} X 0.01	0.350
The LPC model approximates a suspended phase (SP) concentration of 0.154% at the edge of the mixing zone. The toxicity threshold (factored EC_{50}) of 0.706% is higher than the projected SP concentration; therefore, the LPC is not exceeded for Port of Redwood City dredged material.	

March 4, 2014
Revised Table XII
From: Results of Chemical, Physical, and Biological Testing of Sediments from Marin County Service Area 29 at Paradise Cay (Haley & Aldrich, 2014)

TABLE XII.
Calculation of the SF-11 Limiting Permissible Concentration

Project Site:	**Paradise Cay (CSA 29)**
Species:	***Mytilus galloprovincialis***
Disposal Site:	**SF-11**
Sample:	**NC-Comp (Embryo Development)**
Mixing Zone Estimation	
Depth of disposal site (m)	15
Pi	3.14159
Width of vessel (m)	10
Length of vessel (m)	40
Speed of vessel (m/sec)	0.5
Time of discharge (sec)	30
Depth of vessel (m)	5
Mixing zone volume (m^3)	674,489
Volume of Liquid Phase	
Bulk density (constant)	1.3
Particle density (constant)	2.6
Density of liquid phase (constant)	1
Volume of disposal vessel (m^3)	2,000
Liquid phase volume (m^3)	1,625
Concentration of Suspended Phase (SP)	
Percent silt	66.9
Percent clay	32.1
Volume of suspended phase (m^3)	371
Projected Concentration (% SP)	0.055
LC_{50} or EC_{50} from bioassay (%)	70.6
Factored LC_{50} or EC_{50} X 0.01	0.706
The LPC model approximates a suspended phase (SP) concentration of 0.055% at the edge of the mixing zone. The toxicity threshold (factored EC_{50}) of 0.706% is higher than the projected SP concentration; therefore, the LPC is not exceeded for CSA 29 dredged material.	

4.3.2 Benthic Toxicity Testing

In accordance with the SAP, two benthic bioassays were performed with the project composite samples. This testing was done to evaluate potential impacts of the CSA 29 dredged material to benthic communities present at the SF-11 aquatic disposal environment. Results of the two benthic bioassays are shown in Table XIII. A full bioassay data report for these tests is provided in Appendix C.

4.3.2.1 Amphipod Toxicity Bioassay

Amphipod bioassay testing was performed with the CSA 29 sediment samples using the amphipod *Ampelisca abdita*, and resulted in a control treatment survival rate of 96%. No significant exceedance of the acceptable water quality criteria were observed during the amphipod bioassay. The survival rate observed with the NC-Comp and SC-Comp sample treatments, 97% and 95%, respectively, both higher than the SF-11 database value for *A. abdita* survival (92%) indicating the CSA 29 sediments meet the amphipod toxicity criteria for aquatic disposal suitability.

The potassium chloride reference toxicant was tested at nominal concentrations of 0.25, 0.5, 1, 2, and 4 grams per liter potassium chloride (g/L KCl). The calculated LC_{50} for survival was 1.4 g/L KCl, which was within the typical response range considered to be two standard deviations of the laboratory mean (0.67 – 1.7 g/L KCl), indicating normal *A. abdita* sensitivity based on mortality. Results of *A. abdita* reference toxicant testing are provided in Table XIV.

4.3.2.2 Polychaete Benthic Toxicity Bioassay

No significant exceedance of the acceptable water quality criteria was observed during the benthic polychaete bioassay. Mean survival achieved for the 10-day *N. arenaceodentata* test was 100% for the laboratory control. Mean survival rate calculated for CSA 29 samples were also both 100%, indicating the sample meets the polychaete toxicity criteria for aquatic disposal suitability.

The potassium chloride reference toxicant was tested at nominal concentrations of 0.25, 0.5, 1, 2, and 4 g/L KCl. The calculated LC_{50} for survival was 1.4 g/L KCl, which was within the typical response range considered to be two standard deviations of the laboratory mean (1.1 – 2.2 g/L KCl), indicating normal polychaete sensitivity based on mortality. Results of *N. arenaceodentata* reference toxicant testing are summarized in Table XV.

Table XIII
Results Summary of Benthic Toxicity Results

Species	Sample Identification	% Survival (Mean ± SD)	% Survival per Replicate				
			A	B	C	D	E
A. abdita	Control	96 ± 4.2	95	100	95	90	100
	NC-Comp	97 ± 2.7	100	95	95	100	95
	SC-Comp	95 ± 3.5	95	95	95	100	90
N. arenaceodentata	Control	100 ± 0	100	100	100	100	100
	NC-Comp	100 ± 0	100	100	100	100	100
	SC-Comp	100 ± 0	100	100	100	100	100

TABLE XIV
Reference Toxicant Data Summary *Ampelisca abdita*

KCl (g/L)	Mean % Survival	LC_{50} (g/L)
Control	100	1.4
0.25	95.0	
0.5	95.0	
1	90.0	
2	5*	
4	0*	

* The survival response at this treatment was significantly less than the Lab Control response at $p < 0.05$.
Typical Response Range (mean + 2SD): 0.67 – 1.7 g/L KCl
Sensitivity: Normal

TABLE XV
Reference Toxicant Data Summary *Neanthes arenaceodentata*

KCl (g/L)	Mean % Survival	LC_{50} (g/L)
Control	100	1.4
0.25	100	
0.5	100	
1	100	
2	0*	
4	0*	

* The survival response at this treatment was significantly less than the Lab Control response at $p < 0.05$.
Typical Response Range (mean + 2SD): 1.1 – 2.2 g/L KCl
Sensitivity: Normal

4.4 Quality Control

4.4.1 Analytical Chemistry

Chemical analyses of sediment samples were validated through the use of QC applications. Method or reagent blank; laboratory control sample (LCS) and laboratory control sample duplicate (LSCD) analyses; and matrix spike (MS) and matrix spike duplicate (MSD) were performed at a frequency of 5% of the samples where applicable to the methodology. Recoveries of surrogates added to each sample, as well as the recovery of analytes from LCS/LCSD and MS/MSD samples were used to assess lab accuracy. The relative percent difference (RPD) between duplicates is used to assess lab precision. The samples were shipped and received in good condition within the acceptable temperature range of 4 $\pm$ 2°C. A detailed review of the quality assurance/quality control (QA/QC) parameters required under PN 99-4 is provided in the analytical chemistry reports (Appendices B and C).

4.4.2 Bioassay Quality Control

All bioassay toxicity tests followed method protocols and met QA/QC criteria with a few minor exceptions in water quality as noted in the preceding sections. None of the water quality protocol deviations were expected to affect test results. All toxicity test data underwent a 100% data review by Pacific EcoRisk's internal QA Officer.

5. DISCUSSION

The physical composition of material collected from the North Cay and South Cay sample areas of CSA 29 was very similar. All contaminants measured in both composite samples were either detected at concentrations below ASCs, BTs and TMDL thresholds, or were reported at levels below acceptable MDLs. In addition, the two composite samples met all aquatic disposal suitability criteria for both water column and benthic toxicity. Based on the preponderance of evidence exhibited with these results, the material proposed for dredging from both sample areas within CSA 29 should be considered suitable for aquatic disposal at SF-11.

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