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Field Report
Baseline Studies Conducted for the Designation of an Ocean Dredged Material Disposal Site, Apra Harbor, Guam

Draft Report

Prepared For:

Department of the Navy
Naval Facilities Engineering Command Pacific
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February 2009

WESTON SOLUTIONS

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ACRONYMS AND ABBREVIATIONS

ADCP	acoustic Doppler current profiler
ASTM	American Society of Testing and Materials
AVS	acid volatile sulfides
BP	bioaccumulation potential
CCC	Criteria Continuous Concentration
CMC	Criteria Maximum Concentration
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DI	deionized water
DDT	Dichlorodiphenyltrichloroethane
COC	Chain of Custody
CTD	Conductivity/Temperature/Depth
CVAFS	Cold Vapor Atomic Fluorescence Spectrometry
DGPS	differential Global Positioning System
DO	Dissolved Oxygen
DPS	Dynamic Positioning System
EC_{50}	median effective concentration
EDD	Electronic Data Deliverable
EDL	Estimated Detected Limit
EIS	Environmental Impact Statement
ELAP	Environmental Laboratory Accreditation Program
ER-L	Effects Range Low
ER-M	Effects Range Median
FID	Further Identification
GC/MS	Gas Chromatography/Mass Spectrometry
GEPA	Guam Environmental Protection Agency
GIS	Geographic Information System
GovGuam	Government of Guam
GPS	Global Positioning System
HDPE	high density polyethylene
HRGC/HRMS	high resolution gas chromatography-high resolution mass spectrometry
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ITM	Inland Testing Manual
MLLW	Mean Lower Low Water
MSAS	Multi-Functional Satellite Augmentation System
NAVFAC/PAC	Naval Facilities Engineering Command, Pacific
NAVOCEANO	Naval Oceanographic Office
NCOM	Navy Coastal Ocean Model
ODMDS	Ocean Dredged Material Disposal Site
PAG	Port Authority of Guam
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
pH	Hydrogen Ion Concentration
QA	Quality Assurance
QC	Quality Control
SAP	Sampling and Analysis Plan
SCCWRP	Southern California Coastal Water Research Project
SIM	Selective Ion Monitoring
SM	Standard Methods
SOP	Standard Operating Procedure

SRF	Ship Repair Facility
SVOC	Semi-Volatile Organic Compound
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TON	Total Organic Nitrogen
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WAAS	Wide Area Augmentation System
ZSF	Zone of Siting Feasibility

UNITS of MEASURE

°C	degrees Celsius
cm	centimeters
cm^3	cubic centimeters
cy	cubic yards
fps	feet per second
ft	feet
g	grams
in	inches
L	liters
kg	kilograms
km	kilometers
km^2	square kilometers
kph	kilometers per hour
m	meters
m^3	cubic meters
mcy	million cubic yards
mL	milliliters
m/s	meters per second
oz	ounces
mm	millimeters
mph	miles per hour
nm	nautical miles
sq. nm	square nautical miles
µm	microns; micrometers

1.0 INTRODUCTION

1.1 Objective

The objective of this field sampling program was to characterize the site conditions within and surrounding two potential ocean dredged material disposal sites (ODMDS) offshore of Apra Harbor, Guam. This program included the sample collection, processing, analysis and reporting of environmental parameters such as sediment and water quality, benthic and demersal communities and the collection of regional oceanographic current data.

1.2 Purpose and Need

Both the Navy and the Port Authority of Guam (PAG) have plans to expand their operations in Apra Harbor, Guam. Expansion of the Apra Harbor Naval Complex and Commercial Port is necessary to accommodate increases in vessel and cargo traffic, newer classes of vessels and dockside maintenance and support operations. Expansion plans would require construction dredging activities to increase water depths for the safe navigation of military and commercial vessels.

Currently planned construction projects and future maintenance dredging projects within Inner and Outer Apra Harbor are anticipated to generate 5,400,000 cy (4,128,596 m^3) of dredged material requiring management. Also, construction and maintenance dredging by the PAG may be initiated in the future at Commercial Port as part of a deep draft wharf project and at Agana Boat Basin, Agat Marina and Tumon Bay (for recreational swimming purposes) generating an unknown volume of dredged material for disposal (Guam Environmental Protection Agency [GEPA], 2000). The volume of dredged material expected to be generated around Guam over the next 30 years by the Navy and PAG far exceeds the ability of each entity to stockpile or beneficially use the material.

Currently, the Navy has three existing dredged material dewatering facilities (Orote Point, Ship Repair Facility [SRF], and Field 5 located between Marine Drive and Sumay Drive) and is considering the possible construction of an additional dredged material dewatering facility at an open field located south of the Commissary. The three existing dewatering facilities are near capacity. The open field located south of the Commissary is estimated to have a capacity of 250,000 cy (191,139 m^3). These existing and proposed dewatering facilities will have a total capacity of 2,100,000 cy (1,605,565 m^3). Proposed beneficial use alternatives will have a need for approximately 900,000 cy (688,099 m^3). Together, proposed dewatering facilities and beneficial use alternatives can manage 3,000,000 cy (2,293,665 m^3) of material.

While the preferred alternative for management of clean material is beneficial use, the structural quality and anticipated material needs will likely limit beneficial use as a management alternative (Weston, 2006). Similarly upland disposal sites have limited capacity and are a preferred alternative for management of contaminated material. An ODMDS would provide the Navy and PAG with an alternative for managing the additional 2,400,000 cy (1,834,932 m^3) of clean material.

2.0 STUDY AREA

2.1 Zone of Siting Feasibility

Screening and identification of potential ODMDS were conducted using a process known as the ZSF (Mathis and Payne, 1984). The ZSF identified the maximum area for which designation of an ODMDS was economically and operationally feasible. The ZSF was based on several considerations, including:

- Cost of transporting dredged material to the disposal site,
- Type of disposal plant,
- Navigation restrictions,
- Political and other jurisdictional boundaries, and
- Distance to the edge of the continental shelf.

The ZSF study identified the regulatory, technical, logistical, economic and environmental issues, including social and cultural resource concerns which would constrain the placement of a potential ODMDS. Once identified, these constraints were layered within a geographic information system (GIS) to determine areas not suitable for the placement of an ODMDS. Next, an economic feasibility analysis was conducted to determine the maximum practical haul distance for routine dredging operations known as the economic feasibility arc. Areas beyond the limits of any constraints, but within the limits of the economic feasibility arc, were determined to be suitable alternatives for the placement of an ODMDS.

Figure 1 illustrates all of the eliminated areas, or constraints, due to navigational lanes and hazards, Government of Guam (GovGuam) jurisdictional boundaries, marine protected areas, parks, ocean outfalls, fishing areas, visual resources and continental shelf considerations. Due to the rapidly increasing project depths, many of the eliminated areas were contained within the GovGuam jurisdictional boundary. For example, the marine preserves extend to a depth of -600 ft (-183 m) mean lower low water (MLLW), which occurs within 1.0 nm (1.9 km) of shore and within the GovGuam jurisdictional boundary. Figure 1 also superimposes the economic feasible distances from the entrance to Outer Apra Harbor for maintenance (16 nm [29 km]) and construction (25 nm [46 km]) dredging projects onto the areas eliminated from further consideration.

The results of the ZSF study suggested that there were two regions located offshore of Guam that may be suitable for placement of an ODMDS (Weston and Belt Collins, 2006). Since both maintenance and construction dredging projects may dispose of dredged material at the ODMDS, the shorter of the two economically feasible distances, or that which is dependent on maintenance dredging projects, was chosen to set the outer limit of feasibility. The first region, north of the entrance to Outer Apra Harbor, is approximately 12.4 nm (23.0 km) away (Figure 1). This northern region occupies an area approximately 17 sq. nm (58 km^2). The second region, northwest of the entrance to Outer Apra Harbor, is approximately 8.9 nm (16.4 km) offshore of Guam. This region occupies an area approximately 45 sq. nm (152 km^2).

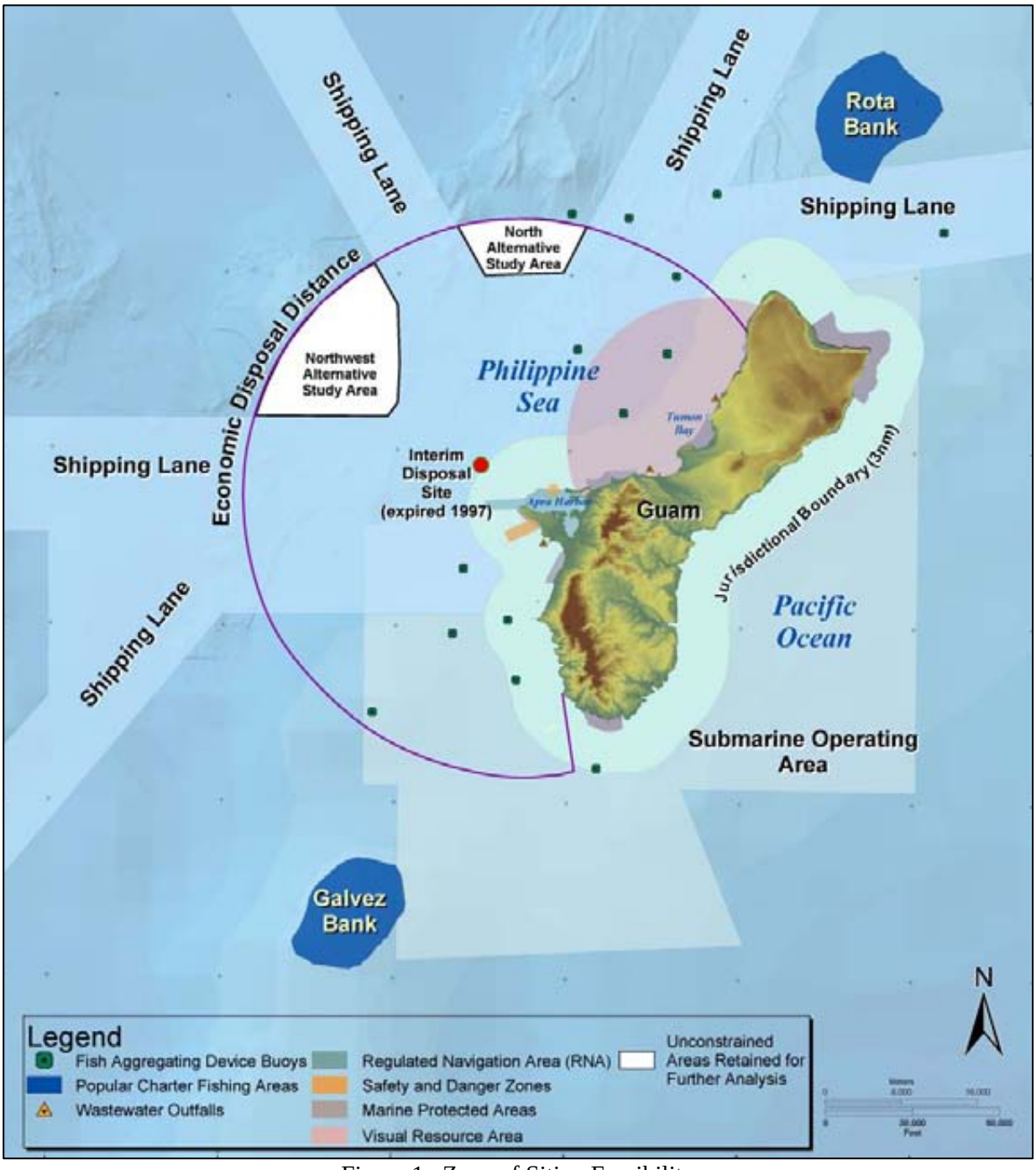

Figure 1. Zone of Siting Feasibility

2.2 Extended Impact Zone

As dredged material disposed at an ODMDS settles through the water column, it would be transported away from the target disposal site by oceanographic currents. The area where dredged material ultimately is deposited on the seafloor is identified as the extended impact zone.

Extended impact zones were developed for two potential ODMDS locations. These zones were predicted by evaluating oceanographic current data generated from the Naval Oceanographic Office (NAVOCEANO) Navy Coastal Ocean Model (NCOM) to determine regional oceanographic current patterns and applying these patterns to a model to predict the transport and deposition of dredged material from several potential ODMDS offshore of Guam. The *Draft Report, Ocean Current Study, Ocean Dredged Material Disposal Site, Apra Harbor, Guam* (Weston and Belt Collins, 2007), specifies the methods used to evaluate the NCOM current data and the results of the fate and transport modeling using the Short Term FATE (STFATE) model.

Model analyses were conducted for four separate scenarios (fine-grained versus coarse-grained material and disposal volumes of 300,000 cy [229,366 m^3] versus 1 mcy [764,555 m^3]). As expected, the coarse-grained material tended to settle more quickly and closer to the target disposal site than fine-grained material which tended to stay in suspension longer and be deposited farther from the target disposal site. Assuming the disposal of 1 mcy (764,555 m^3) over a one-year period, a maximum deposit thickness of 1.6 ft (0.5 m) resulted from the disposal of coarse-grained material. The largest aerial extent of deposits greater than 0.04 in (1 mm) thick (41 sq. nm [142 km^2]) resulted from the disposal of fine-grained material. Figure 2 illustrates the maximum extended impact zone for each alternative assuming the disposal of 1 mcy (764,555 m^3) of predominantly fine-grained material. The extended impact zones are oval in shape, having a width of 6.5 nm (12.0 km) and a length of 8.1 nm (15.0 km), and are elongated towards the northeast from the point of disposal (Weston and Belt Collins, 2007).

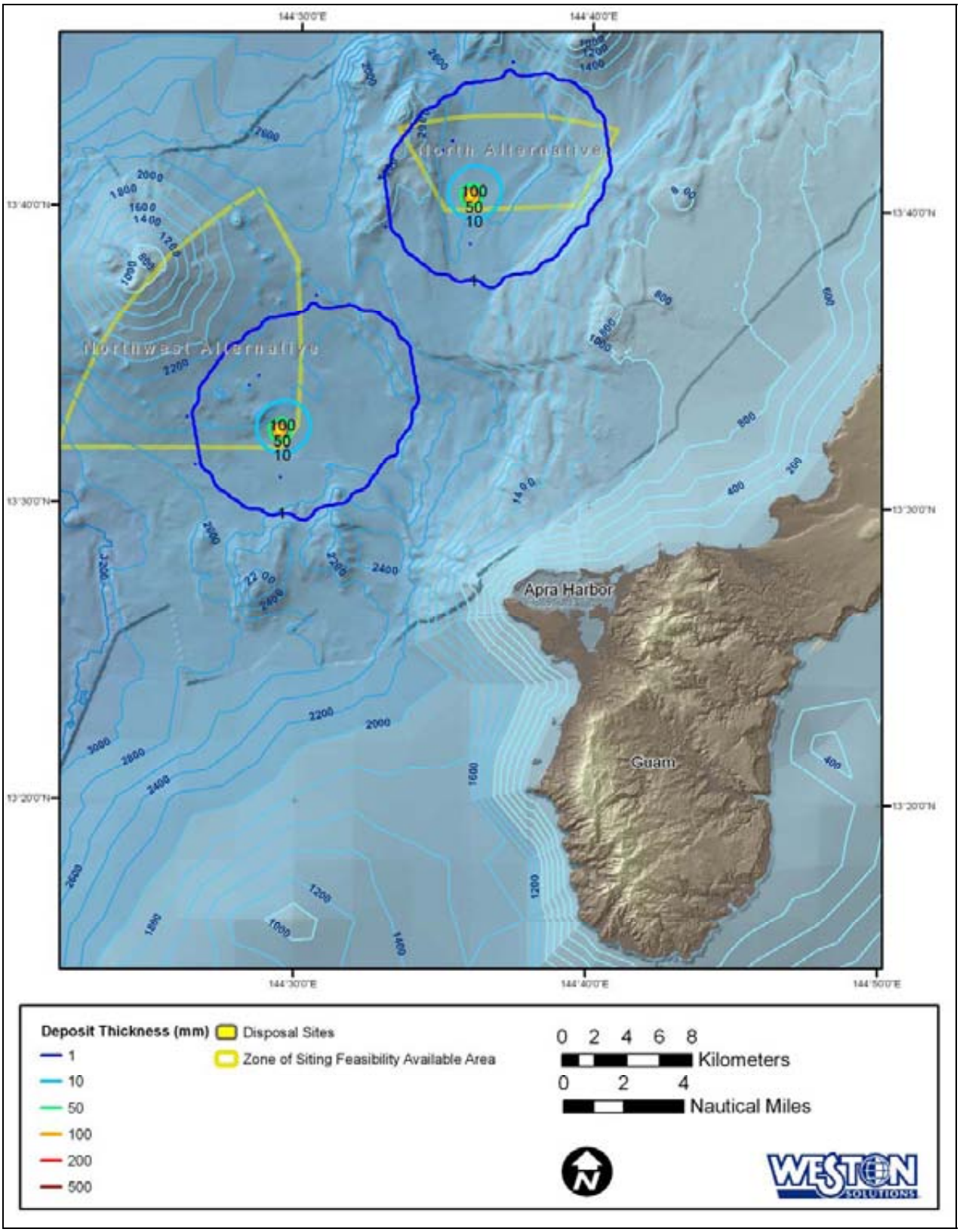

Figure 2. Deposit Thickness and Area for the Disposal of 1 mcy of Predominantly Fine-Grained Material

3.0 MATERIALS AND METHODS

3.1 Field Collection Program

Three separate field efforts were required to successfully perform the field collection program. The first effort, to construct and place two deep sea moorings outfitted with arrays of current meters, was conducted between January 14 and January 18, 2008. The second effort, to collect water, sediment, benthic and fish community samples, was conducted between April 3 and April 25, 2008. The third effort, to retrieve the two deep sea moorings and download the current meter data, was conducted between December 10 and December 13, 2008. Daily field cruise logs were kept during each field effort and are presented in Appendix A.1.

3.1.1 Equipment

3.1.1.1 Water Column

A Seabird Electronics SBE 9*plus* conductivity/temperature/depth (CTD) instrumentation package was the primary device for measuring full oceanographic profiles of physical water quality parameters such as conductivity, temperature, dissolved oxygen (DO), transmissivity and turbidity (Figure 3). A backup system, or secondary data collection device, consisting of a Seabird Electronics SBE 25 Sealogger CTD instrumentation package was simultaneously deployed. Conductivity, temperature and pressure (depth) were measured using sensors standard to the SBE 9*plus*. The dissolved oxygen sensor was an SBE43 model. Transmissivity was measured using a Wetlabs C-Star transmissivity sensor. Turbidity was measured using a Seapoint Turbidity Sensor.

Water samples were collected by interfacing a Seabird Electronics SBE 11*plus* V2 deck unit with a Seabird Electronics SBE 32 Carousel outfitted with 24 General Oceanics 10-L Niskin water samplers (Figure 3). An electro-magnetic conducting cable between the sampler and the deck unit allowed scientists evaluating the water quality data to control real-time sampling.

The CTD and water samplers were deployed using the starboard mounted squirt boom (Figure 3).

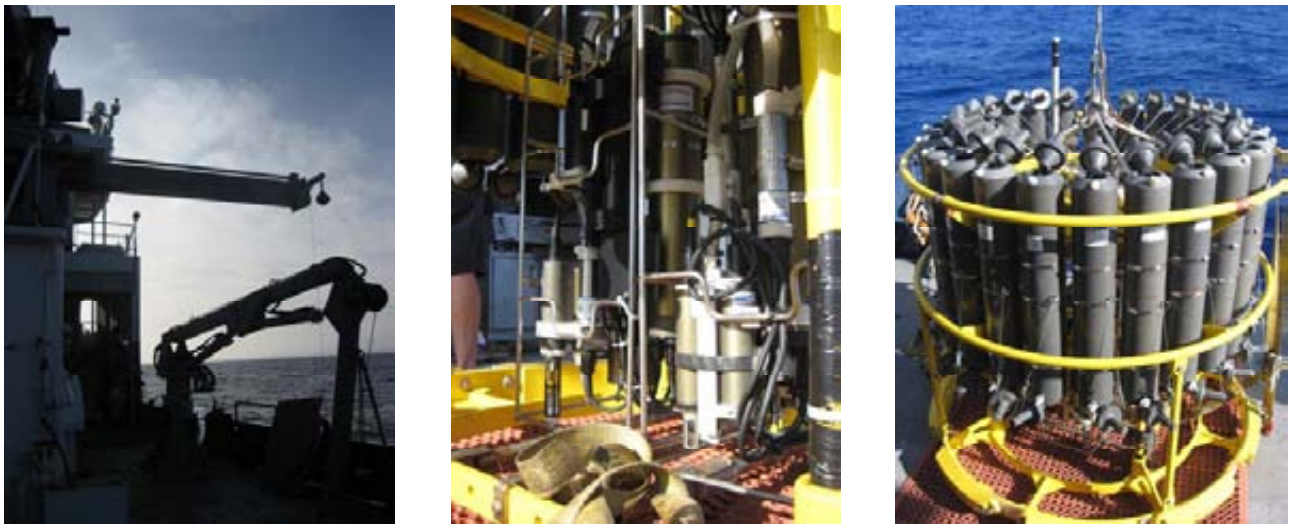

Figure 3. Water Sampling Equipment: Starboard Mounted Squirt Boom [top] Onboard the *R/V Melville* (left), CTD Instrumentation Package (center), Niskin Water Samplers Mounted on a Carousel (right).

3.1.1.2 Sediment Samples

Sediments were collected using an Ocean Instruments MK-III spade-type boxcore (Figure 4). The boxcore was 20 in (50.8 cm) square and was capable of collecting cores to 24 in (61 cm) below the sediment surface. Seven interchangeable boxes were onboard the vessel in the case one or more boxes were damaged during deployment, sediment collection or retrieval.

Two backup systems were onboard in the case the MK-III boxcore ceased to function properly. These systems included an Ocean Instruments MC-800 multicorer and an Ocean Instruments BX-750-AL Deep Sea Geochemical boxcore.

The sediment sampler was deployed using the stern mounted A-frame (Figure 4).

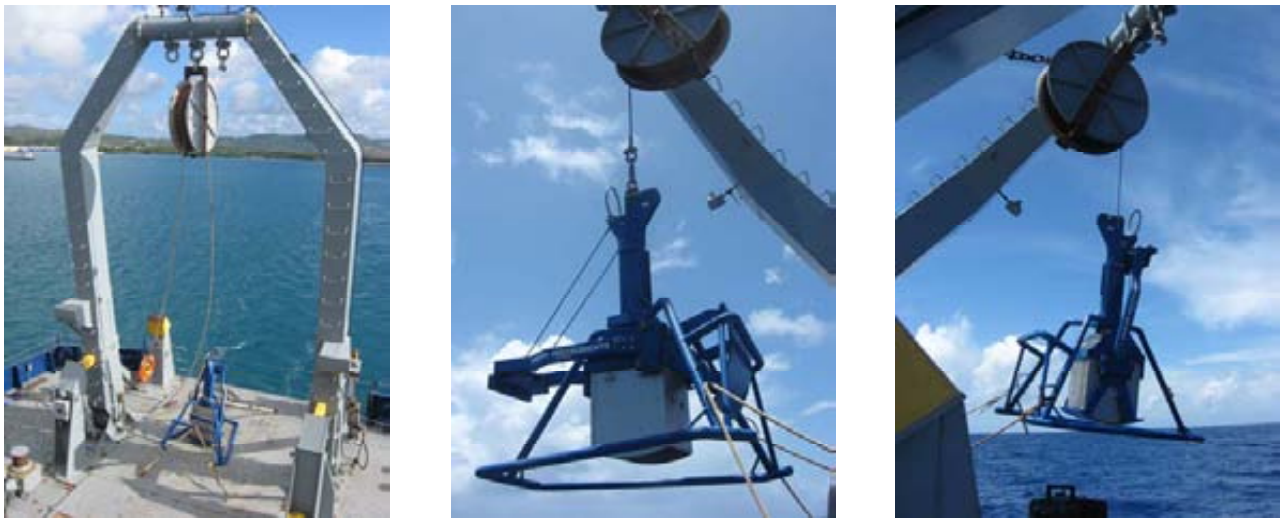

Figure 4. Sediment Sampling Equipment: Stern Mounted A-Frame Onboard the *R/V Melville* (left), Boxcore Being Deployed (center), Boxcore Being Retrieved (i.e. Triggered; right)

3.1.1.3 Invertebrate Sampling (Benthic Communities)

Macroinfauna and meiofauna samples were subsampled from the grab samples collected using the Ocean Instruments MK-III spade-type boxcore (see Section 3.1.1.2).

3.1.1.4 Fish Community Surveys

Beam Trawl Surveys

Two beam trawls and three different trawl nets were designed for the collection of epibenthic organisms (fish and invertebrates). Two 12 ft (3.6 m) wide plumb staff beam trawls were the selected apparatus for conducting trawls (Figure 5). The beam set 18 in (0.46 m) off the seafloor, attached to two sleds on each end. The sleds were 6 in (15.2 cm) wide and 30 in (0.76 m) in length.

Two of each different net design were mobilized onto the vessel and ultimately used. Each net design had the same basic structure. The nets were 26-30 ft (8-9 m) in length and had 1.5 in. (38 mm) body mesh and 0.25 in. (6 mm) codend mesh. The nets were composed of HDPE Sapphire netting which provided positive buoyancy. Additional buoyancy was provided along the headrope by attaching floatation or bundled polyethylene line. The trawls were equipped with chain drops along the mudline, chafe mat and tied dump. A three point bridle was used to connect the beam trawl to the trawl wire.

A "reversible" beam trawl was designed and mobilized onto the vessel as a backup to the more conventional beam trawl designs. This modified beam trawl was designed to "fish" regardless of which side landed on the seafloor.

The beam trawls were deployed using the stern mounted A-frame.

Figure 5. Beam Trawls: On Deck Awaiting Deployment (left), Being Retrieved (right)

Fish Trap Deployments

In an effort to supplement the collection of demersal organisms from beam trawls, fish traps were deployed to collect fish and epibenthic invertebrates. Fish traps measured 3 ft x 2 ft x 1 ft (0.9 m x 0.6 m 0.3 m) with a 1 in (2.5 cm) mesh wire covering (Figure 6). Prior to deployment, one of the two traps deployed at each station was covered with a 0.25 in (6 mm) net to retain smaller fish and inverterbrates. Traps were baited with a mixture of mackerel, mahimahi, skipjack tuna, squid and catfood. Fish traps were weighted and connected to a 6 ft (1.8 m) surface float (e.g., jim buoy) by 1/8 in (3 mm) Spectra line. The traps were then allowed to free fall through the water column during deployment.

Fish traps were deployed and retrieved from the stern using the mooring winch to unspool and spool the Spectra line.

Figure 6. Fish Traps: On Deck Awaiting Deployment (left), Surface Float (right)

Underwater Camera System

To further supplement the assessment of the fish and epibenthic inverterbrate community on the seafloor, an underwater digital video and still image camera system was deployed. The Seatronics DTS6000 provided real time video and captured high resolution digital stills of the seafloor and biological community. The system was equipped with a Kongsberg 14-366 real time video camera; Kongsberg OE 14-208 digital stills camera; altimeter; depth sensor; heading, pitch and roll attitude sensor; and CTD instrumentation package (Figure 7). An onboard control unit comprised of two video monitors, digital video recorder and computer was maintained in the science party's main laboratory and controlled the DTS6000 system through single coaxial armoured cable.

The DTS6000 system was deployed using the starboard mounted A-frame.

Figure 7. Underwater Camera: On Deck Awaiting Deployment (left), Onboard Control Unit (right)

3.1.1.5 Oceanographic Currents

Two oceanographic current meter arrays were moored to the seafloor to collect *in situ* current data. These data were then used to confirm NCOM model results and further evaluate the area of sediment deposits on the seafloor. The moorings were built using one-quarter inch jacketed wire rope attached to a 2,500 lbs (1,134 kg) anchor via two ORE Offshore Model 8242XS acoustic releases mounted in tandem. For buoyancy and to keep the mooring line in a vertical position, five syntactic foam floats, providing between 250 and 1000 lbs of buoyancy each, were placed along the mooring line. Four Nortek Deep Water Aquadopp current meters were clamp-mounted along each mooring at depths of approximately -1,000 ft (-300 m); -3,300 ft (-1,000 m); -5,650 ft (-1,725 m) and 330 ft (100 m) above the seafloor (-7,500 ft [-2,300 m] at mooring location CM1, and -7,050 ft [-2,150 m] at mooring location CM2). The current meters measured currents approximately 3 ft [1 m] from the sensor heads. In addition, one upward-looking Nortek Continental acoustic Doppler current profiler (ADCP) was integrated into a syntactic foam float at the top of the mooring (approximately -500 ft [-150 m] below the sea surface). The ADCP measured currents in 16 ft [5 m] bins, or layers, from the sensor head to the sea surface. Figure 8 and Figure 9 show the current meter array components and illustrate the mooring configuration, once deployed.

The moorings were built and deployed from the "top down" (i.e., the uppermost float was deployed first and dragged behind the vessel as the mooring line and subsequent current meters and floats were deployed, with the mooring anchor the last piece of equipment to be released into the water column, pulling the mooring line from the surface into a vertical position in the water column. All equipment was deployed and retrieved using a stern-mounted A-frame on the *T/V Chamorro*.

Figure 8. Deep Sea Current Meter Array Components: Float with Intergrated Mount for ADCP (left) and Components Waiting Deployment.

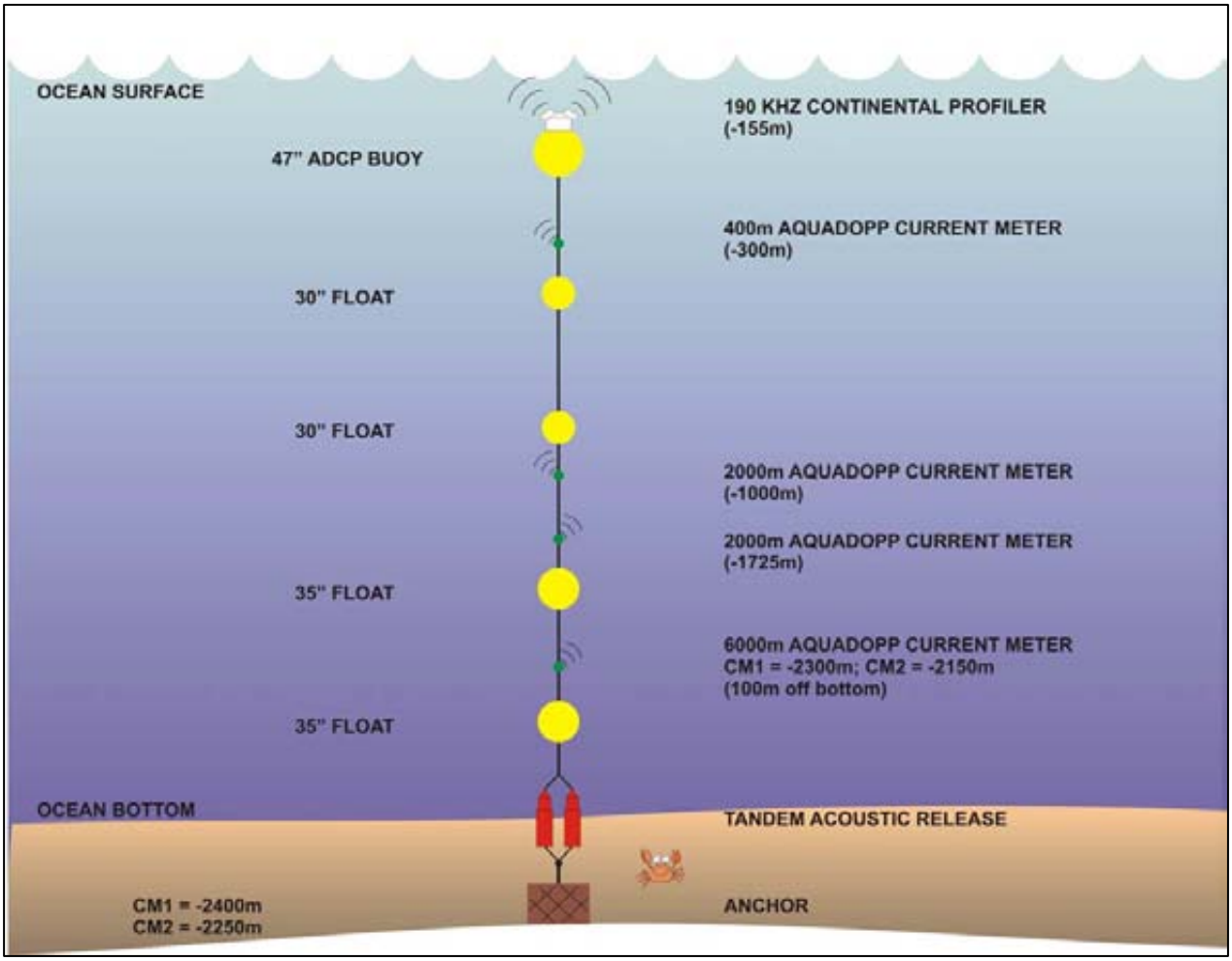

Figure 9. Schematic of Deep Sea Current Meter Mooring as Deployed

3.1.2 Vessel and Navigation

3.1.2.1 Site Characterization Studies

With the exception of deploying and retrieving the current meter moorings, site characterization studies were conducted from the *R/V Melville*, a 279 ft scientific research vessel owned by the US Navy and operated by the Scripps Institute of Oceanography (Figure 10).

Vessel positioning was achieved with the use of a Trimble NT 200 differential Global Positioning System (DGPS) and maintained using a Kongsberg K-POS DP-11 dynamic positioning system. The dynamic positioning system controlled twin "Z" drive propellers, or thrusters, located aft and one "Z" drive propeller located at the bow, each having 360 degrees of maneuverability. The dynamic positioning system enabled the *R/V Melville* to accurately hold station by controlling the propellers to counteract the forces of the wind, waves and current on the vessel. The dynamic positioning system also permitted the vessel to move directly sideways at speeds up to 2 kts (1 m/s), which was specifically useful for retrieving surface buoys.

The *R/V Melville* was equipped with two A-frames and one squirt boom for deploying scientific equipment. The stern mounted A-frame was used for deploying and retrieving the boxcore, beam trawls and fish traps. The starboard mounted A-frame was used for the deployment and retrieval of the underwater digital still and video camera system. Each A-frame was rated to greater than 32,500 lbs (14,740 kg) breaking strength with a safe working load (SWL) of 14,000 lbs (6,350 kg) and 20,000 lbs (9,071 kg) for the stern and starboard mounted A-frames, respectively. The starboard mounted squirt boom was used for deploying and retrieving the CTD and water sampler. The squirt boom had a SWL of 1,500 lbs (680 kg).

Figure 10. *R/V Melville* offshore of Guam

3.1.2.2 Current Meter Deployment and Retrieval

The current meter moorings were deployed and retrieved from the *T/V Chamorro*, an ocean-going tug vessel. The vessel was outfitted with a stern mounted A-frame for the safe deployment and retrieval of the moorings. The A-frame had a SWL of 10,000 lbs (4,535 kg). Vessel positioning was achieved with the use of a DGPS.

3.1.3 Sampling Locations

Sampling areas were randomly selected with the exception of two areas which were selected to represent the center of each proposed ODMDS. The randomly selected sampling areas were generated by overlaying uniformly sized hexagons, which depict the sampling areas, across the study region. Hexagons were set at approximately 2.0 nm (3.7 km) across. The size of the hexagons was determined by the distance a trawl survey, operating at 2 kts (1 m/s), would cover in 1 hour. Seven sampling areas were then randomly selected across the region with the stipulation that any two areas did not occur side-by-side. The target sampling station for each task (i.e., environmental parameter to be sampled) was at the center of the sampling area (i.e., hexagon), with the exception of the fish trawls which were conducted across the entire sampling area. If the target sampling station could not be sampled for sediments due to the physical characteristics of the site (i.e., large cobble or debris prevents penetration or normal operation of the boxcore), the vessel was moved to another location within the target sampling area. The Sampling and Analysis Plan (SAP) generated for the field sampling program listed the target, or planned, station coordinates (Weston and Belt Collins, 2007).

3.1.3.1 Water Column

As specified in the SAP (Weston and Belt Collins 2007), profiles of the water column using a CTD instrumentation package were collected at all nine stations; however, water quality samples were collected at only three stations. Water quality samples were collected at Station 2 and Station 7, representing the center of each of the proposed ODMDS, and Station 5, representing an upstream (i.e. "upcurrent") location proposed for use as a reference site for future dredged material evaluations. Water samples were collected at four discrete depths (one above the thermocline, one at the top of the thermocline, one between the thermocline and the bottom, and one near the bottom). The final locations for each CTD cast and water quality sample collected are listed in Table 1 and Table 2 and illustrated in Figure 11. Water sampling and CTD cast field logs are presented in Appendix A.2.

Table 1. Final Field Coordinates, Water Depth and Deployment Time for CTD Casts

Station	Date	Time Deploy On Bottom Retrieve	Water Depth (m)	Latitude (N)		Longitude (E)	
				deg.	decimal min.	deg.	decimal min.
GO 1	4/21/2008	15:00	2352	13	42.834	144	37.633
		15:56					
		16:55					
GO2	4/21/2008	22:45	2271	13	40.416	144	35.945
	4/21/2008	23:45[1]					
	4/22/2008	0:40					
GO 3	4/21/2008	12:30	2140	13	41.026	144	38.442
		13:22					
		14:15					
GO 4	4/22/2008	1:27	2085	13	36.312	144	34.13
		2:05					
		2:40					
GO 5	4/20/2008	4:10	2250	13	33.902	144	36.345
		4:50					
		5:30					
GO 6	4/22/2008	5:10	2505	13	35.800	144	29.588
		5:55					
		6:45					

GO 7	4/22/2008	12:40	2439	13	33.089	144	28.497
		13:38					
		14:40					
GO 8	4/22/2008	15:23	2554	13	32.600	144	25.400
		16:25					
		17:38					
GO 9	4/23/2008	4:55	2610	13	31.201	144	31.923
		5:40					
		6:30					

[1] - Time not recorded; Estimated Based on Deployment and Retrieval Times

Table 2. Final Field Coordinates, Depth and Collection Times for Water Samples

Station	Date	Time	Sample ID	Sample Location	Sample Depth (m)	Latitude (N)		Longitude (E)	
						deg.	decimal min.	deg.	decimal min.
GO-2	4/6/08	22:15	GO2-1	Bottom	2240	13	40.417	144	35.947
		22:48	GO2-2	Mid-Column	1199				
		23:22	GO2-3	Thermocline	115				
		23:25	GO2-4	Surface	51				
GO-5	4/11/08	1:20	GO5-1	Bottom	2147	13	33.906	144	37.404
		1:40	GO5-2	Mid-Column	992				
		1:55	GO5-3	Thermocline	143				
		2:00	GO5-4	Surface	50				
GO-7	4/10/08	0:52	GO7-1	Bottom	2385	13	33.1	144	28.501
		1:15	GO7-2	Mid-Column	1299				
		1:45	GO7-3	Thermocline	157				
		1:50	GO7-4	Surface	50				

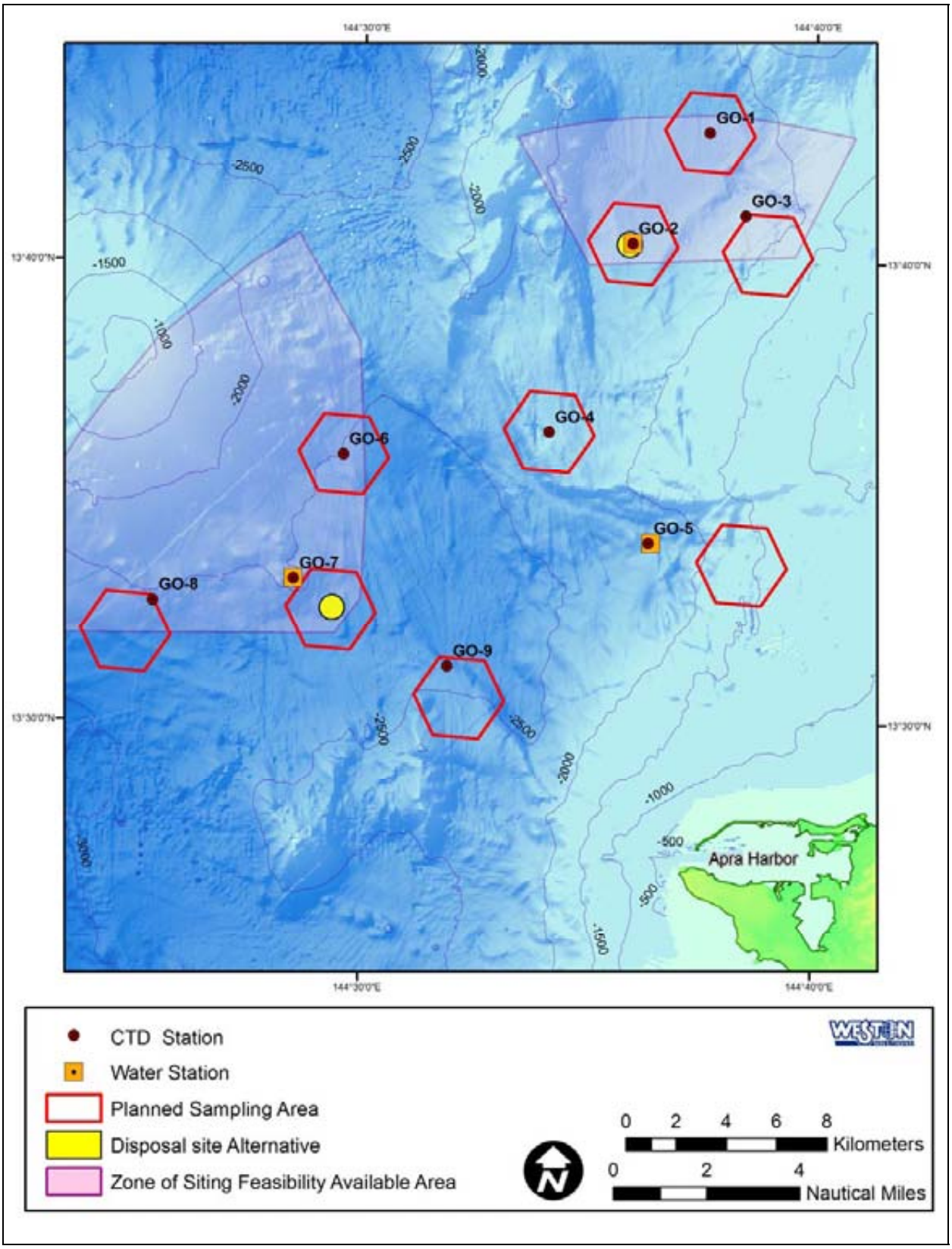

Figure 11. Final Sampling Locations for CTD Casts and Water Samples

3.1.3.2 Sediment Samples

Sediment samples to characterize the *in situ* sediment were collected at all nine stations in accordance with the SAP (Weston and Belt Collins 2007). Figure 12 illustrates the final locations for each sediment grab sample. Sediment from each of the nine stations was analyzed for physical and chemical parameters. Sediment was also designated for bioaccumulation testing according to the following compositing scheme: the first composite was made from grab samples collected at Stations 1-3; the second composite was made from grab samples collected at Stations 6-8; and the third composite was made from grab samples collected at Station 5. Sediment from Stations 4 and 9 were not included in either of the two project samples or reference sample submitted for bioaccumulation testing. Additional sediment from Station 5 was submitted to Weston's bioassay laboratory in Carlsbad, California for solid phase (SP) bioassay tests.

Final sampling locations were consistent with the planned, or target, sampling locations as listed in the SAP (Weston and Belt Collins 2007) with a few exceptions. At Station 2, the physical characteristics of the sediment resulted in the last grab sample (designated for bioaccumulation testing) being taken 0.3 nm (0.5 km) northeast of the planned sampling location and within the target sampling area. At Station 3, the first three attempts were unsuccessful (near complete washout) due to physical characteristics of the sediment; the station was moved 0.8 nm (1.5 km) to the northwest (offshore of the steep underwater slope) of the planned sampling location and at the boundary of the target sampling area. At Station 5, the planned station was moved 1.2 nm (2.3 km) to the west-northwest prior to sampling due to the charted locations of underwater cables. Station 5 was subsequently moved a total of 0.9 nm (1.7 km) west due to unsuitable (gravelly) substrate and several unsuccessful attempts. At Station 7, the final sampling location was located slightly outside the target sampling area because the planned station was moved approximately 1.1 nm (2 km) to the northwest prior to sampling due to the charted locations of underwater cables. At Station 8, the final sampling location was located slightly outside the target sampling area for two reasons. First, the planned station was moved approximately 0.9 nm (1.7 km) to the northeast prior to sampling due to the charted locations of underwater cables. Second, this new station was subsequently moved an additional 0.3 nm (0.5 km) due east because observations of the sediment and a slightly bent boxcore from previous grabs suggested the presence of a hard, rocky substrate. At Station 9, the planned station was moved approximately 0.7 nm (1.3 km) to the north prior to sampling due to the charted locations of underwater cables; it was subsequently moved an additional 0.3 nm (0.5 km) due west because the first attempt at this new location collected a large cobble (approximately 10 in [25 cm]) which suggested the presence of a hard, rocky substrate. Appendix A.3 presents the field logs for boxcore sampling.

Table 3. Final Field Coordinates, Water Depth, Penetration and Field Observations for Sediment Samples

Station	Grab No.	Date	Time Deploy On Bottom Retrieve	Water Depth (m)	Wire Length at Bottom (m)	Penetration (cm)	Grade Good (G) Fair (F) Poor (P)	Epifaunal Organisms	Volume (L)	Color	Odor	Texture/Grain Size	Latitude (N)		Longitude (E)		Comments
													deg.	decimal min.	deg.	decimal min.	
GO 1	1	04/05/08	20:40 21:47 22:55	2352	2383	25.4	F	no	14	yellowish brown	no	silty sand	13	42.831	144	37.634	
GO 1	2	04/06/08	5:20 6:24 7:25	2352	2383	not measured	P	no		yellowish brown	no	silty sand	13	42.831	144	37.633	lost surface sediment
GO 1	3	04/06/08	9:30 10:50 12:05	2352	2382	15	G	no	8	yellowish brown	no	silty sand	13	42.832	144	32.633	
GO 1	4	04/12/08	19:40 20:43 21:45	2354	2384	18	F	no	14	yellowish brown	no	silty sand	13	42.835	144	37.63	partial washout
GO 1	5	04/12/08 04/13/08	22:10 23:05 0:08	2356	2384	18	F	no	12	yellowish brown	no	silty sand	13	42.836	144	37.631	partial washout
GO 1	6	04/17/08	17:44 18:44 19:40	2355	2386	15	F	no	11	yellowish brown	no	silty sand	13	42.833	144	37.630	
GO 1	7	04/17/08	20:00 20:53 21:55	2354	2390	10	F	no	13	yellowish brown	no	silty sand	13	42.832	144	37.630	
GO 1	8	04/17/08 04/18/08	22:15 23:14 0:15	2354	2385	15	F	no	13	yellowish brown	no	silty sand	13	42.834	144	37.630	
GO 2	1	04/06/08	14:20 15:30 16:30	2269	2299	10	G	no		yellowish brown	no	fine sand and silt	13	40.416	144	35.946	
GO 2	2	04/06/08	18:30 19:20 20:24	2269	2299	18	G	no		light yellowish brown	no	silty fine sand	13	40.416	144	35.946	
GO 2	3	04/13/08	6:15 7:10 8:10	2272	2296		P	no	4	yellowish brown	no	silty sand	13	40.419	144	35.945	partial washout
GO 2	4	04/13/08	8:35 9:32 10:30	2268	2294	-	-	-	-	-	-	-	13	40.419	144	35.945	no sample kept, near complete washout
GO 2	5	04/13/08	10:45 11:40 12:40	2269	2294	13	P	no	2	yellowish brown	no	sandy	13	40.419	144	35.945	
GO 2	6	04/13/08	17:55 18:55 19:55	2271	2297	6	G	no	14	yellowish brown	no	sandy silt	13	40.417	144	35.945	very good surface recovery

Table 3. Final Field Coordinates, Water Depth, Penetration and Field Observations for Sediment Samples

Station	Grab No.	Date	Time Deploy On Bottom Retrieve	Water Depth (m)	Wire Length at Bottom (m)	Penetration (cm)	Grade Good (G) Fair (F) Poor (P)	Epifaunal Organisms	Volume (L)	Color	Odor	Texture/Grain Size	Latitude (N)		Longitude (E)		Comments
													deg.	decimal min.	deg.	decimal min.	
GO 2	7	04/13/08	20:25 21:23 22:15	2269	2297	7	F	no	14	yellowish brown	no	sandy silt	13	40.419	144	35.947	mostly good surface
GO 2	8	04/18/08	1:20 2:15 3:10	2268	2297	8	F	no	16	yellowish brown	no	silty sand	13	40.414	144	35.948	
GO 2	9	04/18/08	3:25 4:20 5:15	2269	2297	13	F	no	19	yellowish brown	no	silty sand	13	40.414	144	35.947	
GO 2	10	04/18/08	5:28 6:22 7:20	2269	2302	10	P	no	0	yellowish brown	no	sandy	13	40.415	144	35.948	near complete washout, very sandy, no sample retained; station moved 500 m NE (45 deg N)
GO 2	11	04/18/08	8:00 8:55 9:50	2302	2335	no trip	-	-	-	-	-	-	13	40.606	144	36.143	
GO 2	12	04/18/08	10:07 10:59 11:55	2304	2334	10	F	no	11	yellowish brown	no	sandy	13	40.607	144	36.144	
GO 3	1	04/07/08	1:20 2:08 3:00	1987	2016	20	P	-		-	-	-	13	40.198	144	38.93	wash out
GO 3	2	04/07/08	3:35 4:25 5:30	1983	2012	no trip	P	-		-	-	-	13	40.197	144	38.931	box core did not trip
GO 3	3	04/07/08	6:00 6:49 8:03	1985	2014	not measured	P	-		light yellowish brown	no	silty sand	13	40.196	144	38.931	wash out; sample discarded
GO 3	4	04/07/08	8:45 9:52 10:42	2139	2164	not measured	G	no		light yellowish brown	no	silty sand	13	41.026	144	38.442	moved station 3 1500 m to northwest (315 degrees N)
GO 3	5	04/07/08	12:40 13:39 14:33	2124	2160	18	G	no		light yellowish brown	no	silty sand	13	41.026	144	38.441	
GO 3	6	04/13/08	1:10 1:59 3:05	2141	2169	12	F	no	14	yellowish brown	no	silty sand	13	41.025	144	38.441	partial washout
GO 3	7	04/13/08	3:25 4:17 5:20	2141	2164	14	F	no	12	yellowish brown	no	silty sand	13	41.026	144	38.442	partial washout
GO 3	8	04/18/08	12:45 13:37 14:35	2141	2167	13	F	no	5	yellowish brown	no	sandy with trace cobble	13	41.030	144	38.438	

Table 3. Final Field Coordinates, Water Depth, Penetration and Field Observations for Sediment Samples

Station	Grab No.	Date	Time Deploy On Bottom Retrieve	Water Depth (m)	Wire Length at Bottom (m)	Penetration (cm)	Grade Good (G) Fair (F) Poor (P)	Epifaunal Organisms	Volume (L)	Color	Odor	Texture/Grain Size	Latitude (N)		Longitude (E)		Comments
													deg.	decimal min.	deg.	decimal min.	
GO 3	9	04/18/08	14:55 15:47 16:40	2139	2166	13.5	F	no	11	yellowish brown	no	sandy	13	41.030	144	38.438	
GO 3	10	04/18/08	17:00 17:53 18:45	2140	2167	no trip	-	-	-	-	-	-	13	41.030	144	38.438	
GO 3	11	04/18/08	18:55 19:46 20:35	2140	2171	10	F	no	9	yellowish brown	no	silty sand	13	41.029	144	38.438	
GO 4	1	04/10/08	3:20 4:10 5:00	2087	2112	19	F	no		yellowish brown	no	silty sand	13	36.311	144	34.130	
GO 4	2	04/10/08	5:40 6:35 7:25	2085	2112	24	F	no		yellowish brown	no	silty sand	13	36.315	144	24.210	
GO 4	3	04/10/08	15:50 16:42 17:45	2091	2109	19	F	no		yellowish brown	no	silty sand					
GO 4	4	04/10/08	19:55 20:45 21:38	2087	2111	no trip	-	-		-	-	-	13	36.312	144	34.13	
GO 4	5	04/10/08	21:40 22:30 23:25	2087	2111	not measured	F	no		yellowish brown	no	silty sand	13	36.312	144	34.13	
GO 5	1	04/11/08	2:25 3:20 4:15	2150	2192	nc	P	no		yellowish brown	no	silty sand	13	33.906	144	37.403	washout; sample not kept
GO 5	2	04/11/08	4:35 5:27 6:20	2156	2196		F	no		yellowish brown	no	silty sand with cobble	13	33.906	144	37.403	layer of cobble at about 8cm depth
GO 5	3	04/11/08	7:00 7:53 8:45	2154	2177		P	no	-		no	gravel	13	33.906	144	37.405	cobble/gravel (3-4 in length); no sediment; no sample collected
GO 5	4	04/11/08	9:15 10:05 10:55	2199	2242	17	F	no		yellowish brown	no	sitly sand	13	33.911	144	36.772	moved vessel position 1000 m W (270 deg N)
GO 5	5	04/18/08 04/19/08	22:30 23:24 0:20	2197	2242	no trip	-	-	-	-	-	-	13	33.898	144	36.773	

Table 3. Final Field Coordinates, Water Depth, Penetration and Field Observations for Sediment Samples

Station	Grab No.	Date	Time Deploy On Bottom Retrieve	Water Depth (m)	Wire Length at Bottom (m)	Penetration (cm)	Grade Good (G) Fair (F) Poor (P)	Epifaunal Organisms	Volume (L)	Color	Odor	Texture/Grain Size	Latitude (N)		Longitude (E)		Comments
													deg.	decimal min.	deg.	decimal min.	
GO 5	6	04/19/08	0:25 1:20 2:15	2200	2243	no trip	-	-	-	-	-	-	13	33.898	144	36.773	
GO 5	7	04/19/08	2:40 3:37 4:30	2270	2299	25	G	no	24	yellowish brown	no	silty sand	13	33.903	144	36.344	
GO 5	8	04/19/08	4:50 5:45 6:41	2273	2298	17	G	no	14	yellowish brown	no	silty sand	13	33.902	144	36.344	
GO 5	9	04/19/08	7:20 8:12 9:05	2270	2298	21	G	no	9	yellowish brown	no	silty sand	13	33.903	144	36.344	
GO 5	10	04/19/08	9:32 10:25 11:20	2269	2296	no trip	-	-	-	-	-	-	13	33.902	144	36.344	
GO 5	11	04/19/08	11:24 12:15	2274	2295	19	G	no	20	yellowish brown	no	silty sand	13	33.901	144	36.343	
GO 6	1	04/09/08	3:50 5:00 6:05	2508	2538	17	F	no		yellowish brown	no	silty sand	13	35.800	144	29.582	
GO 6	2	04/09/08	8:10 9:12 10:20	2507	2537	15	F	no		yellowish brown	no	silty sand	13	35.800	144	29.584	
GO 6	3	04/09/08	12:36 13:40 14:55	2508	2537	no trip	-	-	-	-	-	-	13	35.799	144	29.584	
GO 6	4	04/09/08	15:15 16:14 17:10	2509	2532	21	F	no		yellowish brown	no	silty sand	13	35.798	144	29.584	
GO 6	5	04/13/08 04/14/08	23:50 0:52 1:50	2506	2542	no trip	-	-	-	-	-	-	13	35.800	144	29.587	no trip; winch wire wrapped
GO 6	6	04/14/08	2:00 3:00 4:05	2509	2539	17	F	no	8	yellowish brown	no	sandy silt	13	35.799	144	29.587	line boxcore with plastic to reduce washout - no success.
GO 6	7	04/14/08	5:40 6:45 7:50	2510	2537	15	F	no	10	yellowish brown	no	sandy silt	13	35.799	144	29.588	replaced rubber mat on spade
GO 6	8	04/14/08	8:15 9:16 10:20	2509	2535	21	F	no	6	yellowish brown	no	silty sand	13	35.799	144	29.587	partial washout

Table 3. Final Field Coordinates, Water Depth, Penetration and Field Observations for Sediment Samples

Station	Grab No.	Date	Time Deploy On Bottom Retrieve	Water Depth (m)	Wire Length at Bottom (m)	Penetration (cm)	Grade Good (G) Fair (F) Poor (P)	Epifaunal Organisms	Volume (L)	Color	Odor	Texture/Grain Size	Latitude (N)		Longitude (E)		Comments
													deg.	decimal min.	deg.	decimal min.	
GO 6	9	04/14/08	10:40 11:40 12:40	2507	2532	22	F	no	11	yellowish brown	no	silty sand	13	35.799	144	29.587	partial washout
GO 6	10	04/14/08	13:07 14:15 15:15	2509	2539	18	F	no	7	yellowish brown	no	silty sand	13	35.800	144	29.588	
GO 6	11	04/16/08	12:30 13:34 14:35	2508	2538	24	F	no	10	yellowish brown	no	silty sand	13	35.800	144	29.587	
GO 6	12	04/16/08	15:00 16:02 17:03	2508	2537	no trip	-	-	-	-	-	-	13	35.801	144	29.589	
GO 6	13	04/16/08	17:15 18:15 19:20	2509	2539	16	F	no	12	yellowish brown	no	silty sand	13	35.801	144	29.586	
GO 6	14	04/16/08	19:37 20:41 21:40	2511	2539	17	F	no	14	yellowish brown	no	silty sand	13	35.801	144	29.586	
GO 7	1	04/09/08	18:05 19:10 20:25		2481	19	G	no	12	yellowish brown	no	silty sand	13	33.101	144	28.5	
GO 7	2	04/09/08	21:00 22:00 23:05	2442	2489	25	G	no		yellowish brown	no	silty sand	13	33.099	144	28.501	
GO 7	3	04/14/08 04/15/08	22:10 23:16 0:15	2442	2493	no trip	-	-	-	-	-	-					
GO 7	4	04/15/08	0:28 1:29 2:30	2442	2489	18	G	no	17	yellowish brown	no	silty sand	13	33.102	144	28.503	
GO 7	5	04/15/08	2:49 3:47 4:45	2442	2490	18	G	no	15	yellowish brown	no	silty sand	13	33.102	144	28.503	
GO 7	6	04/17/08	9:00 9:59 11:00	2436	2476	no trip	-	-	-	-	-	-	13	33.093	144	28.513	shackles hung up
GO 7	7	04/17/08	11:04 12:02 13:02	2449	2476	22	G	no	20	yellowish brown	no	silty sand	13	33.092	144	28.512	cobble to 3" in dia. Below 10 cm.
GO 8	1	04/11/08	17:40 18:45 19:50	2587	nc	14	F	no		yellowish brown	no	sandy silt	13	32.601	144	25.400	cobble in grab sample

Table 3. Final Field Coordinates, Water Depth, Penetration and Field Observations for Sediment Samples

Station	Grab No.	Date	Time Deploy On Bottom Retrieve	Water Depth (m)	Wire Length at Bottom (m)	Penetration (cm)	Grade Good (G) Fair (F) Poor (P)	Epifaunal Organisms	Volume (L)	Color	Odor	Texture/Grain Size	Latitude (N)		Longitude (E)		Comments
													deg.	decimal min.	deg.	decimal min.	
GO 8	2	04/11/08	20:20	2562	2588	no trip	-	-	-	-	-	-	13	32.601	144	25.401	
			21:25														
			22:30														
GO 8	3	04/11/08	22:45	2554	2586	16	G	no	20	yellowish brown	no	silty sand	13	32.599	144	25.400	
			23:47														
		04/12/08	0:50														
GO 8	4	04/12/08	1:20	2556	2581	no trip	-	-	-	-	-	-	13	32.599	144	25.400	
			2:29														
			3:30														
GO 8	5	04/12/08	3:45	2558	2594	no trip	-	-	-	-	-	-	13	32.599	144	25.400	shackles hung up
			4:46														
			5:45														
GO 8	6	04/12/08	6:00	2560	2590	no trip	-	-	-	-	-	-	13	32.601	144	25.402	
			7:04														
			8:05														
GO 8	7	04/12/08	8:33	2560	2601	30	G	no	16	yellowish brown	no	silty sand	13	32.598	144	25.674	moved station 8 due east (90 deg N). Possible rocky substrate due to bent core box
			9:34														
			10:45														
GO 8	8	04/16/08	22:57	2556	2591	30	G	no	25	yellowish brown	no	silty sand	13	32.602	144	29.396	
		04/17/08	0:00														
			1:01														
GO 8	9	04/17/08	1:40	2556	2590	33	G	no	25	yellowish brown	no	silty sand	13	32.601	144	25.296	
			2:44														
			3:50														
GO 9	1	04/15/08	22:27	2669	2699	no sample	-	-	-	-	-	-	13	31.202	144	32.200	big rock, complete washout; moved station 500m W (270 deg N)
			23:37														
		04/16/08	0:45														
GO 9	2	04/16/08	1:10	2612	2645	13	F	no	9	yellowish brown	no	silty sand	13	31.204	144	31.924	
			2:14														
			3:18														
GO 9	3	04/16/08	3:50	2613	2650	12	F	no	9	yellowish brown	no	silty sand	13	31.202	144	31.924	
			4:55														
			6:05														

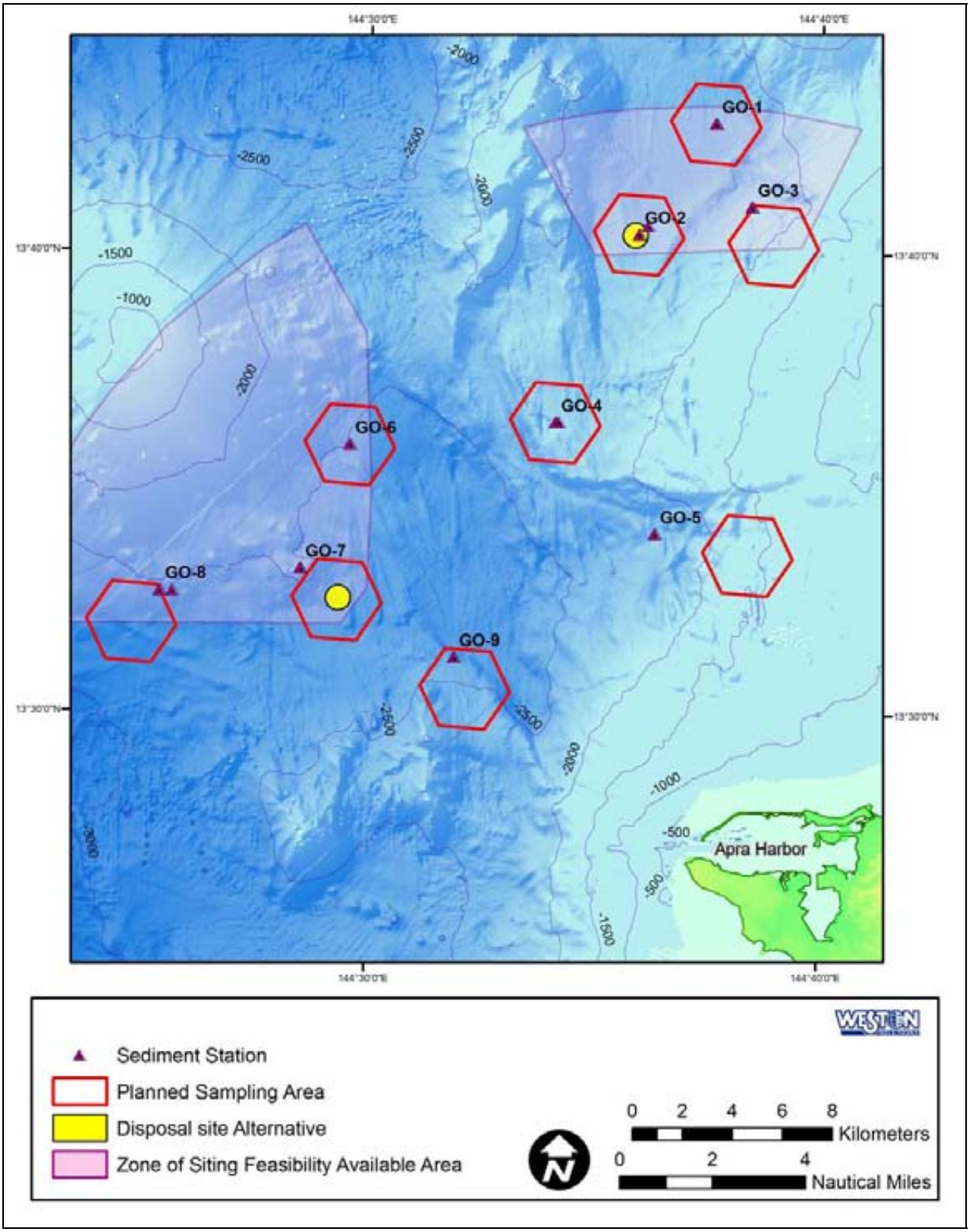

Figure 12. Final Sampling Locations for Sediment Samples

3.1.3.3 Fish Community Surveys

Beam Trawl Surveys

The fish community surveys, or trawls, were conducted across the entire sampling area. Unlike sampling for water or sediment samples which occur at discrete points, fish community surveys were conducted by towing a beam trawl along a planned transect. Due to the sparse fish population expected at the extreme operating depths, the trawl was planned to be 1 hour in duration from the time the beam contacts the bottom. At 2 kts (1 m/s) the estimated distance is approximately 2.0 nm (3.7 km).

Table 4 lists the coordinates for the start and end (i.e., beam on bottom and beam off bottom) of each survey. Figure 13 and Figure 14 show the final locations of each trawl. Surface current, swell direction and bathymetry were factors that were considered in the field when finalizing trawl location and direction. Ideally, trawls were conducted into the surface current and swell direction and along isobaths, to the maximum extent practical, but minor adjustments were made to account for underwater cables and bathymetric features. Field logs for the beam trawl surveys are presented in Appendix A.4.

Fish Trap Deployments

Due to a low abundance of demersal organisms in the beam trawls, baited fish traps were deployed in an effort to collect additional fish or epifaunal invertebrates for tissue chemistry analyses. Fish traps were deployed at two stations in each of the proposed alternative areas (Station 1 and 2 in the North Alternative area and Station 6 and 7 in the Northwest Alternative Area). Table 5 lists the final field coordinates for the placement (deployment) of each fish trap and Figure 13 and Figure 14 illustrates these locations. Field logs for the fish trap deployments are presented in Appendix A.4.

Underwater Video and Digital Still Camera Deployments

The DTS6000 underwater video and digital still camera was deployed at every station except Station 4. Field logs for the underwater video and digital still camera system are presented in Appendix A.4.

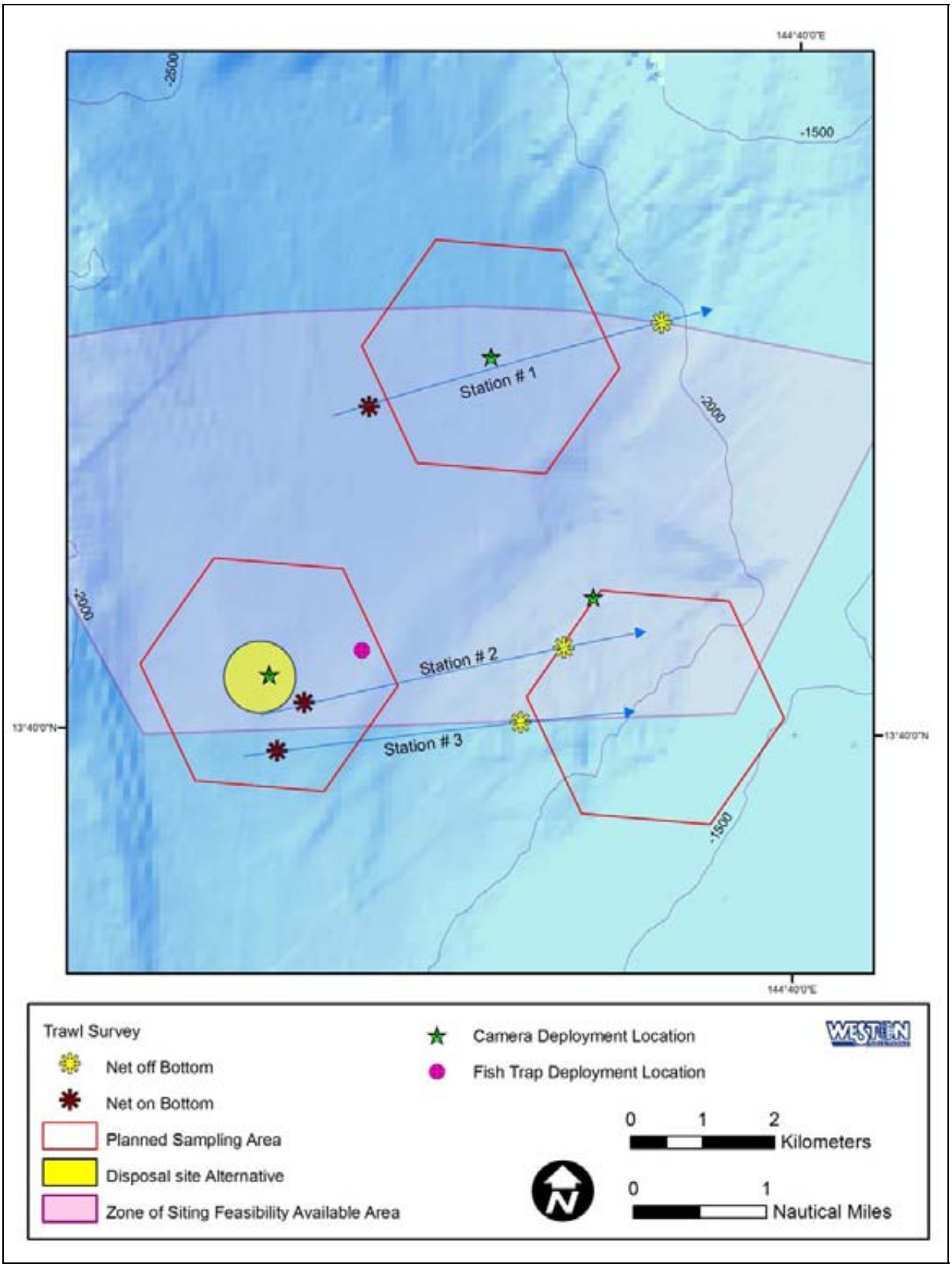

Figure 13. Locations of Fish Trawl Transects, Fish Trap Deployments and Underwater Camera Surveys in the North Alternative Area

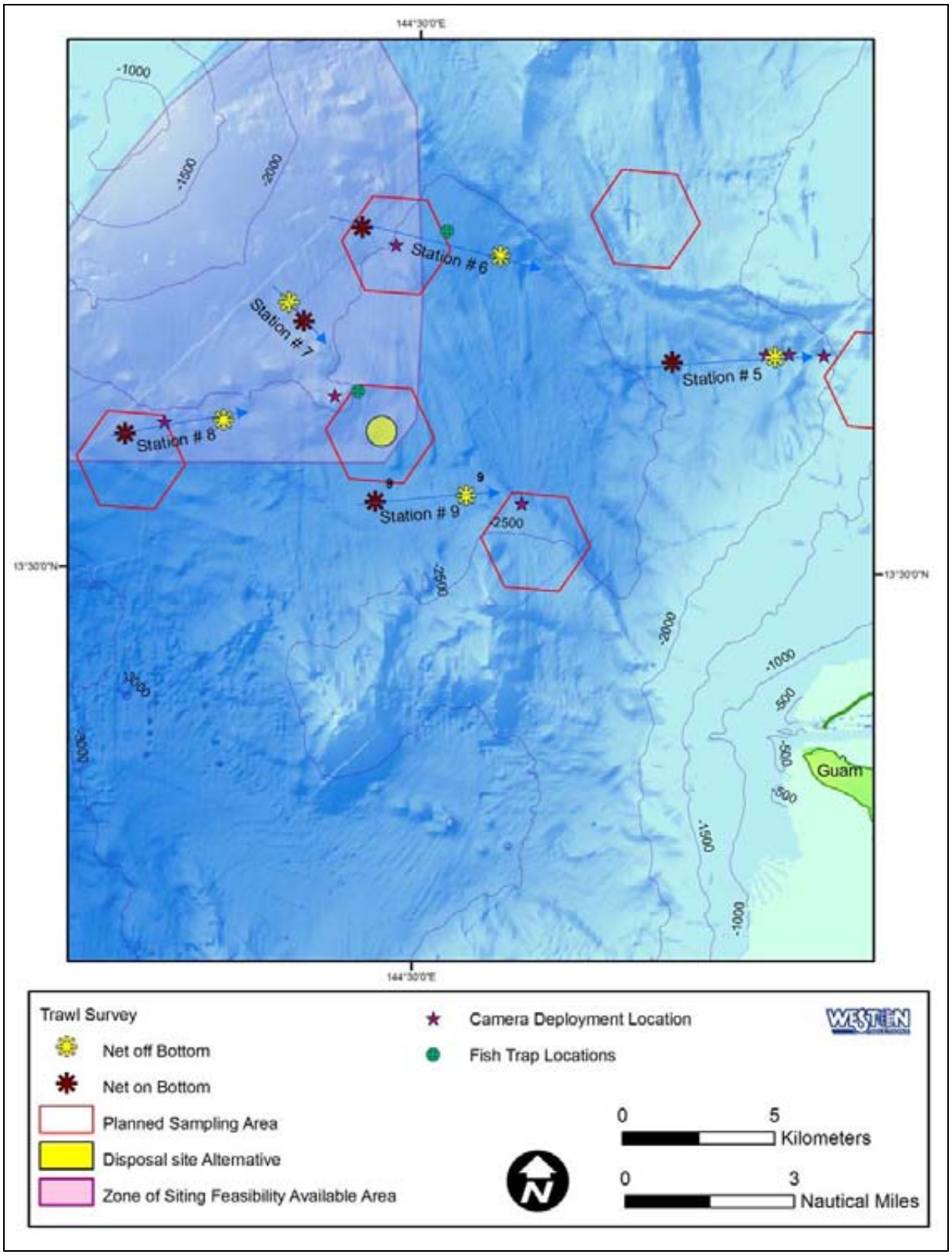

Figure 14. Locations of Fish Trawl Transects, Fish Trap Deployments and Underwater Camera Surveys in the Northwest Alternative and Inshore Study Areas

Table 4. Final Field Coordinates for Beam Trawl Surveys

Station	Net Status	Date	Time	Relative to Vessel					Relative to Net				Wire Out (m)	Comments
				Latitude (N)		Longitude (E)		Water Depth (m)	Latitude (N)		Longitude (E)			
				DD	MM.MMM	DD	MM.MMM		DD	MM.MMM	DD	MM.MMM		
GO-1	In Water	4/8/2008	9:45	13		144		2111	-		-		-	
	On Bottom	4/8/2008	11:47	13		144		2357	13	42.447	144	36.695	3723	Recovered Tarball
	Off Bottom	4/8/2008	12:47	13	41.882	144	34.330	2200	13	43.103	144	38.945	3723	
	On Board	4/8/2008	~14:00	13	43.006	144	38.246		-		-		-	
GO-2	In Water	4/8/2008	3:45	13	43.637	144	40.474	1963	-		-		-	
	On Bottom	4/8/2008	5:52	13		144		2215	13	40.207	144	36.215	3714	
	Off Bottom	4/8/2008	6:52	13	40.000	144	33.140	1984	13	40.639	144	38.217	3700	
	On Board	4/8/2008	~8:00	13	40.693	144	37.788		-		-		-	
GO-3	In Water	4/7/2008	21:56	13	41.224	144	39.753	2166	-		-		-	
	On Bottom	4/7/2008	23:50	13		144		2140	13	39.839	144	36.011	3185	
	Off Bottom	4/8/2008	0:50	13	39.489	144	33.837	1806	13	40.074	144	37.889	3219	
	On Board	4/8/2008	2:00	13	40.041	144	37.683		-		-		-	
GO-5	In Water	4/20/2008	12:30	13	40.269	144	39.539	2666	-		-		-	
	On Bottom	4/20/2008	14:38	13	40.550	144	42.453	2270	13	33.749	144	34.639	3850	Net Recontacts Rising Slope After Off Bottom
	Off Bottom	4/20/2008	15:38	13	33.681	144	31.958		13	33.858	144	36.517	3510	
	On Board	4/20/2008	~18:00	13	33.884	144	36.287		-		-		-	
GO-6	In Water	4/20/2008	6:45	13	33.988	144	38.208	1769	-		-		-	
	On Bottom	4/20/2008	9:02	13		144		2590	13	36.110	144	28.969	3950	
	Off Bottom	4/20/2008	10:27	13	35.857	144	25.937	2333	13	35.621	144	31.490	3350	
	On Board	4/20/2008	11:35	13	35.776	144	30.598		-		-		-	
GO-7	In Water	4/15/2008	12:40	13	35.257	144	33.150	2637	-		-		-	
	On Bottom	4/15/2008	14:56	13		144		2533	13	34.427	144	27.920	4144	Beam Caught on Bottom
	Off Bottom	4/15/2008	20:30	13	32.710	144	24.204		13	34.763	144	27.639		
	On Board	4/15/2008	~21:45	13	33.140	144	28.894		-		-		-	
GO-8	In Water	4/15/2008	6:24	13	33.116	144	28.660	3122	-		-		-	
	On Bottom	4/15/2008	8:48	13		144		2580	13	32.382	144	24.679	4184	
	Off Bottom	4/15/2008	9:48	13	31.890	144	21.720	2550	13	32.648	144	26.470	4269	
	On Board	4/15/2008	11:40	13	32.654	144	26.320		-		-		-	
GO-9	In Water	4/20/2008	18:40	13	32.937	144	28.089		-		-		-	
	On Bottom	4/20/2008	20:52	13		144		2665	13	31.212	144	29.255	3405	
	Off Bottom	4/20/2008	22:07	13	31.149	144	28.918	2713	13	31.338	144	30.908	2810	
	On Board	4/20/2008	23:30	13	31.324	144	30.915		-		-		-	
					31.467		32.596							

Table 5. Final Field Coordinates for Deployment of Fish Traps

Station	Status		Date	Time	Latitude (N)		Longitude (E)		Comments
					DD	MM.MMM	DD	MM.MMM	
GO 1	Deploy	buoy in water	4/10/2008	12:45	13	42.241	144	35.618	2 Hagfish
		trap in water	4/10/2008	14:30	13	43.021	144	38.170	
	Retrieve	buoy out of water	4/12/2008	17:20	13	43.960	144	37.927	
		trap out of water	4/12/2008	19:05	13	44.208	144	38.858	
GO 2	Deploy	buoy in water	4/8/2008	0:05	13	40.135	144	34.941	No fish
		trap in water	4/8/2008	1:47	13	40.608	144	36.658	
	Retrieve	buoy out of water	4/10/2008	9:45					
		trap out of water	4/10/2008	11:00					
GO 6	Deploy	buoy in water	4/14/2008	18:45					2 Hagfish
		trap in water	4/14/2008	20:40	13	36.056	144	30.516	
	Retrieve	buoy out of water	4/16/2008	9:45	13	36.292	144	31.121	
		trap out of water	4/16/2008	11:30					
GO 7	Deploy	buoy in water	4/12/2008	13:25	13	32.767	144	26.634	No fish; bait eaten clean
		trap in water	4/12/2008	15:05	13	33.179	144	28.921	
	Retrieve	buoy out of water	4/14/2008	16:25	13	33.922	144	29.529	
		trap out of water	4/14/2008	17:55	13	34.301	144	30.336	

3.1.3.4 Oceanographic Currents

Additional oceanographic current monitoring was conducted to confirm NCOM model results. Two current meter arrays were moored within the study region, one located on the inshore side and one located on the offshore side of the region of interest. The mooring locations were not co-located within target sampling areas to avoid possible entanglement during sampling operations (e.g., fish trawls etc.). Once deployed, the survey team pinged the acoustic release units to determine their range from the surface. Coupled with geographic coordinates from the surface, the coordinates for the final mooring locations were calculated using the method of lease squares. The coordinates for the final mooring locations are listed in Table 6 and illustrated in Figure 15. Final mooring locations were within 490 ft (150 m) for CM1 and 1,310 ft (400 m) for CM2 of planned locations.

Table 6. Final Field Coordinates for Current Meter Moorings

Station	Date Deployed	Latitude (N)		Longitude (E)		Water Depth
		DD	MM.MMM	DD	MM.MMM	(m)
CM1	1/18/2008	13	36.839	144	31.872	2,427
CM2	1/17/2008	13	32.413	144	36.126	2,264

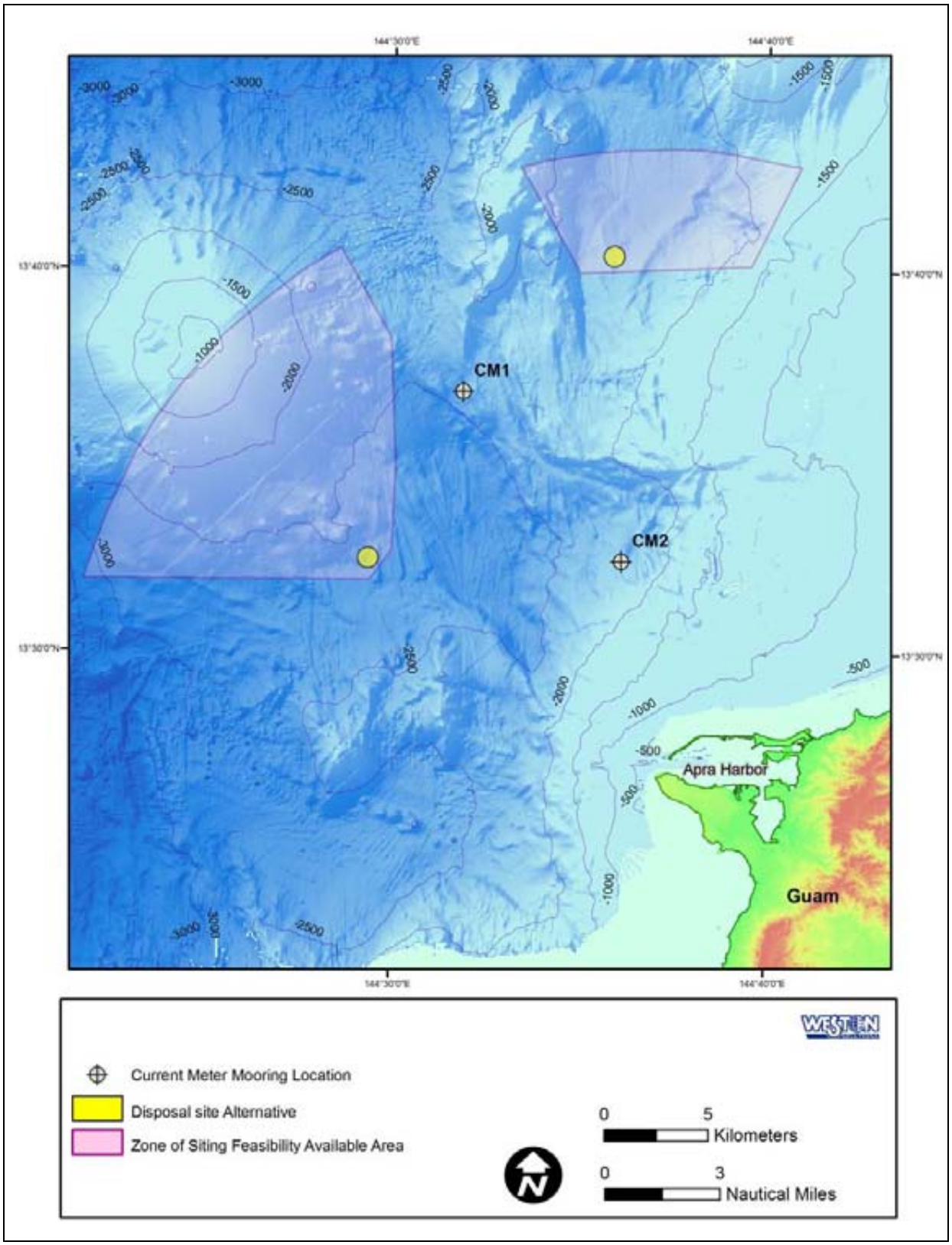

Figure 15. Locations of Deep Sea Current Meter Moorings.

3.1.4 Sample Collection and Handling

3.1.4.1 Water Column

During deployment, proprietary software, SEASOFT, provided real-time graphs of the raw water quality data on a shipboard computer display. This enabled the scientific crew to evaluate the data and make final decisions regarding sampling depths. Water samples were automatically collected by selecting an option in the software when the CTD was at a specified depth. Although only one Niskin bottle was required to collect adequate volume for the required analyses, six 10-L Niskin bottles were triggered to close at each of four depths per station sampled to ensure successful sample collection. Raw CTD data were saved to disc as a binary file for additional post-processing in SEASOFT.

Once onboard, aliquots were taken from the Niskin water samplers and sample processing and preservation techniques were initiated. For dissolved metals, dissolved orthophosphate, nitrate and nitrite analyses, the water samples were filtered according to the following methods. First, the filtration apparatus was cleaned using 2% nitric acid in order to reduce residual zinc associated with the apparatus from approximately 2 ppb to 0.1 ppb. The 2% nitric acid was pulled through the filter using a vacuum pump and discarded. Next, the filtration apparatus was rinsed twice with deionized (DI) water; each time the DI water was pulled through the filter and discarded. Finally, seawater was placed in the filtration apparatus and pulled through the filter. Filtered seawater was placed in laboratory supplied sample bottles. Upon completion of the filtration process, a 1-L aliquot was ultimately placed in an unpreserved plastic bottle and kept cool (<4°C) for dissolved metals analysis and a 1-L aliquot was placed in an unpreserved plastic bottle and frozen for dissolved orthophosphate, nitrate and nitrite analyses. Each sample was labeled as "filtered".

For polycyclic aromatic hydrocarbons (PAHs), chlorinated pesticides, polychlorinated biphenyls (PCBs; Aroclors and individual congeners) analyses, the water samples were preserved using dichloromethane. A 950 mL aliquot of unfiltered seawater was placed in a 1-L amber glass bottle and 50 mL of dichloromethane was added. The solution was then vigorously shaken for 2 minutes. This process was completed twice in order to obtain the required volume for the analyses. The samples were kept cool (<4°C). Each sample bottle was labeled as "preserved".

For ammonia analysis, a 250 mL aliquot of unfiltered seawater was placed in an amber glass jar containing a sulfuric acid (H_2SO_4) preservative. The samples were kept cool (<4°C).

For TOC analysis, a 250 mL aliquot of unfiltered seawater was placed in a clear glass jar containing a phosphoric acid (H_3PO_4) preservative. The samples were kept cool (<4°C).

3.1.4.2 Sediment Samples

Once onboard, the boxcore was secured to the deck and the sample box was removed and placed on a dolly. The sample box was then moved to a sample processing station, secured and sample processing commenced. The sample was then assessed to determine whether the sample was acceptable. If the sediment surface of the sample was highly disturbed (i.e. unacceptable sediment penetration, washed out surface, sample canted to one side), the sample was disposed and another attempt was made. A minimum of two attempts were made at each station to obtain an acceptable sample, before a decision was made to move the station to another location.

In nearly all cases, the disposition of sediment from each grab per station followed the protocol as outlined in Table 7 and displayed in Figure 16. In cases where the sample was mildly disturbed (i.e. partial washout) and it was determined the remaining sediment could be sampled without sacrificing sample integrity, the subsampling scheme may have been slightly altered to maximize the use of available sediment.

For chemical analyses, including TOC, two samples were collected from the boxcore at each station, one for analysis (comprised of two 4 oz [~200 cm^3] subsamples composited together) and one for archive (comprised of one 4 oz [~200 cm^3] subsample), using a 2.0 in. (5.1 cm) inner diameter dimension by 5.9 in. (15 cm) tall plexiglass coring tube. The three tubes were placed following the placement of the three plexiglass coring tubes for meiofauna sample collection and subsequent siphoning of the overlying water, if present. Each tube was pushed into the top ~4 in. (10 cm) of the sediment. Remaining samples for other analyses were then taken. The two tubes representing the subsample to be analyzed were slowly drawn from the sediment and the subsample was removed from the plexiglass core and placed into a stainless steel mixing bowl. The two subsamples were then thoroughly homogenized into one composite sample using a stainless steel mixing spoon and placed into a certified pre-cleaned glass jar. The one tube representing the subsample to be archived was slowly drawn from the sediment, removed from the plexiglass core and placed into a certified pre-cleaned glass jar. The samples were kept cool (<4°C).

For physical analyses (grain size), after the overlying water had been siphoned off, as necessary, one plastic bag was filled with approximately 50 g of sediment from the boxcore using stainless steel spoons. The samples were kept cool (<4°C).

Table 7. Disposition and Approximate Volumes of Sediment per Grab

Grab No.	Sediment Disposition	Volume
1	Chemistry #1	0.2 L (one 4 oz jar)
	Chemistry #2	0.2 L (one 4 oz jar)
	Chemistry Archive	0.2 L (one 4 oz jar)
	Grain Size	0.2 L (one 4 oz bag)
	Meiofauna #1	0.1 L
	Meiofauna #2	0.1 L
	Meiofauna Archive	0.1 L
	Macroinfauna #1	6.25 L
	Bioaccumulation	up to ~17.5 L
2	Macroinfauna #2 and #3 or Macroinfauna #2 and Bioaccumulation	6.25 L each or 6.25 L and 18.75 L
3	Macroinfauna #3 and Bioaccumulation or Bioaccumulation	6.25 L and 18.75 L or 25 L
4	Bioaccumulation	25 L

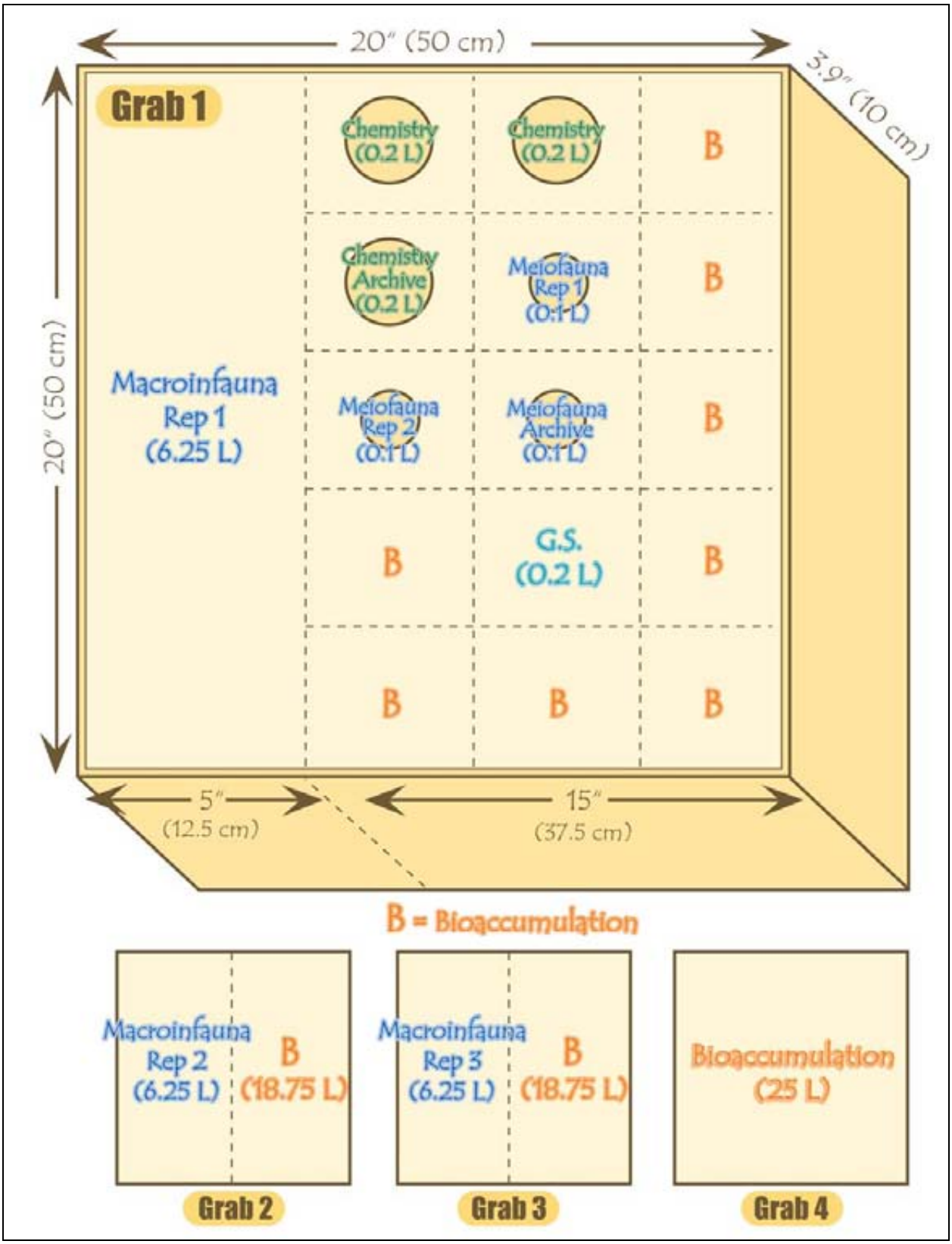

Figure 16. Schematic Illustrating Number of Boxcore Attempts and Associated Sediment Disposition.

3.1.4.3 Invertebrate Sampling (Benthic Communities)

Macroinfauna

Macroinfaunal organisms are defined as those organisms that are retained on a 0.5-mm sieve. Three replicates were collected at 9 stations for macroinfaunal analysis using a 25 L boxcorer. Once the box corer was retrieved, the sample was assessed to determine whether the sample was acceptable. If the sediment surface of the sample was highly disturbed (i.e. unacceptable sediment penetration, washed out surface, sample canted to one side), the sample was disposed and another attempt was made. A minimum of two attempts were made at each station to obtain an acceptable sample, before a decision was made to move the station to another location.

Once the sample was determined to be acceptable, all of the cores that were used for meiofauna and chemistry were inserted into the sediment to ensure that the overlying water was captured for those analyses. A plexiglass insert was then placed evenly down the middle of the box corer so that one portion of the boxcore (6.25 L) was used for the macroinfaunal sample (Figure 16). All overlying water, if present, was then siphoned off using a small hand pump. Using a large scoop, the top ~4 in (10 cm) of sediment was removed and placed into a 5-gallon bucket.

Samples were then gently rinsed over a 0.5-mm sieve with filtered seawater to remove the sediment. Once washed, the remaining sample was rinsed into a plastic sample jar using a narcotizing solution of magnesium sulfate (25 g $MgSO_4$ for every liter of seawater) and a label with the station information was added. After the sample sat in magnesium sulfate for 30 minutes, buffered formalin was added as a preservative to achieve a 10% buffered formalin solution. The sample was gently shaken to ensure that the preservative was evenly distributed. A poison sticker and an additional label with station information were placed on top of the sample jar. Samples were stored at room temperature and in a shaded area.

Meiofauna

Meiofaunal organisms live in benthic sediments and are between 0.063 and 0.5 mm in length. Meiofaunal samples were collected at 9 stations with the same boxcorer as used in collection of the macroinfaunal samples. Three samples were collected from the box corer at each station, two for analysis and one for archive, using a 1.35 in (3.5 cm) inner diameter dimension by ~4 in (10 cm) tall plexiglass coring tube (Figure 16). With the overlying water still in the box corer, if present, each tube was pushed into the top ~2 in (5 cm) of the sediment. After insertion, the remaining overlying water in the box corer was siphoned off. Remaining samples for other analyses were then taken. The coring tube was slowly drawn from the sediment.

If present, the overlying water was poured into a small plastic sample jar along with the top ~2 in (5 cm) of sediment from the coring tube. A narcotizing solution of magnesium sulfate (25 g $MgSO_4$ for every liter of seawater) was used to rinse any residual sediment from the cores into the sample jar. The entire sample was then covered with the magnesium sulfate solution and shaken vigorously. Once the sample had sat for 30 minutes, the liquid was then decanted through nested 500-µm and 63-µm sieves. The sample remaining on the 63-µm sieve was then backwashed into a sample jar (using magnesium sulfate again) and a label added with station information. Buffered formalin was then added as a preservative to achieve a 10% buffered formalin solution. The jar was lightly shaken to ensure that the preservative was thoroughly mixed with the sample. A poison sticker and an additional label with station information were placed on top of the sample jar. Samples were stored at room temperature and in a shaded area.

3.1.4.4 Fish Community Surveys

After the trawl had been retrieved, the catch was placed in tubs for processing. An initial sorting was conducted, separating the catch into major categories (e.g., echinoderms, arthropods, macrourids, myxinids, etc.).

Identification of fish and invertebrates collected during the trawl was conducted on the *R/V Melville*, following the trawl, to the maximum extent possible. Although there were limited resources (e.g., taxonomic keys or field guides) for identifying deep sea species from this region of the western Pacific Ocean, several references were available to assist in the identification process. These references included Smith's Sea Fishes (Smith and Heemstra, 1986), Fish of the Japanese Archipelago (Masuda et al. 1984), Deep-Water Teleostean Fish of California (Fitch and Lavenburg, 1968), Guide to Coastal Marine Fishes of California (Miller and Lea, 1972) and Pacific Coast Fishes (Eschmeyer et al., 1983). For those organisms not identified in the field, the organism were properly preserved, labeled FID (Further Identification) and shipped to Weston's benthic laboratory in Carlsbad, California, for final identification.

Vouchers were generated for a representative organism of a given species. For specimens too large to be properly preserved, photo vouchers were generated. At a minimum, the voucher included the identification (to species level, when possible), collection date, site name and location, and depth (Appendix A.4). Vouchers will be archived at Weston's office in Carlsbad, California until the project has been completed, at which point they will be offered to museum collections (e.g., Scripps Institute of Oceanography or Los Angeles County Museum of Natural History).

After the initial sorting, each individual organism from the catch was measured for length and weight, examined for gross pathology, and enumerated (using log forms presented in Appendix A.4). Photographs were taken of a representative individual for all species.

Fish were measured using a standard measuring board or a tape measure for larger specimens. Lengths were recorded to the nearest millimeter. For bony fishes, the length recorded was from the anterior tip of the head to the posterior end of the caudal peduncle (slightly anterior of the visible origin of the caudal fin rays) or end of the vertebrae if no caudal peduncle was present.

Fish were weighed using spring scales. Weights were collected to the nearest gram for smaller fish and to the nearest tenth of a kilogram for larger fish. Multiple spring scales capable of weighing different sizes (weights) were available. Scales were calibrated each day. If a tare bucket (or similar device) was used, the weight of the tare bucket was recorded, the total (gross) weight of the tare bucket and fish was recorded, and the net weight (gross weight minus tare bucket) was also recorded (Appendix A.4).

While measuring the individual specimens for length and weight, an examination of the organism for gross pathology was conducted and recorded on the Trawl Species Record Form. Types of pathology recorded included:

- Fin erosion
- Tail erosion
- Tumors
- External parasites
- Eye parasites
- Color anomalies
- Skeletal deformities
- Lesions
- Other, including suspected net abrasions (with a description of the pathology or anomalous condition)

The total number of individuals for each species was recorded.

Although taxonomic keys and field guides enabled the scientists to accurately identify the specimens, due to the extreme depths from which these specimens were being collected, many of the specimens were inherently unfamiliar. Therefore, several safety precautions were used to protect the scientists from

venomous spines, sharp teeth or other specimen-specific defense mechanisms. Heavy duty latex gloves were worn when handling the fish or invertebrates.

Specimens requiring further identification or were selected as vouchers were properly preserved. For soft-bodied invertebrates, the preferred method of preservation was first to be fixed in a 10% buffered formalin solution then transferred to a 70% ethanol solution. Fish were placed in plastic bags and frozen so that subsequent DNA analysis could be performed, as requested by Scripps Institute of Oceanography.

Fish with body cavities greater than 60 mm were slit with a scalpel (down the right side for bilaterally symmetrical fish; down the blind side for flatfish; or down the ventral side for dorsoventrally flattened fish) enabling the 10% buffered formalin solution to preserve internal organs as well. The fish and invertebrates were placed in plastic bags or plastic containers, and a 10% buffered formalin solution added until the organism was covered. A label indicating the sample was in a formalin solution was placed on the sample container. After a minimum of 3 days but less than a maximum of 7 days, the organism was removed from the 10% buffered formalin solution and then was gently rinsed with either filtered seawater from a spray nozzle. The formalin solution was captured in a 5-gallon bucket and treated, or neutralized, with Tissue-Tek® NEUTRA-GUARD® prior to disposal. Once the organism had been thoroughly rinsed, it was returned to the original container. The sample container was then filled with 70% ethanol, making sure to cover the sample by several inches, original labels were placed back into the container, and an ethanol label was placed over the formalin label to indicate that the transfer had taken place. Dates of transfer were filled out in the sample log datasheets. Samples were then stored on the vessel at room temperature in a safe and secure manner.

3.1.4.5 Oceanographic Currents

The Aquadopp current meters were configured to collect data once every hour. Individual measurements collected over a one minute period were averaged and recorded. The Continental ADCPs were configured to collect data from each 16 ft [5 m] interval from the sea surface to a depth of -500 ft [155 m] once every hour. For each bin, or layer, individual measurements collected over a one minute period were averaged and recorded.

3.1.5 Sample Shipping

Prior to shipping, jars containing samples for physical, chemical or biological analyses were placed in sealable plastic bags and securely packed inside the cooler with ice packs or dry ice. As noted above, a COC form was completed and placed inside the cooler containing the listed samples. The cooler lids were securely taped shut and shipped to Weston's Carlsbad, California office. After sample processing, if necessary, samples were then delivered to the appropriate laboratory as listed in Table 8.

Samples with short holding times or that required preservation at either <4°C or frozen (water, sediment and fish/invertebrate specimens) were shipped via Continental Air Cargo Express, to maintain sample integrity. Continental provided refrigerated (<4°C) storage prior to and after each air shipment to further maintain sample integrity. Samples preserved in the field and that did not require preservation at <4°C (benthic samples preserved in 70% ethanol) were shipped via ocean freight according to Weston's SOP for shipment and transportation of hazardous or dangerous goods. Once the samples were shipped, the point of contact at each laboratory was contacted and informed to expect the delivery of samples.

Table 8. Analytical Laboratories, Point of Contact and Shipping Information

Laboratory	Analyses Performed	Point of Contact	Shipping Information
Weston Solutions, Inc.	Benthic Sorting	Ms. Sheila Holt (760) 795-6900 (760) 795-6914 direct	Weston Solutions, Inc. 2433 Impala Drive Carlsbad, CA 92010
	Bioassay Testing	Ms. Amy Margolis (760) 795-6900 (760) 795-6959 direct	
CRG Marine Laboratories	Sediment and Tissue Chemistry	Mr. Richard Gossett (310) 533-5190 x130	CRG Marine Laboratories 2020 Del Amo Boulevard, Suite 200 Torrance, CA 90501
NewFields *Northwest*, LLC	Laboratory-based Tissue Bioaccumulation Analyses	Mr. Jack Word (360) 297-6040 (360) 297-6060 direct Mr. Brian Hester (360) 297-6070 direct	NewFields *Northwest*, LLC 4729 NE View Drive. Port Gamble, WA 98364

Benthic macroinfauna and meiofauna samples and fish samples requiring further identification were first shipped to Weston's Benthic Laboratory in Carlsbad, California. After the macroinfauna and meiofauna samples were sorted, these samples were hand delivered to the appropriate taxonomists for final identification. The fish samples were hand delivered to the Scripps Institute of Oceanography for final identification. The epibenthic invertebrate samples were hand delivered to the appropriate taxonomist for final identification.

3.1.6 Sample Processing and Storage

3.1.6.1 Water Column

No additional sample processing was required for water samples collected onboard the *R/V Melville* and designated for physical or chemical analyses. Sediment samples were stored either at 4°C or frozen (Section 3.1.4.1) until delivered to the chemistry laboratory for analyses.

3.1.6.2 Sediment Samples

No additional sample processing was required for sediment samples collected onboard the *R/V Melville* and designated for physical or chemical analyses. Sediment samples were stored frozen, with the exception of samples designated for grain size analysis which were stored at 4°C, until delivered to the chemistry laboratory for analyses. A sub-sample from each Station, as well as the composite used in biological testing, was archived frozen in the event that further delineation of chemical contamination is required.

Sediment designated for biological testing was stored at 4 °C until processed. Three composite samples, representing the two potential alternative areas and the proposed reference location, were created from individual sediment grabs. The composite representing the North Alternative area was comprised of individual grab samples from Stations 1-3. The composite representing the Northwest Alternative area was comprised of individual grab samples from Stations 6-8. The proposed reference site composite was comprised of material from Station 5. For each composite, each grab sample was homogenized to a

uniform consistency at the laboratory using a stainless steel mixing apparatus. The composite samples were generated from the areas by homogenizing sediment from each grab location from each station in a given area. The composite sample for each area was then placed into clean polyethylene sediment bags and stored at 4°C until delivered to the appropriate bioassay laboratory for analyses.

3.1.6.3 Invertebrate Sampling (Benthic Communities)

Macroinfauna Samples

A small portion of the sample was placed in a sorting tray and sorted carefully and systematically using a dissection microscope. Each tray was examined 2-3 times and organisms were placed in vials containing 70% ethanol according to five major taxonomic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla. While sorting, an estimated total count was kept for quality assurance/quality control (QA/QC) purposes. Appropriate labels were used for each vial and a sort sheet was completed. Sorted or "grunge" material was returned to 70% ethanol for storage and logged back into the storage location. The number of vials and jars containing specimens was recorded on sort sheets and organized for taxonomy. Qualified taxonomists identified each organism and kept an actual specimen count. The organisms were identified to the lowest possible taxon for each phylum. The taxonomists created a client infaunal voucher collection to allow for verification of future identifications. Taxonomists vouchered a minimum of one specimen for each species identified. Any client or personal vouchers taken were noted on taxonomic data sheets and labels were placed in the vials with the appropriate voucher information.

Meiofauna Samples

Meiofauna samples were analyzed by the same method as the macroinfauna samples with two exceptions. One, the sample was rinsed over a sieve size that was smaller than 63-µm, rather than a 0.3-mm sieve (using a sieve one size smaller than that used during sample collection is a QA/QC procedure to prevent loss of whole or partial organisms). Two, only two species groups were sorted from the meiofauna samples: nematodes and harpacticoid copepods.

3.1.6.4 Fish Community Surveys

No additional sample processing was required for macroepifauna samples collected onboard the *R/V Melville* and designated for taxonomic identification. Specimens were stored frozen until delivered to the appropriate taxonomists for identification.

3.1.6.5 Oceanographic Currents

After retrieval, data from current meters and current profilers were downloaded to a laptop computer using Nortek proprietary software. The raw X, Y, Z data (relative to the instrument's internal reference system) were processed and output to ASCII text files that included E, N, U vectors (relative to degrees True North) and a resultant speed and direction (also relative to degrees True North).

Data were processed similarly to the methods identified in the *Ocean Current Study, Ocean Dredged Material Disposal Site, Apra Harbor, Guam* (Weston and Belt Collins 2007b). The ASCII text files were imported into a SAS® database (SAS 2006). The E, N, U vectors were processed into daily averages (net current speed and direction) from which monthly then seasonal averages were determined.

A series of plots were made in Grapher (Golden Software 2005). Rose diagrams representing the frequency of distribution of current directions and speed for each depth at a single location and vector plots representing daily averaged current velocities at each location by month and depth were created. These plots provided a cursory review of the spatial (both horizontal and vertical) as well as temporal patterns in the data. Once patterns were identified, more quantitative statistical analyses were conducted using SAS software to identify significant trends or differences in the currents.

3.1.7 Documentation and Chain of Custody

Samples were considered to be in custody if they were: (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a secured container. The principal documents used to identify samples and to document possession were Chain of Custody (COC) records, field log books, 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 (completed COCs were included with the analytical results and are presented in Appendix B). Each person who had custody of the samples signed the form and ensured that the samples were not left unattended unless properly secured. Minimum documentation of sample handling and custody included the following:

- Sample identification
- 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

The completed COC form was placed in a sealable 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 were included in the final analytical report prepared by the laboratory, and were considered an integral part of that report.

3.2 Physical and Chemical Analyses

Physical and chemical parameters to be measured in this testing program were selected to provide data on the background concentrations of potential contaminants of concern in the receiving sediments collected from two alternative ODMDS, a proposed reference site and the surrounding region, in accordance with the guidance document for designation of ODMDS (Pequegnat et al., 1990). Current U.S. Environmental Protection Agency (USEPA) SW-846 analytical methods were used in chemical analysis (USEPA, 2001). The specific sediment analyses and target detection limits are specified in the SAP developed for this project (Weston and Belt Collins Hawaii, 2007).

3.2.1 Water

Standard Method 4500 was used for the analysis of ammonia (-NH_3 F), dissolved orthophosphate (-P E), nitrate (-NO_3 E) and nitrite (-NO_2 B). Total organic carbon (TOC) was analyzed following the procedures outlined in EPA 415.1. The analysis for priority pollutant metals (except mercury) was conducted using an inductively coupled plasma emissions spectrometer equipped with a mass detector (ICP-MS), in accordance with USEPA 1640m. Mercury analysis was conducted using cold vapor atomic fluorescence spectrometry (CVAFS) in accordance with USEPA 245.7m. Organics, including PAHs, chlorinated pesticides, and PCBs, were analyzed using gas chromatography-mass spectrometry with selected ion monitoring (GC/MS SIM) according to USEPA 625m. This method followed serial extraction with methylene chloride and alumina and gel permeation column cleanup procedures. PCBs were measured as Aroclors and individual congeners, separately.

3.2.2 Sediment

Project sediments were analyzed for the contaminants listed in Table 8 of the SAP (Weston and Belt Collins Hawaii 2007). The target detection limits (sediment – dry weight) were also presented in the SAP. All analytical methods used to obtain physical measurements or contaminant concentrations followed USEPA, Standard Methods (SM) and American Society of Testing and Materials (ASTM) procedures, with the exception of grain size which followed procedures developed by Plumb (1981).

3.2.2.1 Physical Analyses

Physical analyses of the sediment included grain size, TOC, and total solids. Grain size was analyzed to determine the general size classes that make up the sediment (e.g., gravel, sand, silt, and clay) using the light-scattering instrumentation as described in SM 2560 D. The frequency distribution of the size ranges of the sediment was presented in the final laboratory data report. TOC was determined using the Lloyd Kahn method (USEPA Region II, 1988). Sediment was treated with acid to remove the inorganic carbon (carbonates and bicarbonates) prior to TOC analysis using the USEPA 9060A protocol. Percent solids were measured to convert concentrations of the chemical parameters from a wet-weight to a dry-weight basis. Percent solids were determined by EPA 160.3.

3.2.2.2 Chemistry Analyses

The analysis for total sulfides followed SM 4500-S2-D while the analysis for ammonia followed SM 4500-NH_3 F. Total Kjeldahl Nitrogen (TKN) was analyzed using modified SM 4500 NOrgB. Total organic nitrogen (TON) was calculated by subtracting the ammonia concentration from the TKN concentration. The analysis for priority pollutant metals (except mercury) was conducted using an ICP-MS, in accordance with USEPA 6020m. Mercury analysis was conducted using CVAFS in accordance with USEPA 245.7m. The analysis for acid volatile sulfides (AVS) was conducted in accordance with Plumb (1981)/Trace Element Research Laboratory's (TERL) Method 013 and was determined by releasing sulfide from sediment particles with hydrogen chloride and trapping hydrogen sulfide gas in a base then measuring it by colorimetry. The analysis for simultaneously extracted metals (SEM) was conducted using ICP-MS following EPA 200.8. Organics, including PAHs, chlorinated pesticides, and PCBs, were analyzed using GC/MS SIM according to USEPA 8270m. This method followed serial extraction with methylene chloride and alumina and gel permeation column cleanup procedures. PCBs were measured as Aroclors and individual congeners, separately. Tributyltin (TBT) and its derivatives were analyzed by GC/MS according to Krone et al. (1989), following a cleanup procedure involving methylene chloride extraction and Grignard derivatization. Dibenzo-*p*-dioxins and dibenzofurans were analyzed by high resolution gas chromatography-high resolution mass spectrometry (HRGC/HRMS) following isotope dilution. Gross alpha and beta particle counts were determined following USEPA 900.0 using an alpha gas particle counter.

3.2.2.3 Analysis of Sediment Contaminants and Comparison to ER-L and ER-M Values

Results of chemical analyses of project dredged materials were compared to effects range-low (ER-L) and effects range-median (ER-M) values developed by Long et al. (1995). The effects range values are helpful in assessing the potential significance of elevated sediment-associated contaminants of concern, in conjunction with biological analyses. Briefly, these values were developed from a large data set where results of both benthic organism effects (e.g., toxicity tests, benthic assessments) and chemical concentrations were available for individual samples. To derive these guidelines, the chemical values for paired data demonstrating benthic impairment were sorted in according to ascending chemical concentration. The 10^{th} percentile of this rank order distribution was identified as the ER-L and the 50^{th} percentile as the ER-M. While these values are useful for identifying elevated sediment-associated contaminants, they should not be used to infer causality because of the inherent variability and uncertainty of the approach. The ER-L and ER-M sediment quality values are used in conjunction with bioassay testing and are included for comparative purposes only.

3.2.3 Tissue

3.2.3.1 Bioaccumulation Tissue Chemistry

Tissue analysis was performed to determine the availability of sediment contaminants taken up by the test organisms. Percent lipids were measured following extraction procedures outlined EPA 8270 then using gravimetric values for final calculations. The remaining chemistry analyses on tissues were conducted using the same methods for sediment samples (Section 3.2.2.2). The target constituent list and detection limits (based on wet weight) for tissue analysis (including pre-exposure samples) was presented in the project SAP (Weston and Belt Collins Hawaii, 2007). Tissue composites from each replicate were analyzed separately.

3.3 Species Identification

Organisms collected from the beam trawl surveys and fish trap deployments were submitted to appropriate experts for identification. Fish samples were provided to Mr. Richard Rosenblatt, Ph.D., a Professor of Marine Biology at Scripps Institute of Oceanography for identification and inclusion into the Scripps Institute of Oceanography's fish collection library. Invertebrate samples were provided to two taxonomists, Mr. John Ljubenkov and Mr. Tony Phillips, Ph.D., for identification.

3.4 Toxicity Testing

As outlined in the SAP, bioassay testing was performed on the proposed reference site composite sample and three individual grab samples that comprised the proposed reference site composite sample. Toxicity testing for this project included three SP toxicity tests and two bioaccumulation potential tests. All testing and analysis was performed in accordance with the general guidelines provided in the Ocean Testing Manual (OTM; USEPA/U.S. Army Corps of Engineers [USACE], 1991); the Inland Testing Manual (ITM; USEPA/USACE, 1998) was used as guidance for more specific methodologies and test conditions. Specific bioassays performed for this project are summarized in Table 9.

Table 9. Toxicity Testing on Sediment Collected from the Proposed Reference Site for a Future Designated Guam ODMDS, Offshore of Guam.

Test Type	Type of Organism	Taxon	Project Sediments	Control Sediment	Reference[1] Toxicant	Ammonia[1] Reference Toxicant
Solid Phase (SP)	Amphipod	*Ampelisca abdita*	X	X	X	X
	Amphipod	*Eohaustorius estuaries*	X	X	X	X
	Polychaete	*Neanthes arenaceodentata*	X	X	X	X
Bioaccumulation Potential (BP)	Bivalve	*Macoma nasuta*	X	X		
	Polychaete	*Nephtys caecoides*	X	X		

[1] Shaded areas indicate tests or treatments that are not applicable to the selected tests.

3.4.1 Solid Phase Testing

SP bioassays were performed to estimate the potential impact of ocean disposal of dredged sediment on benthic organisms that attempt to re-colonize the area. Dredged material was tested in 10-day SP tests using three species: marine amphipods (*Ampelisca abdita* and *Eohaustorius estuarius*) and a polychaete worm (*Neanthes arenaceodentata*). Two marine amphipods were selected due to findings in recent sediment characterization studies of Apra Harbor dredged material (MEC Analytical Systems and Hawaii Pacific Engineers, 2005; Weston Solutions and Hawaii Pacific Engineers, 2005a, 2005b; Weston Solutions and Belt Collins Hawaii, 2005, 2007) that indicate a wide range of sediment types throughout the harbor (e.g., predominantly fine-grained material in Inner Apra Harbor and predominantly coarse-grained material in Outer Apra Harbor). *A. abdita* tends to perform better SP tests conducted on fine-grained sediments whereas *E. estuarius* tends to perform better in SP tests in which the material is predominantly sand. Prior to testing, the project and control sediments were sieved to remove organisms by press-sieving the sediment through a 2.0 mm mesh screen using only the water available in the sediment sample. Each sediment type (project and control) was run with five replicates.

Threee separate rounds of bioassay tests were conducted. The first round consisted of composited sediment from the proposed reference location (Station 5), sediment from three individual grabs that comprised the composite and laboratory control sediment. The second and third rounds consisted solely of composited sediment from the proposed reference location (Station 5). Each round was conducted using separate batches of test organisms. This study design was developed to investigate the variability of sediment used to develop the composite sample and organism response.

3.4.1.1 Ampelisca abdita 10-day SP Test

Bioassay tests using *A. abdita* were conducted in accordance with the procedures outlined in the ITM (USEPA/USACE, 1998) and the amphipod testing manual (USEPA, 1994). Test animals and laboratory control sediment were supplied by Aquatic Research Organisms, Hampton, New Hampshire. Sediment was placed in five replicate 1 L glass jars to a thickness of 2 cm (150 mL), to which was added approximately 600 mL of 28 ± 2 ppth seawater. Additional surrogate replicates (no animals) for each treatment were set-up to obtain measurement of pore water ammonia at test initiation and termination. The test was run under continuous light at a temperature of 20 ± 2°C and under gentle aeration. On Day 0, an initial set of water quality parameter measurements were made including temperature, DO, hydrogen ion concentration (pH), and salinity for each replicate. Ammonia was measured in the overlying water of a composite of replicates from each control, reference, and test site. Daily water quality measurements including DO, temperature, salinity, and pH were taken for one replicate for each treatment. In addition, a surrogate replicate from each test treatment was broken down, and sediment pore water was extracted via centrifugation for subsequent analysis of ammonia. At test initiation, organisms were randomly distributed to test chambers (20 animals per chamber). Animals remaining in the water column and exhibiting abnormal behavior were replaced after 1 hour. The chambers were covered with petri dishes to minimize evaporation. Daily water quality measurements were taken and the number of surviving animals counted. On Day 10, the sediments from the chambers were sieved through a 0.5 mm screen, and the number of survivors was recorded. Test results were compared to test acceptability criterion (i.e., ≥90% mean survival in controls at test termination or 96 hours post-exposure). A reference toxicant test was conducted using cadmium chloride to establish sensitivity of test organisms used in the evaluation of project sediments according to Lee (1980). An additional reference toxicant test was also conducted using ammonium chloride (total measured ammonia per liter and calculated un-ionized ammonia per liter) to evaluate the potential influence of ammonia toxicity. The experimental design, bioassay procedures and water quality measurements for the SP test on project sediments using *A. abdita* are shown in Table 10.

Table 10. Experimental Design, Bioassay Procedure and Water Quality Measurements for the 10 day SP Bioassay Using *Ampelisca abdita* and *Eohaustorius estuarius*.

Toxicity Test Experimental Design 10-Day SP Bioassay			
Sample Identification		GO5 Composite; GO5-Grab 7; GO5-Grab 11; GO5-Grab 14	
Test Species		***Ampelisca abdita***	***Eohaustorius estuarius***
Test Procedures		ITM (USEPA/USACE, 1998); OTM (USEPA/USACE, 1991); USEPA (1994)	
Test Type/Duration		Static - Acute SP/10 days	
Sample Storage Conditions		4°C, dark, minimal head space	
Control Water Source		Scripps Pier seawater, 3 μm filtered, UV sterilized	
Recommended Water Quality Parameters	Temperature	20 ± 2°C	15 ± 2 °C
	Salinity	20 - 35 ± 2 ppth	2 - ≤ 28 ppth
	Dissolved Oxygen	> 60% saturation ≥ 6.0 milligrams per liter (mg/L)	> 60% saturation ≥ 6.0 mg/L
	pH	Monitor for pH drift	
	Overlying Total Ammonia	Lab NOEC = 24.1 – 52.5 mg/L	Lab NOEC = 69.5 - 172 mg/L
	Overlying Un-ionized Ammonia	Lab NOEC = <0.596 – 2.15 mg/L	Lab NOEC = 1.105 – 2.125 mg/L
	Interstitial Total Ammonia	< 30 mg/L	< 60 mg/L
	Interstitial Un-ionized Ammonia	< 0.4 mg/L	<0.8 mg/L
Photoperiod		Continuous light	
Test Chamber		1 L glass jars	
Replicates/Sample		5	5
No. of Organisms/Replicate		20	20
Exposure Volume		2 cm sediment, 600 mL water	2 cm sediment, 600 mL water
Feeding		None	
Water Renewal		None	

3.4.1.2 Eohaustorius estuarius 10-day SP Test

Bioassay tests using *E. estuarius* were conducted in accordance with the procedures outlined in the ITM (USEPA/USACE, 1998) and the amphipod testing manual (USEPA, 1994). Test animals and laboratory control sediment were supplied by Northwestern Aquatic Sciences in Newport, Oregon. Composited sediment from the proposed reference location (Station 5), sediment from three individual grabs that comprise this composite and laboratory control sediment were placed in five replicate 1 L glass jars to a thickness of 2 cm (150 mL), to which was added approximately 600 mL of 20 ± 2 ppth seawater. Additional surrogate replicates (no animals) for each treatment were set-up to obtain measurement of pore water ammonia at test initiation and termination. The test was run under continuous light at a temperature of 15 ±2°C and under gentle aeration. On Day 0, an initial set of water quality parameter measurements were made including temperature, DO, pH, and salinity for each replicate (ammonia was measured in the overlying water of a composite of replicates from each control, reference, and test site). Daily water quality measurements including DO, temperature, salinity, and pH were taken for one replicate for each treatment. In addition, a surrogate replicate from each test treatment was broken down, and sediment pore water was extracted via centrifugation for subsequent analysis of ammonia. At test initiation, organisms were randomly distributed to test chambers (20 animals per chamber). Animals remaining in the water

column and exhibiting abnormal behavior were replaced after 1 hour. The chambers were covered with petri dishes to minimize evaporation. Daily water quality measurements were taken and the number of surviving animals counted. On Day 10, the sediments from the chambers were sieved through a 0.5-mm screen, and the number of survivors was recorded. Test results were compared to test acceptability criterion (i.e., ≥90% mean survival in controls at test termination or 96 hours post-exposure). A reference toxicant test was conducted using cadmium chloride to establish sensitivity of test organisms used in the evaluation of project sediments according to Lee (1980). An additional reference toxicant test was also conducted using ammonium chloride (total measured ammonia per liter and calculated un-ionized ammonia per liter) to evaluate the potential influence of ammonia toxicity. The experimental design, bioassay procedures and water quality measurements for the SP test on project sediments using *E. estuarius* are shown in Table 10.

3.4.1.3 Neanthes arenaceodentata 10-day SP Test

Bioassay tests using *N. arenaceodentata* were conducted in accordance with the procedures outlined in the ITM (USEPA/USACE, 1998). Juvenile worms were supplied by Don Reish of Long Beach, California. Composited sediment from the proposed reference location (Station 5), sediment from three individual grabs that comprise this composite and native control sediment from Upper Newport Bay, California were placed in five replicate 1 L glass jars to a thickness of 2 cm (150 mL), to which was added approximately 600 mL of seawater. Additional surrogate replicates (no animals) for each sediment sample were set up to obtain measurement of pore water ammonia at test initiation and termination. The test was run under continuous light at a temperature of 20 ± 2°C, a salinity of 28 ± 2 ppth and gentle aeration. A surrogate replicate from each test treatment was broken down, and sediment pore water was extracted via centrifugation for subsequent analysis of pore water ammonia. Overlying water was collected from each replicate and composited at test initiation and termination for ammonia analysis. At test initiation, organisms were randomly distributed to test chambers (10 animals per chamber). The chambers were covered to minimize evaporation. Daily water quality measurements including DO, temperature, salinity, and pH were taken for one replicate for each treatment. The number of dead and surfaced animals was noted for each replicate. On Day 10, the sediments from the chambers were sieved through a 0.5 mm screen, and the number of survivors was recorded. Test results were compared to test acceptability criterion (i.e., ≥90% mean survival in controls at test termination or 96 hours post-exposure). A reference toxicant test was conducted using cadmium chloride to establish sensitivity of test organisms used in the evaluation of project sediments according to Lee (1980). An additional reference toxicant test was also conducted using ammonium chloride (total measured ammonia per liter and calculated un-ionized ammonia per liter) to evaluate the potential influence of ammonia toxicity. The experimental design, bioassay procedures and water quality measurements for the SP test on project sediments using *N. arenaceodentata* are shown in Table 11.

Results from the SP tests were analyzed by statistically comparing survival of the organisms that were exposed to control sediments to the survival of the organisms that were exposed to the project material (USEPA/USACE, 1991 and USEPA/USACE, 1998). Statistical tests, including analysis of variance, *t*-tests, or non-parametric tests, were used to analyze data, depending on the assumptions of the individual tests (i.e., homogeneity of variance) as specified in the OTM (USEPA/USACE, 1991).

Table 11. Experimental Design, Bioassay Procedure and Water Quality Measurements for the 10 day SP Bioassay Using *Neanthes arenaceodentata*.

Toxicity Test Experimental Design 10-Day SP Bioassay		
	Sample Identification	GO5 Composite; GO5-Grab 7; GO5-Grab 11; GO5-Grab 14
	Test Species	***Neanthes arenaceodentata***
	Test Procedures	ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); ASTM E1611 (2005b)
	Test Type/Duration	Static - Acute SP/10 days
	Sample Storage Conditions	4°C, dark, minimal head space
	Control Water Source	Scripps Pier seawater, 3 μm filtered, UV sterilized
Recommended Water Quality Parameters	Temperature	20 ± 1°C
	Salinity	20 - 35 ± 2 ppth
	Dissolved Oxygen	> 60% saturation = > 4.6 mg/L
	pH	Monitor for pH drift
	Overlying Total Ammonia	Lab NOEC = 64.1 – 73.0 mg/L
	Overlying Un-ionized Ammonia	Lab NOEC = 1.382 – 1.794 mg/L
	Interstitial Total Ammonia	< 30 mg/L
	Interstitial Un-ionized Ammonia	Lab NOEC = 1.02 mg/L
	Photoperiod	12 hours light : 12 hours dark
	Test Chamber	1 L glass jars
	Replicates/Sample	5
	No. of Organisms/Replicate	10
	Exposure Volume	2 cm sediment, 600 mL water
	Feeding	None
	Water Renewal	None

3.5 Bioaccumulation Potential Testing

Assessment of bioaccumulation potential (BP) was carried out using the polychaete worm *Nephtys caecoides* and the bivalve *Macoma nasuta* over a 28 day test period. *N. caecoides* were supplied by Aquatic Research Organisms of Hampton, New Hampshire, and *M. nasuta* were supplied by J & G Gunstone Clams of Port Townsend, Washington. Bioaccumulation tests were conducted in accordance with procedures outlined in OTM (USEPA/USACE, 1991) and the ITM (USEPA/USACE, 1998). Each of these tests was initiated using project sediment and control sediment in the same manner as the 10-day SP tests.

The bioaccumulation study was conducted in 44.5 x 26.5 x 21.5 cm plastic tubs with a continuous flow (1.8-3.1 mL/sec) of clean, filtered (20 μm) North Hood Canal seawater (28–32 ppth salinity) at 15 ± 2°C. Exposures were conducted under 16 hour light:8 hour dark photoperiod, and animals were not fed over the 28-day exposure. *N. caecoides* and *M. nasuta* were exposed in the same container. Test organisms (both clams and worms) were placed in 4 L of test sediments with 11 L of seawater (5 replicates each). Tanks were stocked at densities of 20 animals per replicate for exposures with *N. caecoides* and 30 animals per replicate for *M. nasuta* exposures. Water quality measurements including salinity, pH, DO,

overlying total ammonia, and temperature were monitored in all replicates on Day 0 and Day 28. On days 1-27, temperature, salinity, DO, and pH were measured on one alternating replicate per treatment. The number of dead and surfaced animals was noted for each replicate daily.

Test organisms were recovered at exposure termination (28 days) by gently sieving test sediments through a 1.0 mm stainless steel screen. All surviving clams and worms were counted and placed in sediment-free, flow-through aquaria under test conditions for a period of 24 hours in order for the organisms to purge their gut contents. Following gut purging, animal tissues for each test species from each treatment replicate were placed in clean glass jars with Teflon®-lined lids, frozen, packaged with wet ice in sealed coolers and then sent overnight under COC to the project analytical laboratory. At the analytical laboratory, tissues were subsequently homogenized and assayed for tissue residue levels of contaminants of concern. The experimental design, bioassay procedures and water quality measurements for the BP tests with *N. caecoides* and *M. nasuta* are shown in Table 12 and Table 13, respectively.

Bioaccumulation data was analyzed by statistically comparing chemical concentrations in the tissues of the organisms that were exposed to control sediments to the tissues of the organisms that were exposed to the project material (USEPA/USACE, 1991 and USEPA/USACE, 1998). Statistical tests, including analysis of variance, *t*-tests, or non-parametric tests, were used to analyze data, depending on the assumptions of the individual tests (i.e., homogeneity of variance) as specified in the OTM (USEPA/USACE, 1991).

Table 12. Experimental Design, Bioassay Procedure and Water Quality Measurements for the 28 day Bioaccumulation Studies Using *Nephtys caecoides*.

Toxicity Test Experimental Design 28 Day Bioaccumulation Study		
Sample Identification		GO 1-2-3 Comp.; GO5 Comp.; GO 6-7-8 Comp.
Test Species		***Nephtys caecoides***
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); USEPA (1993); ASTM (2005d)
Test Type/Duration		Flow-through / 28 Days
Sample Storage Conditions		4°C, dark, minimal head space
Control Water Source		North Hood Canal, 20 μm filtered
Recommended Water Quality Parameters	Temperature	10 - 20 ± 2°C
	Salinity	>20 ± 2 ppth
	Dissolved Oxygen	>60% saturation
	pH	Monitor for pH drift
Photoperiod		16 hours light : 8 hours dark
Test Chamber		Plastic Tubs (44.5 x 26.5 x 21.5 cm)
Replicates/Sample		5
No. of Organisms/Replicate		20
Exposure Volume		4 L sediment
Feeding		None
Water Renewal		Flow through rate: 1.8 - 3.1 mL per second

Table 13. Experimental Design, Bioassay Procedure and Water Quality Measurements for the 28 day Bioaccumulation Study using *M. nasuta*.

Toxicity Test Experimental Design 28 Day Bioaccumulation Study		
Sample Identification		GO 1-2-3 Comp.; GO5 Comp.; GO 6-7-8 Comp.
Test Species		***Macoma nasuta***
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); USEPA (1993); ASTM (2005d)
Test Type/Duration		Flow-through / 28 Days
Sample Storage Conditions		4°C, dark, minimal head space
Control Water Source		North Hood Canal, 20μm filtered
Recommended Water Quality Parameters	Temperature	12 – 16°C
	Salinity	≥25 ± 2 ppth
	Dissolved Oxygen	>60% saturation
	pH	Monitor for pH drift
Photoperiod		16 hours light : 8 hours dark
Test Chamber		Plastic Tubs (44.5 x 26.5 x 21.5 cm)
Replicates/Sample		5
No. of Organisms/Replicate		30
Exposure Volume		4 L sediment
Feeding		None
Water Renewal		Flow through rate: 1.8 - 3.1 mL per second

3.6 Seawater for Bioassay Testing

Seawater used in the SP tests came from the Scripps Institution of Oceanography at La Jolla, California. Seawater used in the flow-through BP tests came from North Hood Canal, Port Gamble, Washington. These seawater sources have been used successfully on similar bioassay testing programs by the contracting team. Extensive testing on a variety of test species has shown that there is no significant potential for toxicity or bioaccumulation from seawater collected from La Jolla, California, or Port Gamble, Washington. Good survival of organisms in control sediment has been achieved consistently in previous dredged material testing conducted by participating team laboratories.

3.7 Water Quality

Water quality was monitored daily as appropriate for each test and was recorded on data sheets. At Weston's Carlsbad facility, DO was measured using Orion Model 830A oxygen meters and probes; pH was measured using both the Orion Model 230A pH meters and probes. Salinity and temperature were measured with Orion Model 142 conductivity/salinity meters. Ammonia was analyzed using an Orion 95-12 electrode and the Orion 720A digital ion analyzer with a three-point calibration curve (1, 10, and 100 milligrams per liter (mg/L)). Newfields NW, in Port Gamble, Washington, measured DO, pH and temperature using an Orion 5-Star multimeter and probes. Salinity was measured with a VWR refractometer. Ammonia was analyzed using an Orion 95-12 electrode and the Orion 5-Star multimeter with a three-point calibration curve (1, 10, and 100 mg/L).

3.8 Quality Assurance Procedures

Weston's QC staff performs periodic audits to ensure that test conditions, data collection, and test procedures are conducted in accordance with Weston's standard operating procedures (SOPs). Weston's SOPs have been audited and approved by an independent USEPA-approved laboratory and placed in the QA file as well as laboratory files.

3.8.1 Field Collection and Sample Handling

All relevant project/sample information and field measurements were recorded on customized water-proof core log data forms. A daily field log was maintained, and formal COC procedures were followed and documented. All sampling equipment was cleaned between sample stations. Samples were double-bagged, and both inner and outer bags labeled. Samples were held on ice until delivery via Federal Express to Newfields Northwest in Port Gamble, California. COC forms were prepared in the field during sediment collection by Weston personnel. Once sediments were composited, a new COC was prepared for the transfer of sediments for physical, chemical and biological analyses.

3.8.2 Physical and Chemical Analysis of Water and Sediment Samples

Chemical analyses were performed using QC criteria specified in *Methods for Chemical Analysis of Water and Wastes* (USEPA, 1983) and *Test Methods for Evaluating Solid Waste (SW-846)* (USEPA, 2004a), in a California state-certified laboratory (CRG; California ELAP Certificate #2261). Grain size analyses performed by Aquatic Bioassay & Consulting were consistent with their internal QC criteria. TOC analyses were performed in accordance with QA procedures outlined by USEPA (USEPA, 2004b), ASTM (2005a), the 2006 Department of Defense Quality Systems Manual for Environmental Laboratories (Version 3; DoD 2006), and the 2003 National Environmental Laboratory Accreditation Conference Standard (NELAC 2004) in a Texas state-certified and nationally-accredited laboratory (NELAP Certificate #E87956). Performance was evaluated via the use of standard reference materials or laboratory control samples, method blanks, surrogates, spiked samples, duplicate samples, and internal QC samples. Precision and accuracy objectives were established for method reporting limits (MRLs), spike recoveries, and duplicate analyses.

3.8.3 Bioassay Testing

All toxicity tests were performed in an ELAP accredited laboratory (Weston's Carlsbad Laboratory [ELAP #2613]) or a State of Washington Department of Ecology (WDOE) accredited laboratory (Newfields Northwest, LLC [WDOE #C2021]). Reference toxicant tests and control samples are concurrently run with all bioassay tests.

Each test organism was evaluated in reference toxicant tests during the test period to establish the sensitivity of the test organisms, and reference toxicant median lethal concentration (LC_{50}) values or median effective concentration (EC_{50}) values fell within two standard deviations of the historical laboratory mean. Water quality measurements were monitored daily to ensure that they fell within prescribed limits and corrective actions (USEPA-recommended) were taken when necessary. All limits established for this program meet or exceed those recommended by USEPA.

Control samples were included in all bioassays conducted to provide a reference point for comparison of data from all other treatments. A bioassay control was one known to be free from toxicity but similar to the test media in all other aspects. Data from control samples were used to indicate the health of the test organism and acceptability of the test conditions. All protocols include mortality limits for bioassay controls. If mortality in a control sample exceeded protocol limits or test results were unacceptable, the test was repeated.

3.8.4 Bioaccumulation Tissue Chemistry

Tissue analysis was performed to determine the availability of sediment contaminants taken up by the test organisms. Tissue composites from each replicate were analyzed separately. Bioaccumulation potential test tissues were analyzed for metals, PAHs, organochlorine pesticides, PCBs (both Aroclors and individual congeners) and dioxin/furans.

3.8.5 Data Analysis and Statistical Methods

Major deviations from prescribed protocols required approval of both the client and the QC manager. Circumstances or deviations that might affect the integrity of the study were reported with the results. The data, analyses, and report were also reviewed for accuracy by the QA manager. All data underwent a 100% QA check for accuracy and completeness, and an additional secondary check was performed on a minimum of 10% of the data.

4.0 RESULTS

4.1 Physical Environment

The physical environment in the proposed project area includes waters offshore of Guam from the surface to the seafloor and the associated physical and oceanographic characteristics of this environment. The following sections include descriptions of the overall physical oceanography, characteristics of the water column, regional geology, and characteristics of marine sediments.

4.1.1 Physical Oceanography

In situ current data were collected for the characterization of oceanographic currents over a one-year period. A year of data was collected to potentially identify seasonal variations in current patterns and to characterize potential large-scale eddies that have been documented in the offshore waters around Guam.

4.1.1.1 In Situ Currents

Arrays of four in-line current meters and one upward-looking current profiler were moored at two sites, CM1 and CM2 (Figure 15), for the purpose of recording surface, midwater, and bottom currents over a period of one year in the vicinity of the proposed ODMDS. In-line current meters were positioned at depths of approximately 1,000 ft (305 m), 3,281 ft (1,000 m), 5,702 ft (1,738 m), and at a depth of 328 ft (100 m) above the ocean floor (7,497 ft [2,285 m] at CM1 and 6,982 ft [2,128 m] at CM2). Current direction and velocity were logged by the current meters in 1-hour intervals. For determining the speed and direction of surface currents, a current profiler was located in-line with the current meters at a depth of approximately 492 ft (150 m) below the surface at each location. The current profiler logged surface current data (current velocity and direction) in 16.4 ft (5 m) intervals every 15 minutes from the water's surface to a depth of 164 ft (50 m). Due to electrical problems in the current profiler installed at CM1, surface current data (to a depth of 164 ft [50 m]) was not obtained at this site. Upper surface currents at CM1, to a depth of approximately 82 ft (25 m), were assumed to be predominantly wind driven and therefore were assumed to be similar to those measured at CM2. For ease in interpretation and discussion, current directions and velocities were averaged for each day of the year and plotted as vector plots. Vector plots of average daily mid-water and bottom currents at CM1 are provided in Figure 17 while vector plots of surface water, mid-water and bottom currents at CM2 are provided in Figure 18 and Figure 19.

CM1 Currents

Surface Currents- Depths of 0-82 ft (0-25 m)

It was assumed that sites CM1 and CM2 experienced similar current speeds and directions in their upper surface waters as a result of their close proximity to one another and as a result of the wind-driven nature of upper surface currents. Because surface current data were not collected at CM1, as previously mentioned, CM2 data were used to represent the uppermost surface conditions (82 ft [25 m]) at both sites. During the months of January, February, March, and April 2008, the average daily currents measured at 82 ft (25 m) trended almost exclusively in a west, southwesterly direction with maximum velocities of 1.3 ft/s (0.4 m/s) (Figure 17). The upper surface currents then ran in a predominantly westerly direction in May and in a west, southwesterly direction in June. The months of July and August showed the greatest variability in current direction at 82 ft (25 m) depth, trending from northeast to northwest to southwest and also had the highest measured current velocities (1.7 ft/s [0.54 m/s]). In September, the current direction ranged from northeast to southwest but trend predominantly in a southwest direction. In October through early December the upper surface currents returned to trending almost exclusively in a west, southwesterly direction. Speeds of the upper surface currents were slightly lower during the mid-summer (June and July) and mid-winter months (January and February) (average velocity= 0.27 m/s) than at other times of the year (average velocity = 0.33 m/s).

Mid-water Currents- Depths of 995 ft-5,702 ft (303m-1,738m)

Currents in 995 ft (303 m) of depth at CM1 flowed predominantly in a northerly direction during the first half of the year and in a southerly direction during the second half of the year (Figure 17). The current direction at 995 ft (3,035 m) in depth was erratic during large periods of January, April, August, and October, when no persistent directional pattern was observed. From mid-February through the beginning of April, the current trended in a north/northeasterly direction, before becoming erratic in the latter portion of April and the beginning of May. A southerly shift in current direction occurred in May and was followed by a northeasterly current flow throughout most of June. Currents at CM1 in 995 ft (303 m) depth were the most highly organized in late June through July when they flowed consistently in a southeasterly direction and again in September when they flowed consistently in an easterly direction. In November, currents were somewhat disorganized, initially flowing in a northeasterly direction before shifting and flowing in a predominantly southwesterly direction.

The CM1 yearly average current speed at 995 ft (303 m) depth was 0.06 m/s. Daily average current speeds ranged from 0.002m/s to 0.197m/s. Periods in which erratic current directions were observed over several days generally corresponded with weaker than average current speeds. Disorganized and erratic currents observed throughout the months of January and August were correlated to the weakest average monthly current speeds (0.04 m/s). Similarly, periods which had consistent and organized current directions over the course of one week or more corresponded with higher than average current speeds. July and November had the strongest average monthly current speeds (0.091 m/s and 0.080 m/s, respectively).

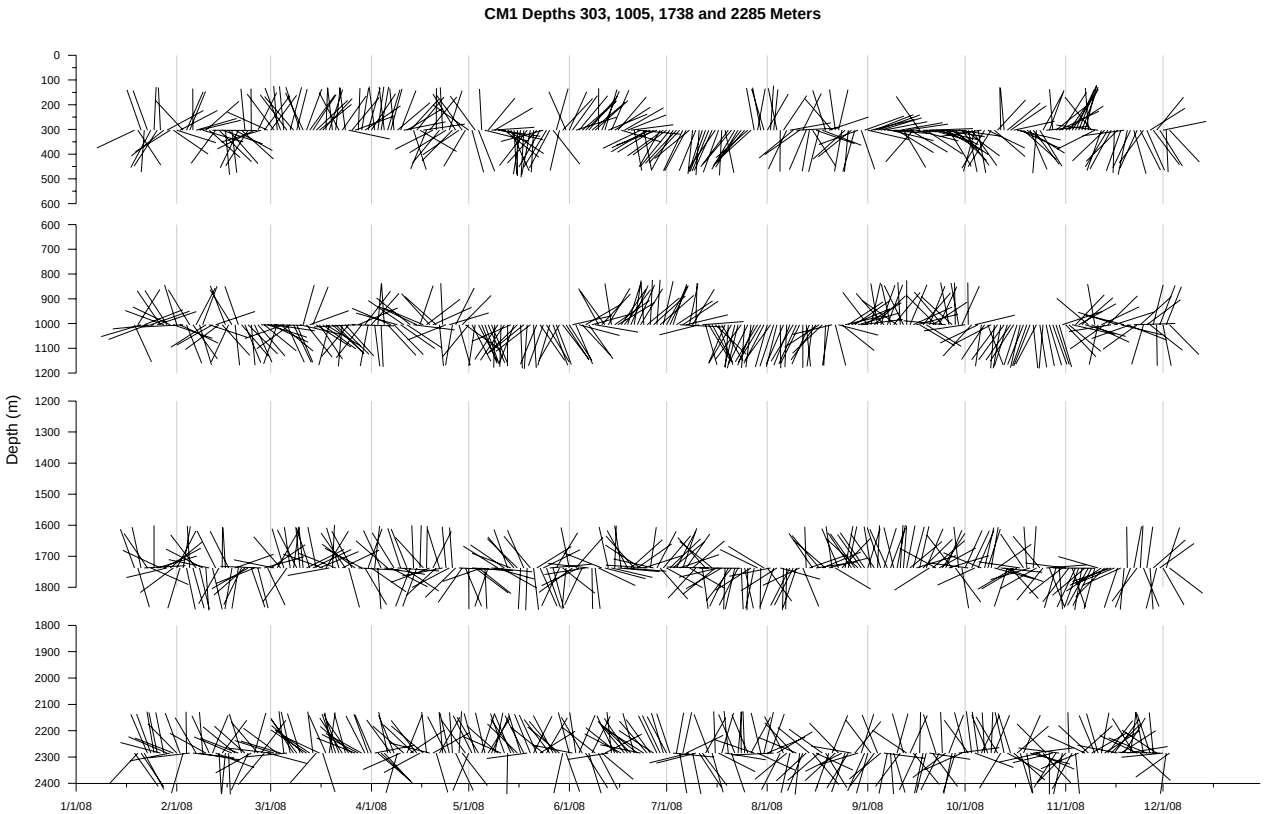

Figure 17. Vector plots of average daily current direction in 303m, 1005m, 1,738m, and 2,285m depths at CM1

Currents in 3,297 ft (1,005 m) of depth at CM1 flowed predominantly in a southeasterly to southwesterly direction throughout the majority of the year (Figure 17). The current direction was erratic during the months of January, February, March, April, and November and corresponded to periods in which below average current velocities were recorded. During the months of May, August, October, and most of July, the CM1 currents at 3,297 ft (1,005 m) consistently flowed in a southerly or southwesterly direction. Throughout the months of June and September the currents trended in a northeasterly to northwesterly direction.

CM1 average current speeds at 3,297 ft (1,005 m) depth (0.13 ft/s [0.040 m/s]) were approximately 40 percent slower than the average yearly velocities measured at 995 ft (303 m) in depth (0.20 ft/s [0.060 m/s]). The months of January and February had the weakest current velocities (0.017 m/s and 0.020 m/s, respectively) while the months of June, July, and October had the strongest average current velocities (0.076 m/s, 0.057 m/s, and 0.057 m/s, respectively).

Site CM1 is somewhat shielded by currents flowing in an easterly direction in a southwesterly direction by 5,000 ft (1,524 m) and 3,280 ft (1,000 m) seamounts located 6 mi (9.6 km) to the west and 4 mi (6 km) to the north, respectively. Currents in 5,702 ft (1,738 m) at CM1 were generally less organized than those observed at other depths, flowing predominantly in either a northerly, northwesterly or southwesterly direction for the majority of the year (Figure 17). The currents at 5,702 ft (1,738 m) flowed consistently in a southwesterly direction from mid-July through the first week of August and the end of October through the second week of November. In contrast, currents ran consistently in a northerly direction throughout March and from mid-August through mid-October. During all other times of the year, current flow at 5,702 ft (1,738 m) was disorganized and erratic, rarely flowing in the same direction for longer than two or three days at a time.

CM1 average yearly current velocities (0.027 m/s) at 5,702 ft (1,738 m) were 33% slower than those (0.040 m/s) measured at 3,297 ft (1,005 m). The seamounts located to the west and north of CM1 likely alter the flow of deepwater currents as they diverge around local seamounts. Average monthly current velocities were relatively stable throughout the year, ranging from 0.017 m/s in May to 0.037 m/s in September.

Bottom Currents- Depth of 7,497 feet (2,285m)

In general, bottom currents at CM1 (7,497 ft [2,285 m]) in depth were somewhat organized, flowing in a northwesterly direction approximately 60% of the year (Figure 17). Deep water currents in this region are typically dominated by the North Pacific Deep Water (NPDW) and the Lower Circumpolar Water (LCPW). Bathymetrically, CM1 is located in a sloping valley between two seamounts. The northeasterly flow of the measured current at 7,497 ft (2,285 m) in depth is likely attributed to the LCPW, which after being split by the island of Guam, deflects in a northward trajectory over the study area as it flows past CM1 into the Pacific Basin (Siedler *et al*. 2004). Bottom currents in this region flowed in a northward direction from February through June and in a mixed direction (primarily northerly or southerly) between the months of July through October. The currents returned to trending in a northerly direction in November.

CM1 average yearly current velocities (0.018 m/s) at 7,497 ft (2,285 m) in depth were less than those (0.027 m/s) measured at CM1 at 5,702 ft (1,738 m) and similar to those (0.021 m/s) measured at CM2 at a depth of 6982 ft (2,128 m). The month of March had the highest average current velocity (0.024 m/s) while the months of August and September had the lowest average current velocities (0.013 m/s). During all other months, the average monthly current velocity varied little, ranging from 0.015 m/s to 0.022 m/s.

CM2 Currents

Surface Currents – Depths of 0 - 492 ft (0 to 150 m)

During the months of January, February, March, and April 2008, the average daily currents measured at 82 ft (25 m) trended almost exclusively in a west, southwesterly direction with maximum speeds of 0.4 m/s (Figure 18). The upper surface currents ran in a predominantly westerly direction in May and in a west, southwesterly direction in June. July and August had the greatest variability in current direction at 82 ft (25 m) depth, trending from northeast to northwest to southwest and also had the highest measured current speeds (0.54 m/s). In September, the current direction ranged from northeast to southwest but ran predominantly in a southwest direction. In October through early December the upper surface currents returned to running almost exclusively in a west, southwesterly direction. Velocities of the upper surface current were slightly lower during the mid-summer (June and July) and mid-winter months (January and February) (average velocity= 0.27 m/s) than at other times of the year (average velocity = 0.33 m/s).

The direction of surface currents at 164 ft (50 m) in depth was well-correlated with currents at 328 ft (100 m) and 492 ft (150 m) throughout most of the year (Figure 18). Average surface current speeds declined slightly with increasing depth, slowing appreciably below 25 m in depth. While the yearly average current speed at 82 ft (25 m) was 0.31 m/s, the average yearly current speeds at 164 ft (50 m), 328 ft (100 m), and 492 ft (150 m) were 0.14 m/s, 0.13 m/s and 0.10 m/s, respectively.

Surface current directions at 164 ft (50 m) to 492 ft (150 m) in depth often ran counter to directions of currents measured at 82 ft (25 m) in depth (Figure 18). In January, currents at 164 ft (50 m), 328 ft (100 m), and 492 ft (150 m) were erratic and not well correlated among the surface depths. In February, March, and April, the surface currents at 164 ft (50 m), 328 ft (100 m), and 492 ft (150 m) were well correlated, and ranged from flowing in a north, northeasterly direction to a south, southeasterly direction. In May and June, the currents predominantly flowed in an easterly direction (ranging from east northeast to southwest) while from July through September the currents changed direction regularly, with no prevailing directional pattern observed. In October, the currents at 164 ft (50 m) and 328 ft (100 m) in depth flowed primarily in a northeasterly direction at the beginning of the month and in a south-southwesterly direction in the middle of the month while at 492 ft (150 m) in depth, the current flowed a predominantly in a northerly direction at the beginning of the month and in a southerly direction at the end of the month. November currents at 164 ft (50 m), 328 ft (100 m), and 492 ft (150 m) flowed predominantly easterly, trending in a northeasterly direction at the end of November and beginning of December.

Mid-water Currents- Depths of 984 ft-5,630 ft (303 m-1,716 m)

Currents in 984 ft (300 m) of depth at CM2 flowed in a northeasterly direction throughout the majority of the year. The current direction at 984 ft (300m) in depth was erratic in January and during a portion of the middle of February when no persistent directional pattern was observed. From mid-February through the beginning of April, the current trended in a north/northeasterly direction, before shifting direction and flowing predominantly southwesterly through mid-May. From mid-May through mid-June and from mid-July through the end of October, the current flowed in a northeasterly direction. Current flow from mid-June through mid-July and from mid-November through the end of November was predominantly in a southerly direction.

CM2 average current velocities at 984 ft (300 m) in depth (0.06 m/s) were approximately 40% slower than the averaged velocities measured at 492 ft (150 m) in depth (0.10 m/s). Disorganized and erratic currents observed in January corresponded with the weakest average current velocity (0.02 m/s) measured for a given month. Periods in which erratic current directions were observed over several days often corresponded with weaker than average current velocities. The highest current velocities were observed from mid-July through mid-November.

Currents in 3,281 ft (1,000 m) of depth at CM2 flowed in a southerly or southwesterly direction throughout the majority of the year. The current direction at 3,281 ft (1,000 m) in depth was erratic during the months of January, April, and November. These months corresponded to periods in which below average current velocities were recorded. During the months of February, March, May, July, October, and portions of August, the CM2 currents at 3,281 ft (1,000 m) flowed in a predominantly southerly or southwesterly direction. Throughout June, September, and for several days at the end of August, the currents trended in a northeasterly to northwesterly direction.

CM2 average current velocities at 3,281 ft (1,000 m) in depth (0.03 m/s) were approximately 50% slower than the average yearly velocities measured at 984 ft (300 m) in depth (0.10 m/s). Periods of weak current velocities were generally correlated with disorganized and erratic current directions. The months of January and March had the weakest current velocities (0.014 m/s and 0.017 m/s, respectively) while the months of July, October, and August had the strongest average current velocities (0.059 m/s, 0.042 m/s, and 0.040 m/s, respectively).

Currents in 5,630 ft (1,716 m) of depth at CM2 were generally less organized than those observed at other depths, flowing predominantly in either a northerly or southwesterly direction for most of the year. During the months of March, April, June, August, and the first two weeks of September, the current flowed mostly in a northerly or northwesterly direction. The current direction was erratic during the months of February, and March, the first two weeks of June, and the months of October and November. These months corresponded to periods in which below average current velocities were recorded. During the months of January and May, the first week of July, and the last two weeks in September, the currents at 5,630 ft (1,716 m) flowed in a predominantly southerly or southwesterly direction.

CM2 average yearly current velocities at 5,630 ft (1,716 m) (0.020 m/s) were slightly less than those measured at 3,281 ft (1,000 m) (0.032 m/s). Periods of weak current velocities at 5,630 ft (1,716 m) in depth were generally correlated with erratic current directions. In contrast to trends observed in upper waters, the month of January had the highest average current velocity (0.029 m/s). The months of June, October, and November had the weakest average current velocities (0.016 m/s, 0.16 m/s and 0.017 m/s, respectively) while the months of January, April, and May had the strongest average current velocities (0.029 m/s, 0.024 m/s, and 0.022 m/s, respectively).

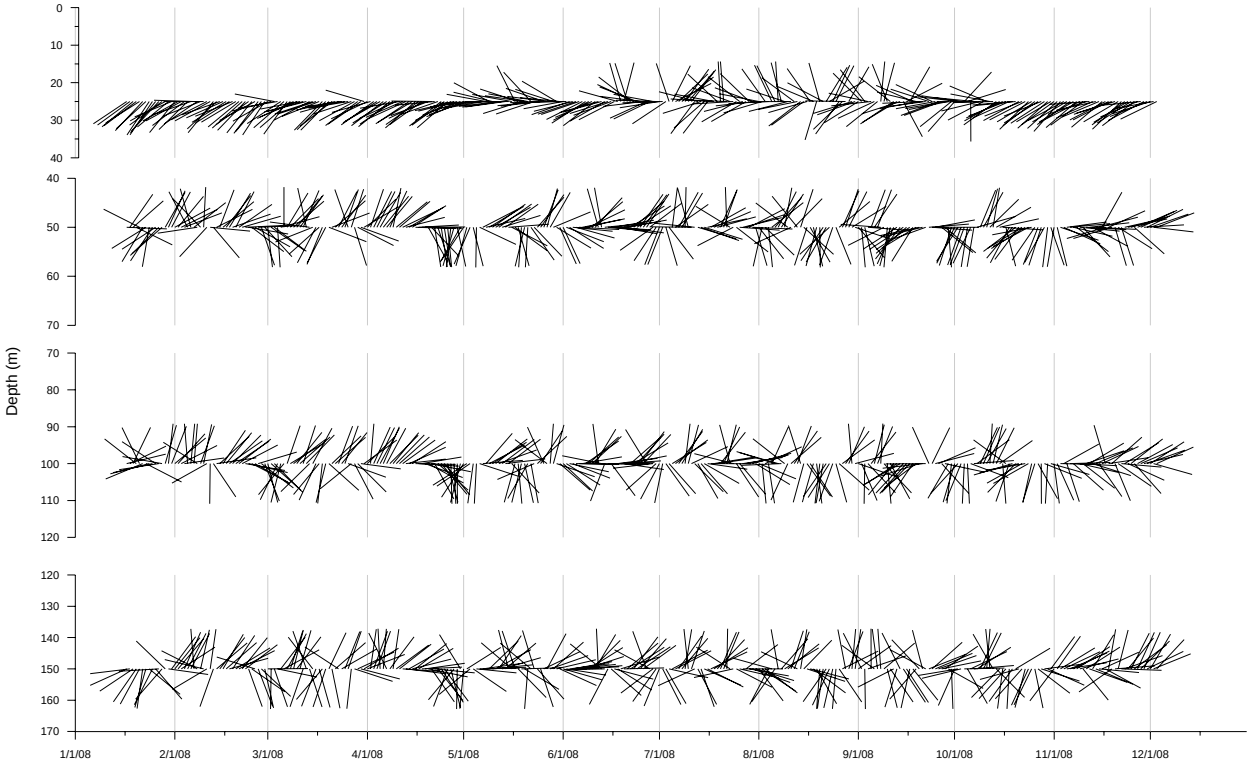

Figure 18. Vector plots of average daily current direction in 25 m, 50 m, 100 m, and 150 m depths at CM2

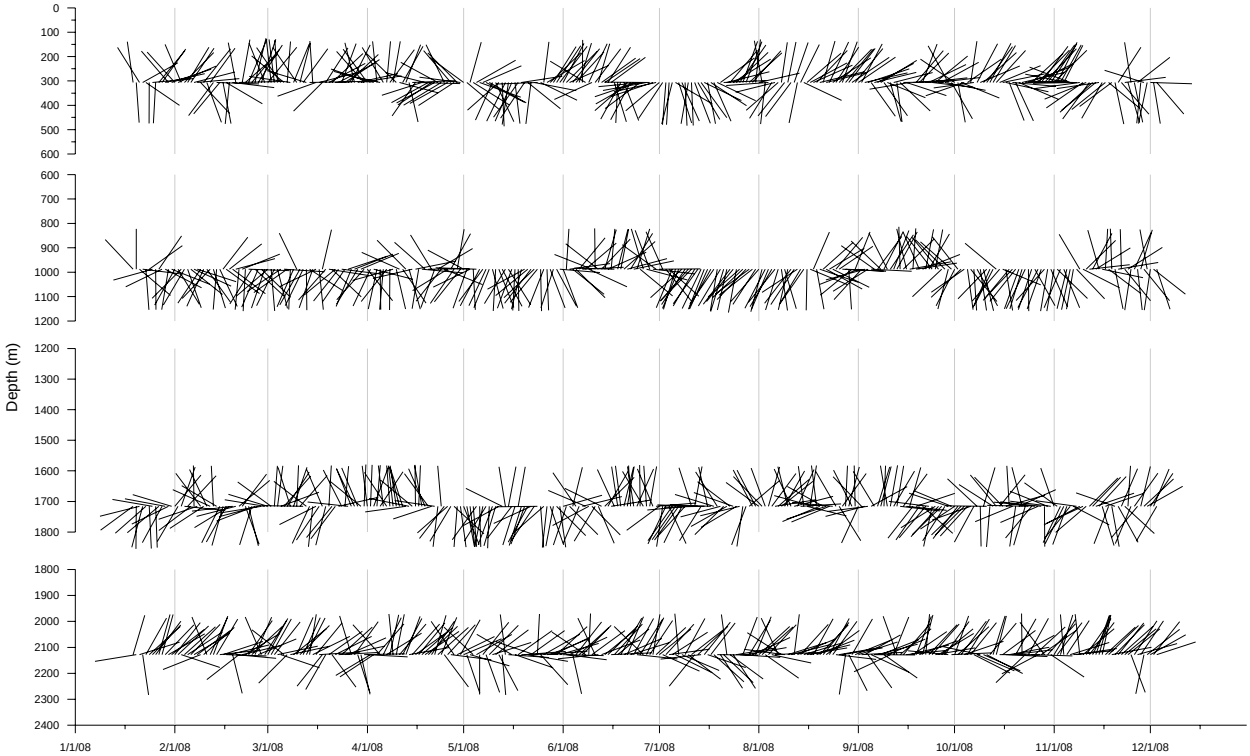

Figure 19. Vector plots of average daily current direction in 306 m, 988 m, 1716 m, and 2128 m depths at CM2

Bottom Currents- Depth of 6,928 ft (2,128 m) depth
In general, bottom currents at CM2 were highly organized, flowing in a northeasterly direction over 70 percent of the year. As stated previously, deep water currents in this region are typically dominated by the North Pacific Deep Water (NPDW) and the Lower Circumpolar Water (LCPW). The northeasterly flow of the measured current at 6,928 ft (2,128 m) in depth is likely attributed to the LCPW, which after being split by the island, deflects in a northward trajectory over the study area as it flows into the Pacific Basin (Siedler *et al*. 2004). During the months of May and July, bottom currents flowed in a southerly to southwesterly direction for one to two-week periods of time. The remainder of the year, the bottom currents ran almost exclusively in a northeasterly direction.

CM2 average yearly current velocities at 6,928 ft (2,128 m) (0.021 m/s) in depth were nearly identical to those measured at 1,700 m (0.020 m/s). The month of January had the highest average current velocity (0.039 m/s). During all other months, the average monthly current velocity varied little, ranging from 0.017 m/s in May to 0.024 m/s in February.

4.1.2 Water Column Characteristics

Water column characteristics included the measurement of temperature, salinity, turbidity, light transmittance and dissolved oxygen using a CTD instrumentation package as well as collecting water samples for ammonia-N, dissolved orthophosphate as P, nitrate-N, nitrite-N, TOC, trace metals, PAHs, chlorinated pesticides and PCBs (both Aroclors and individual congeners).

4.1.2.1 CTD Profiles

Temperature
Temperature profiles in the open oceans tend to have a well mixed surface layer in the upper 330 to 660 ft (100 to 200 m) underlain by a region of rapid temperature decline, known as the thermocline, which may be several hundreds of meters thick. Below the thermocline, temperature gradually decreases to about 34 to 37°F (1 to 3°C) at the seafloor. The maximum water temperatures, as expected, are located in the surface layer where energy from direct sunlight is present but is rapidly dissipated with increasing depth; temperature continuously decreases to the ocean floor.

Historical sea surface temperatures (January 2001 through June 2008) measured offshore of the southwest corner of Guam range from a winter-time low of 80.2°F (26.8°C) to a summer-time high of 86.7°F (30.4°C) with an annual average temperature of 83.7°F (28.7°C; NOAA 2008a).

North Alternative
During the Site Characterization Survey conducted in the Guam ODMDS study area during April, 2008, the average sea surface temperature (measured at 50 ft [15 m]) for the North Alternative (Stations 1-3) averaged 83.7°F (28.7°C), consistent with historical data (Figure 20). Temperatures within the upper water column were fairly uniform, averaging 82.8°F (28.2°C) from the surface down to the top of the thermocline. The top of the thermocline was located between approximately 425 and 525 ft (130 and 160 m) having an average temperature of 81.1°F (27.3°C). The thermocline was approximately 820 ft (250 m) thick, extending to depths of approximately 1,310 ft (400 m). Below the thermocline, temperatures gradually decreased from an average of 48.0°F (8.9°C) to an average of 35.6°F (2.0°C) at the ocean floor (measured approximately 330 ft (100 m) above the bottom at all stations).

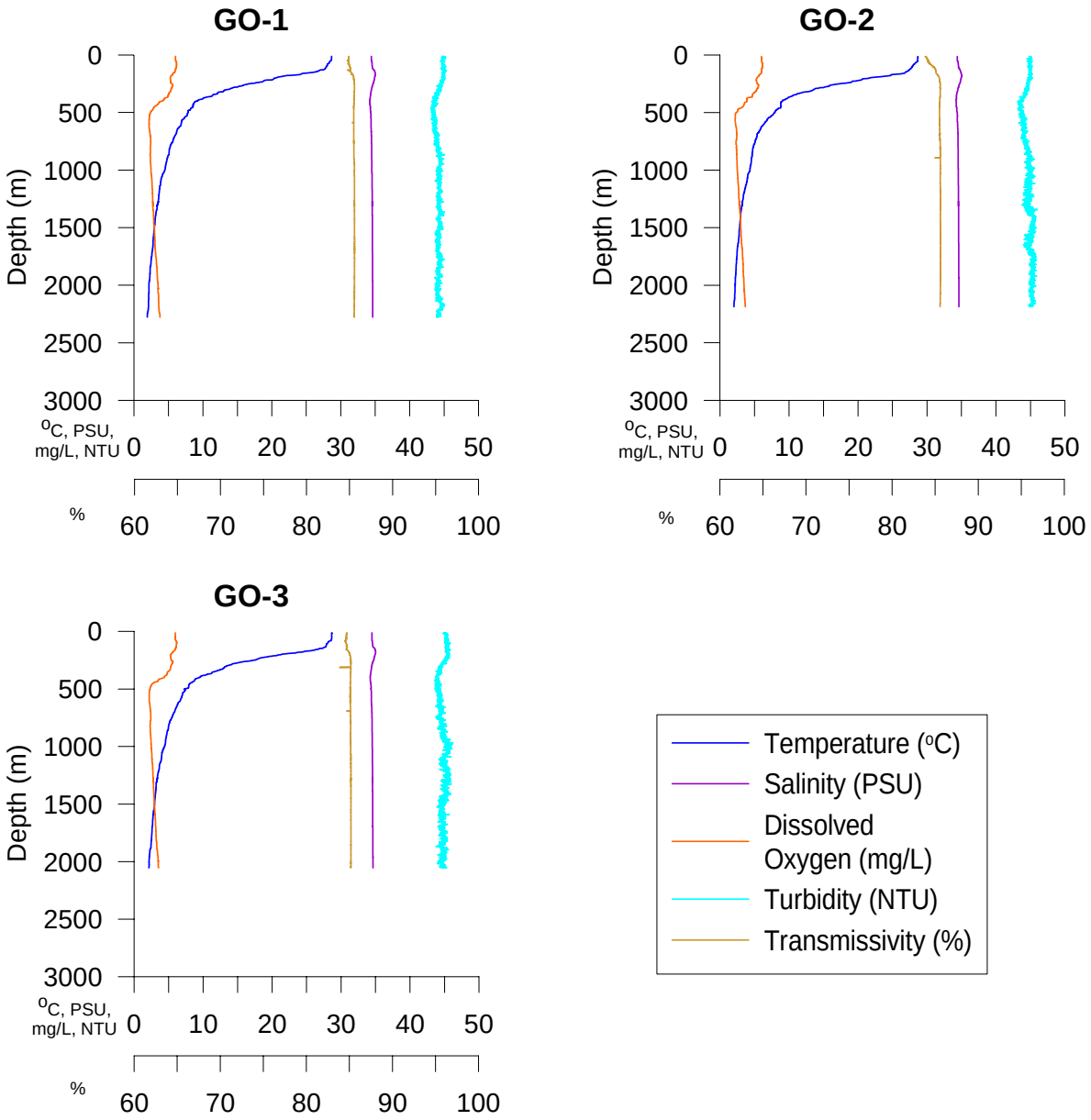

Figure 20. Structure of Water Quality Parameters at Stations in the North Alternative Study Area

Northwest Alternative

During the Site Characterization Survey conducted in the Guam ODMDS study area during April 2008, the average sea surface temperature (measured at 50 ft [15 m]) for the Northwest Alternative (Stations 6-8) averaged 83.7°F (28.7°C), also consistent with historical data (Figure 21). Similar to conditions in the North Alterative study area, temperatures within the upper water column were fairly uniform, averaging 82.8°F (28.2°C) from the surface down to the top of the thermocline. The top of the thermocline was located between approximately 410 and 490 ft (125 and 150 m) having an average temperature of 81.0°F (27.2°C). The thermocline was approximately 790 ft (240 m) thick, extending to depths of approximately 1,250 ft (380 m). Below the thermocline, temperatures gradually decreased from an average of 50.9°F (10.5°C) to an average of 35.2°F (1.8°C) at the ocean floor (measured approximately 330 ft [100 m] above the bottom at all stations).

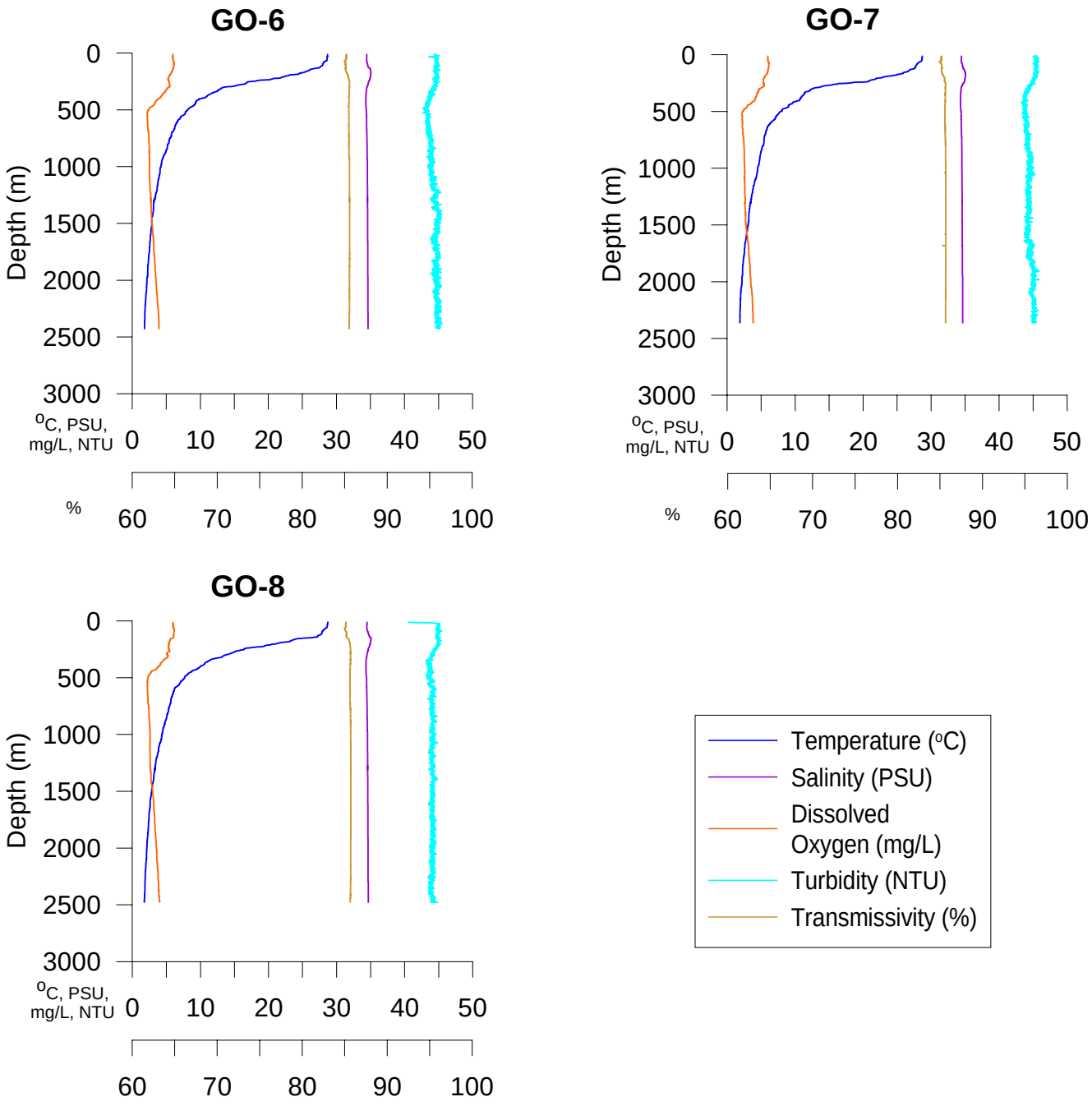

Figure 21. Structure of Water Quality Parameters at Stations in the Northwest Alternative Study Area

Inshore/Proposed Reference Site

In addition to collecting data from three stations within the North and Northwest study areas, three other stations were surveyed to gain a more comprehensive understanding of the regional marine biology, geology and physical oceanographic characteristics. These stations were located inshore of the two study areas and one of these stations was identified as a potential reference location for future Tier III testing. Tier III testing is required under the MPRSA and is described in the Ocean Testing Manual (USEPA and USACE 1991). Tier III testing includes the chemical, bioassay and bioaccumulation testing of project-specific proposed dredged materials to determine their suitability for ocean disposal. Results of Tier III tests are compared to similar tests conducted on reference material. Reference material is collected from

a predetermined reference site having similar characteristics of the study area. Therefore, the surveys conducted in April, 2008, included the collecting of data from a location close to, but beyond the range of possible impacts of a potential ODMDS, to determine its suitability as a possible reference site.

During the Site Characterization Survey conducted in the Guam ODMDS study area during April, 2008, the average sea surface temperature (measured at 50 ft [15 m]) measured at sites inshore of the two study areas, including the proposed reference location for future Tier III testing (Stations 4, 5 and 9) averaged 83.7°F (28.7°C), also consistent with historical data (Figure 22). Similar to conditions in the North and Northwest Alterative study areas, temperatures within the upper water column were fairly uniform, averaging 82.9°F (28.3°C) from the surface down to the top of the thermocline. The top of the thermocline was located between approximately 401 and 460 ft (125 and 140 m) having an average temperature of 81.3°F (27.4°C). The thermocline was approximately 900 ft (275 m) thick, extending to depths of approximately 1,400 ft (425 m). Below the thermocline, temperatures gradually decreased from an average of 48.7°F (9.3°C) to an average of 35.6°F (2.0°C) at the ocean floor (measured approximately 330 ft [100 m] above the bottom at all stations).

Salinity Properties

Salinity is the measure of the amount of dissolved inorganic solids (predominantly chloride and sodium) in seawater. Salinity tends to remain relatively constant through the water column, but may vary slightly near the surface due to evaporation and precipitation and at depth due to mixing of surface and deep waters. A halocline is a significant, vertical salinity gradient that may be found in seawater and affects the density of seawater. For example, an increase in salinity of 1 ppth results in a seawater density of approximately 0.7 kg/m3. Typically located near thermoclines, haloclines interact with the thermocline and may result in the development of a pronounced pycnocline (i.e., strong density gradient).

North Alternative

During the Site Characterization Survey conducted in the Guam ODMDS study area during April, 2008, the average salinity in the surface waters (measured at 50 ft [15 m]) for the North Alternative (Stations 1-3) averaged 34.4 ppth. At the base of the surface water and just above the thermocline, salinity increased rapidly to a maximum average value of 35.0 ppth at about 575 ft (175 m) depth. Salinity then decreased to a minimum average value of 34.2 ppth near the base of the thermocline. Below the thermocline, the salinity remained relatively constant, having an average concentration of 34.6 ppth near the seafloor.

Northwest Alternative

In the Northwest Alternative study area (Stations 6-8), salinity in the surface waters averaged 34.5 ppth across the three stations. Similar to the salinity profile observed at stations in the North Alternative study area, the salinity was consistent in the upper surface waters then rapidly increased to a maximum concentration of 35.1 ppth at about 560 ft (170 m) depth. Salinity then decreased to a minimum concentration of 34.3 ppth near the bottom of the thermocline (1,400 ft [425 m]). Below the thermocline, salinity remained constant, having an average concentration of 34.6 ppth near the seafloor.

Inshore/Proposed Reference Site

Water column salinity profiles at the inshore and proposed reference sites were similar to the North and Northwest Alternative study areas. The average salinity in the surface water was 34.5 ppth. Below the surface layer, salinity rapidly increased to a maximum concentration of 35.1 ppth at about 560 ft (170 m) depth. The minimum salinity concentration occurred at about 1,410 ft (430 m) depth with a concentration of 34.3 ppth. Below the thermocline, salinity remained constant, having an average concentration of 34.6 ppth near the seafloor.

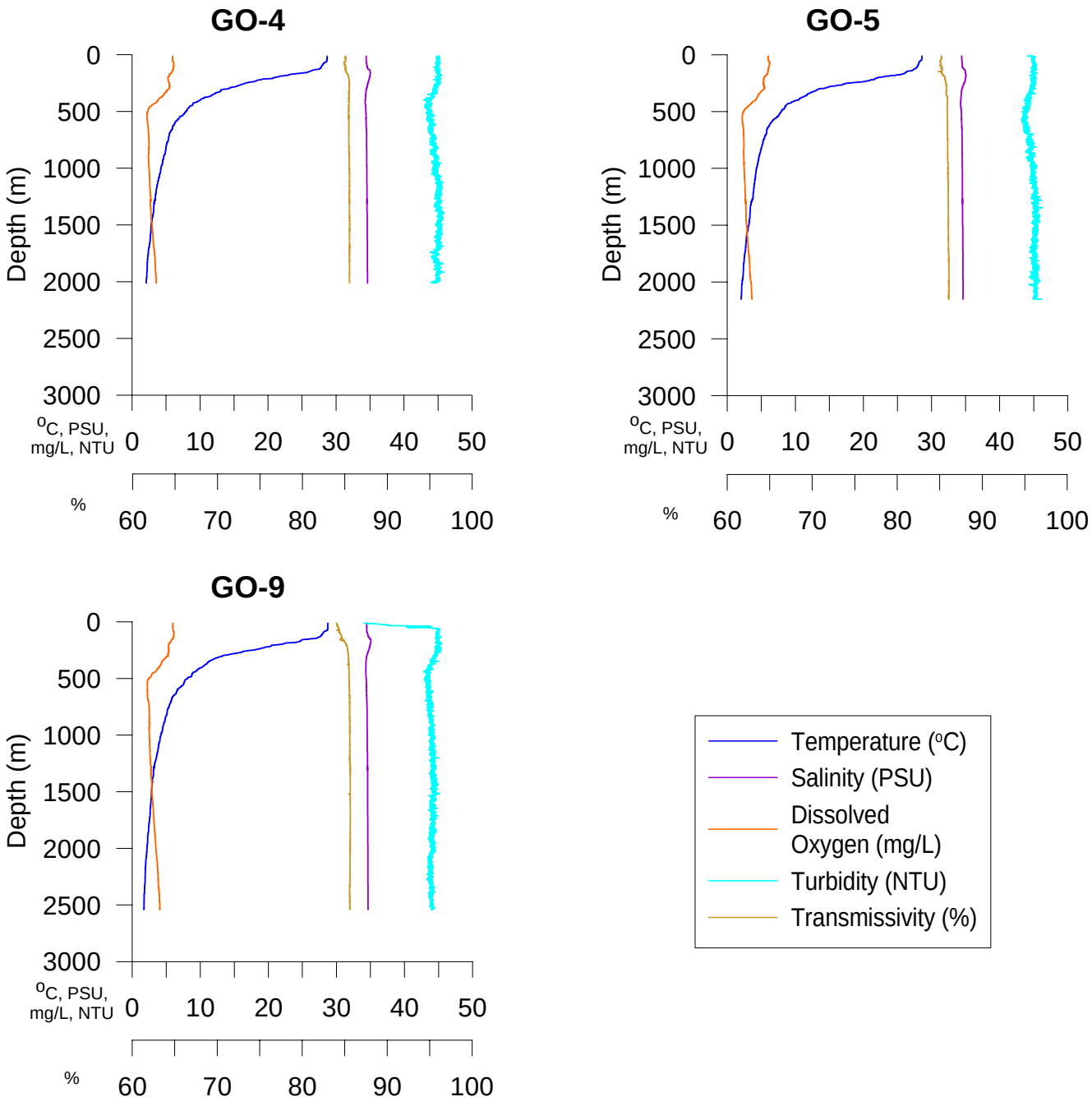

Figure 22. Structure of Water Quality Parameters at Stations at the Inshore and Proposed Reference Sites

Transmissivity and Turbidity

Transmissivity and turbidity are measures of the visual water quality. Transmissivity refers to the amount of light that passes through a sample (high transmissivity values suggest clearer water) whereas turbidity is a measure of the amount of light scattered by a sample (high turbidity values suggest turbid water). The presence of sediments, excessive algal growth and plankton may result in lower transmissivity or higher turbidity values. Water clarity tends to be clearer in oceanic regions due to the absence of suspended sediments from freshwater discharge or resuspension by waves and tides and higher nutrient

concentrations. Transmissivity and turbidity of seawater near Guam is not likely to be effected by seasonal changes due to the consistently warm climate.

North Alternative

Transmissivity was slightly lower in surface waters of the North Alternative study area (Stations 1-3) then in the middle and lower water column (Figure 20). At the surface, the average transmissivity value was 84.5% while in the mid-water column transmissivity values had increased to 85.5%.

Turbidity measured in the North Alternative study area (Stations 1-3) was relatively constant through the water column, however, slight changes in the turbidity measurements did have a discernable trend. Turbidity in the surface waters averaged 44.9 NTU. Minimum turbidity values were measured just below the thermocline, averaging about 43.3 NTU. Turbidity increased slightly through the remainder of the water column, having an average value of 44.5 NTU near the seafloor (Figure 20).

Northwest Alternative

Similar to the findings in the North Alternative study area, the Northwest Alternative study area (Stations 6-8) had fairly consistent transmissivity values throughout the water column, with a slight increase approaching the middle water column and remaining elevated to the bottom water when compared to surface waters (Figure 21). Transmissivity measurements in the Northwest Alternative surface waters were 85.2% and increased slightly to 85.7% approaching the mid-water column.

Turbidity measured in the Northwest Alternative study area (Stations 6-8) followed the same pattern as in the North Alternative study area. Turbidity in the surface waters averaged 43.9 NTU. Minimum turbidity values were measured just below the thermocline, averaging about 42.2 NTU. Turbidity increased slightly through the remainder of the water column, having an average value of 44.9 NTU near the seafloor (Figure 21).

Inshore/Propose Reference Site

The sites inshore of the two study areas, including the proposed reference location for future Tier III testing (Stations 4, 5 and 9) had fairly consistent transmissivity values throughout the water column, with a slight increase approaching the middle water column and remaining elevated to the bottom water when compared to surface waters (Figure 22). Transmissivity measurements at the inshore and reference sites were 84.8% and increased slightly to 85.8% approaching the mid-water column.

Turbidity measured in inshore of the two study areas and at the proposed reference site (Stations 4, 5 and 9) followed the same pattern as in the North and Northwest Alternative study areas. Turbidity in the surface waters averaged 43.5 NTU. Minimum turbidity values were measured just below the thermocline, averaging about 42.1 NTU. Turbidity increased slightly through the remainder of the water column, having an average value of 44.9 NTU near the seafloor (Figure 22). It should be noted that turbidity values measured at Station 9 in the upper 130 ft (40 m) of the water column were inconsistent with measurements made at all other stations visited during the Site Characterization Surveys in April 2008. Measured values at this station were up to 10 NTU lower than other stations; these lower measurements were likely a result of incorrect sensor readings rather than greater water clarity since a corresponding signature was not evident in transmissivity measurements.

Dissolved Oxygen

Sufficient oxygen levels are critical because significant decrease in dissolved oxygen may cause decreases in species diversity. In areas such as the North Pacific Ocean, seawater generally has a higher oxygen content relative to its low rate of consumption near the surface. Below the surface layer, dissolved oxygen tends to decrease, having a minimum concentration near the bottom of the photic zone. This is likely due to oxygen being consumed at a greater rate by respiration of animals and plants and in microbial decomposition of detritus then it is being generated by photosyntyhesis. At greater depths,

dissolved oxygen concentrations tend to increase due to the capacity for denser, colder seawater to contain more oxygen.

North Alternative

Dissolved oxygen concentrations in the surface waters of the North Alternative (Stations 1-3) averaged about 6.00 mg/L (Figure 20). Dissolved oxygen concentrations slowly increased through the surface layer to an average 6.19 mg/L at 260 ft (80 m) depth. Concentrations then decreased to 2.19 mg/L at about 600 m depth. From 1,970 ft (600 m) to the bottom of the water column, dissolved oxygen concentrations slowly increased to 3.66 mg/L.

Northwest Alternative

The average sea surface dissolved oxygen concentration (measured at 50 ft [15 m]) for the Northwest Alternative (Stations 6-8) was 5.98 mg/L (Figure 21). The maximum dissolved oxygen concentration occurred at about 260 ft (80 m) depth with a value of 6.16 mg/L and the minimum dissolved oxygen concentration occurred at about 1,800 ft (550 m) with a value of 2.21 mg/L. Below 1,800 ft (550 m), dissolved oxygen concentrations slowly increased to 3.92 mg/L near the seafloor.

Inshore/Proposed Reference Site

Dissolved oxygen concentrations in the surface waters measured at sites inshore of the two study areas, including the proposed reference location for future Tier III testing (Stations 4, 5 and 9) averaged 5.98 mg/L (Figure 22). Similar to the dissolved oxygen profiles for the North and Northwest Alternative study areas, the dissolved oxygen concentration slowly increased to 6.16 mg/L at about 260 ft (80 m) depth, then decreased to a concentration of 2.21 mg/L at about 1,800 ft (550 m) depth. Below the photic zone, concentrations of dissolved oxygen increased to an average of 3.76 mg/L.

Regional Summary

As expected, water quality parameters, including temperature, salinity, transmissivity, turbidity and dissolved oxygen, measured across all of the study sites were consistent with each other and followed oceanographic trends typical for tropical latitudes. Temperature remained relatively constant in the surface layer, then decreased rapidly through a thermocline layer between water depths of about 490 to 1,310 ft (150 to 400 m), and then steadily decreased to minimum values observed near the seafloor. Salinity concentrations also remained constant in the mixed surface layer, increased sharply near the top of the thermocline, decreased to a minimum value near the base of the thermocline, then remained relatively constant through the remainder of the water column. Transmissivity and turbidity values were relatively constant throughout the entire water column with minor changes. Dissolved oxygen concentrations were greatest near the surface, decreasing to a minimum near the base of the photic zone. Below the photic zone, dissolved oxygen concentrations steadily increased towards the bottom of the water column. These trends are evident in Figure 23 to Figure 26 which depict a representative station from each alternative area (Station 2 for the North Alternative, Station 7 for the Northwest Alternative Area), the proposed reference site (Station 5) and an average of the remaining six study stations. These figures further illustrate the similarity between alternative areas (i.e., there were no significant differences between the North and Northwest Alternative study areas).

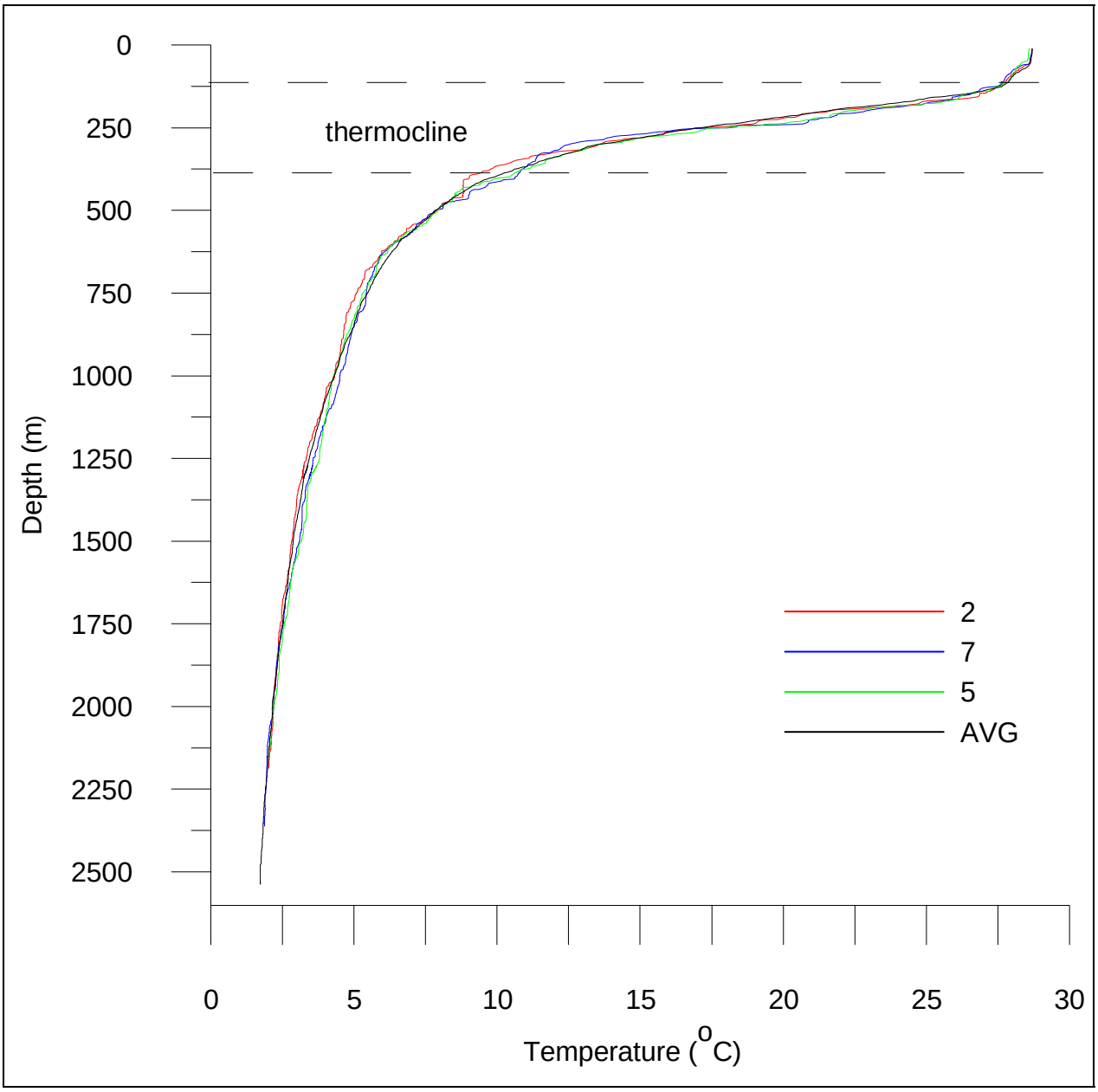

Figure 23. Comparison of Temperature Profiles between Representative Stations in the North, Northwest and Proposed Reference Sites

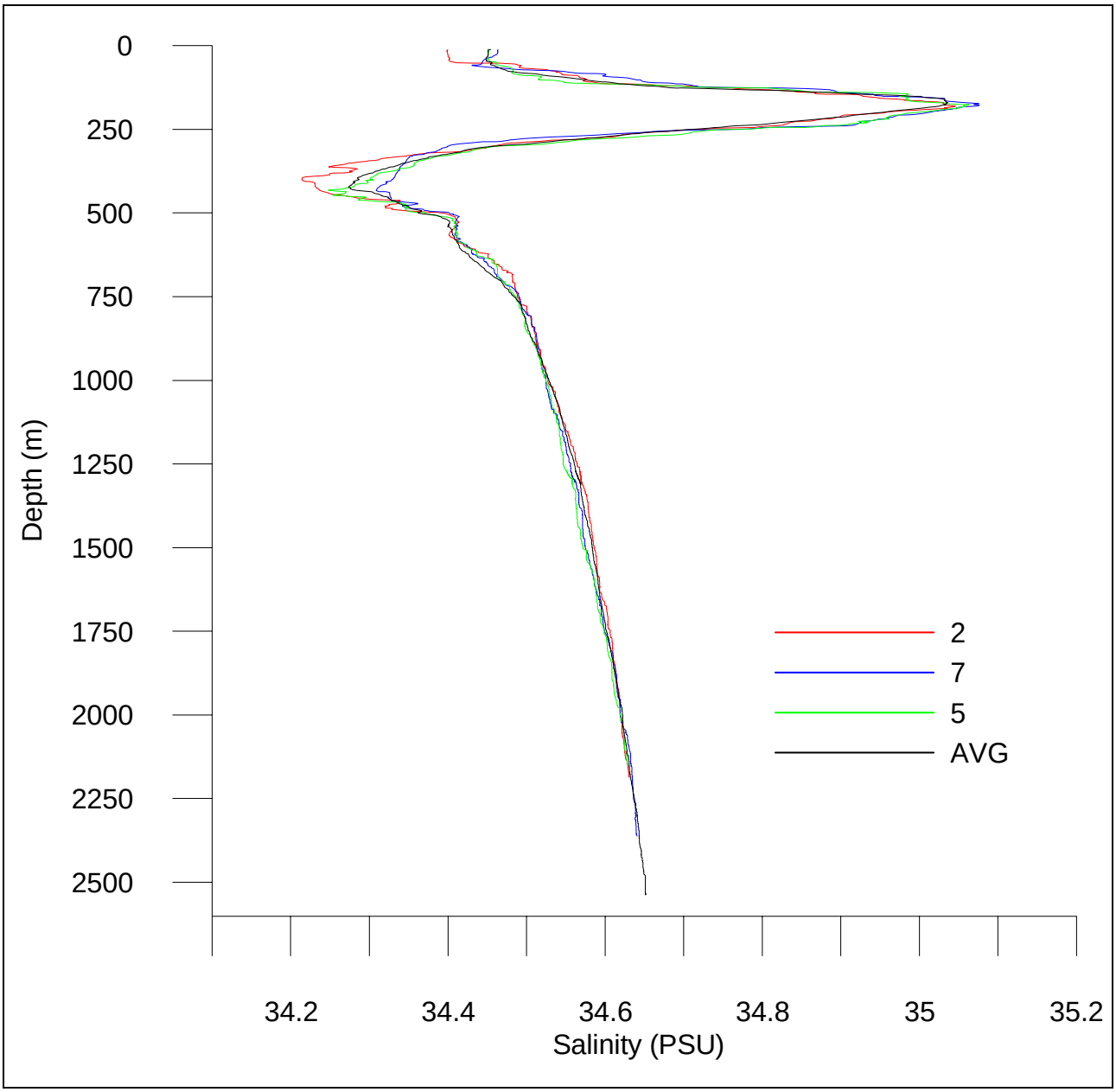

Figure 24. Comparison of Salinity Profiles between Representative Stations in the North, Northwest and Proposed Reference Sites

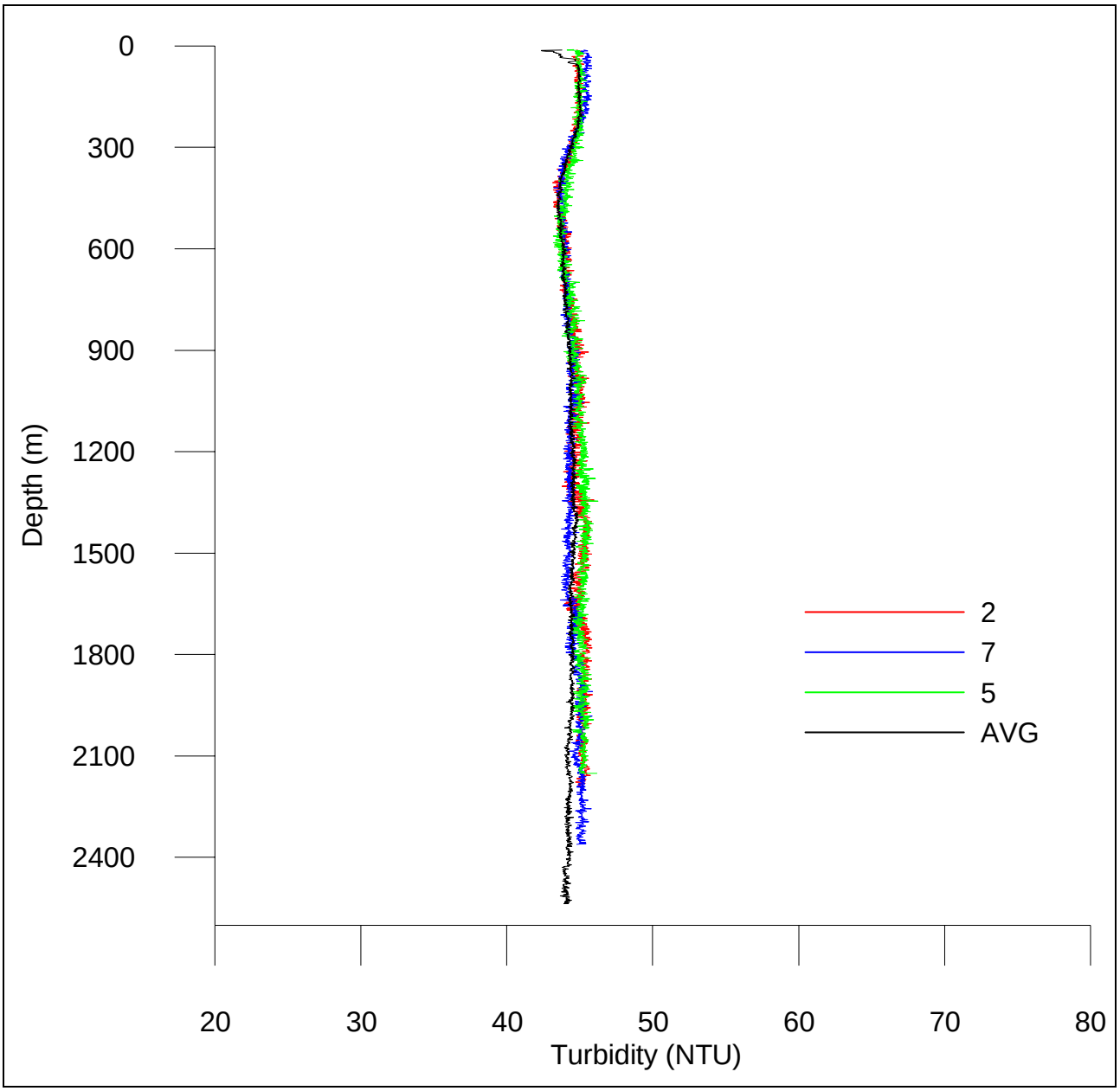

Figure 25. Comparison of Turbidity Profiles between Representative Stations in the North, Northwest and Proposed Reference Sites

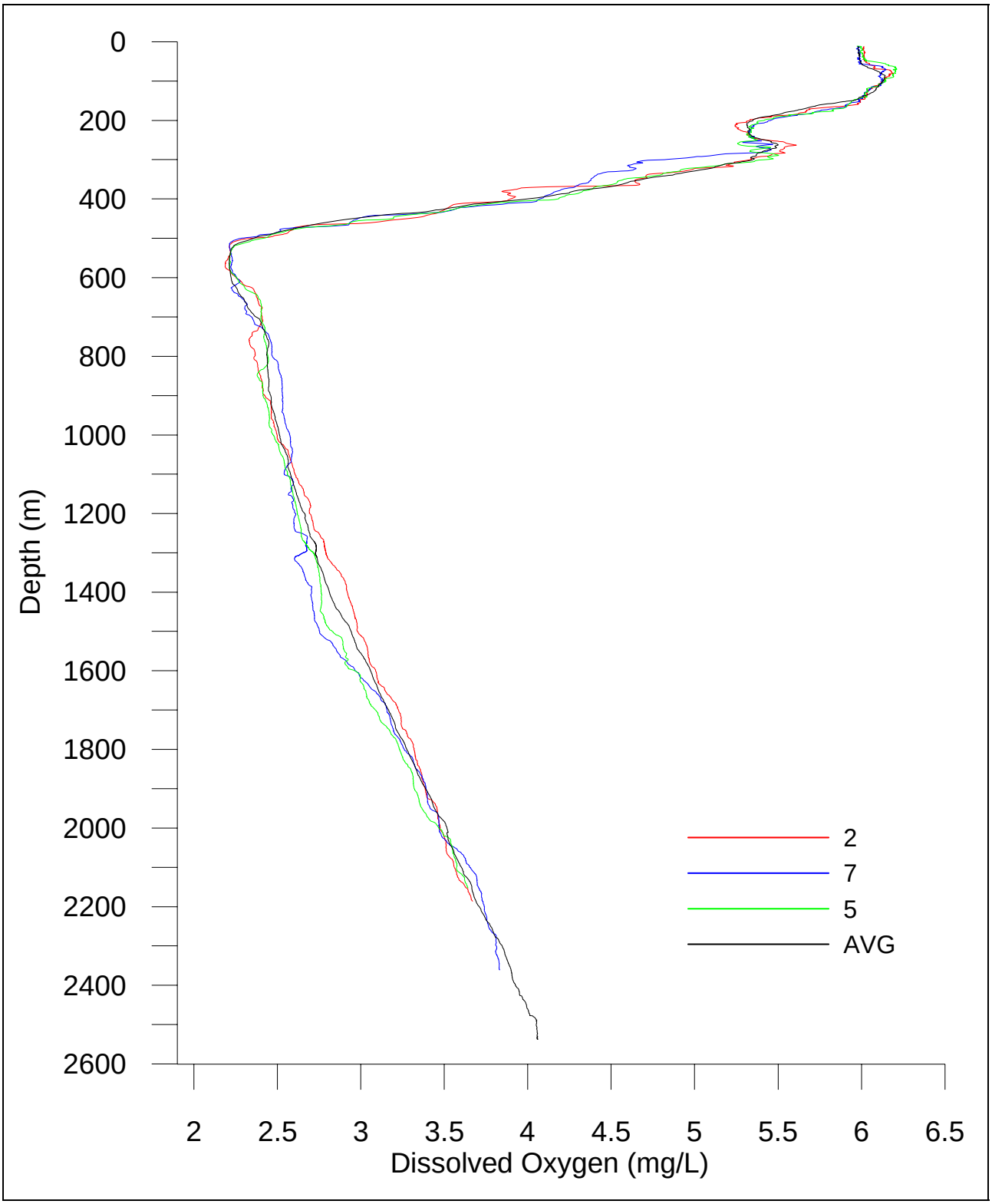

Figure 26. Comparison of Dissolved Oxygen Profiles between Representative Stations in the North, Northwest and Proposed Reference Sites

4.1.2.2 Chemical Analyses

Conventional and chemical analyses were performed on water samples from four discrete depths at each of three locations: one in the North Alternative area, one in the Northwest Alternative area and one at the proposed reference site. Analyses included nitrogen (ammonia, nitrate, nitrite), dissolved orthophosphate, TOC, dissolved trace metals and organic pollutants (PAHs, chlorinated pesticides/PCBs). The results of these analyses are presented in Table 14 and described in the following sections. Complete laboratory analytical results are presented in Appendix C.1.

Table 14. Summary of Conventional and Chemistry Analytical Results of Water Collected Offshore of Guam, with a Comparison to CCC and CMC Water Quality Values and a Deep Ocean Reference

Analyte	Fraction	Units	Station ID		GO-2	GO-2	GO-2	GO-2	GO-5	GO-5	GO-5	GO-5	GO-7	GO-7	GO-7	GO-7	CCC[1]	CMC[2]	Seawater Reference[3]
			Depth Category		Surface	Therm.	Mid	Bottom	Surface	Therm.	Mid	Bottom	Surface	Therm.	Mid	Bottom			
			Depth (m)		51	115	1199	2240	50	143	992	2147	50	157	1299	2385			
			MDL	RL															
General Chemistry																			
Ammonia-N	NA	mg/L	0.03	0.03	<0.03	<0.03	0.03	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	0.04	<0.03	-	-	-
Dissolved Orthophosphate as P	NA	mg/L	0.01	0.01	<0.01	<0.01	0.07	0.08	<0.01	<0.01	0.08	0.07	<0.01	<0.01	0.07	0.06	-	-	-
Nitrate-N	NA	mg/L	0.01	0.05	<0.01	0.01J	0.84	0.5	<0.01	<0.01	0.54	0.33	<0.01	0.01J	0.48	0.51	-	-	-
Nitrite-N	NA	mg/L	0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Organic Carbon	NA	mg/L	0.1	0.2	0.6	0.4	0.3	0.1J	0.4	0.4	<0.1	0.1J	0.4	0.4	<0.1	0.1J	-	-	-
Trace Metals																			
Aluminum (Al)	Dissolved	µg/L	3	6	<3	<3	<3	<3	<3	3J	<3	3.3J	<3	<3	<3	<3	-	-	<3
Antimony (Sb)	Dissolved	µg/L	0.01	0.015	0.15	0.17	0.13	0.11	0.16	0.13	0.14	0.15	0.15	0.14	0.13	0.13	500	1500	0.09
Arsenic (As)	Dissolved	µg/L	0.01	0.015	1.65	1.63	1.99	2.04	1.67	1.79	1.88	2.2	1.5	1.84	1.98	2.1	36	69	1.39
Beryllium (Be)	Dissolved	µg/L	0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-	<0.005
Cadmium (Cd)	Dissolved	µg/L	0.005	0.01	0.007J	0.008J	0.066	0.073	0.006J	0.005J	0.079	0.069	0.085	0.008J	0.084	0.066	8.8	40	0.066
Chromium (Cr)	Dissolved	µg/L	0.025	0.05	0.179	0.182	0.241	0.273	0.177	0.175	0.229	0.263	0.182	0.181	0.24	0.253	-	-	0.423
Cobalt (Co)	Dissolved	µg/L	0.005	0.01	0.114	0.179	0.199	0.258	0.089	0.097	0.092	0.101	0.108	0.103	0.126	0.118	-	-	0.061
Copper (Cu)	Dissolved	µg/L	0.01	0.02	0.25	1.78	2.09	0.53	0.44	0.03	0.3	0.17	<0.01	0.63	<0.01	0.7	3.1	4.8	2.69
Iron (Fe)	Dissolved	µg/L	0.5	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	0.6
Lead (Pb)	Dissolved	µg/L	0.005	0.01	0.005J	0.008J	0.012	0.03	0.006J	<0.005	0.006J	<0.005	0.006J	0.008J	<0.005	0.007J	8.1	210	0.036
Manganese (Mn)	Dissolved	µg/L	0.01	0.02	0.14	0.12	0.12	0.22	0.13	0.11	0.08	0.16	0.11	0.13	0.11	0.28	-	-	2.16
Mercury (Hg)	Dissolved	µg/L	0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.01J	<0.01	<0.01	0.01J	<0.01	<0.01	<0.01	<0.01	0.94	1.8	<0.01
Molybdenum (Mo)	Dissolved	µg/L	0.005	0.01	6.17	6.45	5.79	6.16	6.20	5.90	5.92	6.00	6.37	6.15	6.09	6.08	-	-	7.526
Nickel (Ni)	Dissolved	µg/L	0.005	0.01	0.243	0.261	0.529	0.608	0.248	0.216	0.527	0.565	0.272	0.242	0.529	0.567	8.2	74	0.395
Selenium (Se)	Dissolved	µg/L	0.01	0.015	<0.01	<0.01	0.06	0.07	0.01J	<0.01	0.06	0.07	0.01J	<0.01	0.06	0.07	71	290	0.15
Silver (Ag)	Dissolved	µg/L	0.02	0.04	0.04	0.04	0.05	0.06	0.03J	0.03J	0.03J	0.04	0.03J	0.04	0.04	0.04	-	0.95	<0.02
Thallium (Tl)	Dissolved	µg/L	0.005	0.01	0.008J	0.009J	0.01	0.009J	0.009J	0.009J	0.01	0.009J	0.009J	0.009J	0.009J	0.009J	-	2130	0.006
Tin (Sn)	Dissolved	µg/L	0.005	0.01	0.005J	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-	0.005
Titanium (Ti)	Dissolved	µg/L	0.035	0.07	<0.035	<0.035	<0.035	0.063J	<0.035	<0.035	0.049J	0.048J	<0.035	<0.035	<0.035	0.04J	-	-	0.444
Vanadium (V)	Dissolved	µg/L	0.02	0.04	2.02	1.93	2.13	2.23	2	2.04	2.09	2.23	1.94	2.03	2.15	2.2	-	-	1.69
Zinc (Zn)	Dissolved	µg/L	0.005	0.01	10.6	7.11	10.1	10.3	6.37	6.92	7.82	8.06	5.24	6.48	0.819	9.51	81	90	7.829
Polynuclear Aromatic Hydrocarbons (PAHs)																			
1-Methylnaphthalene	Total	ng/L	1	5	1.5J	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
1-Methylphenanthrene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2,3,5-Trimethylnaphthalene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2,6-Dimethylnaphthalene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2-Methylnaphthalene	Total	ng/L	1	5	<1	<1	<1	1.9J	<1	<1	<1	<1	<1	1.3J	<1	<1	-	300000	-
Acenaphthene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	710000	970000	-
Acenaphthylene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Anthracene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Benz[a]anthracene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Benzo[a]pyrene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Benzo[b]fluoranthene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Benzo[e]pyrene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Benzo[g,h,i]perylene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Benzo[k]fluoranthene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Biphenyl	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Chrysene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Dibenz[a,h]anthracene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Dibenzothiophene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Fluoranthene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	16000	40000	-

Table 14. Summary of Conventional and Chemistry Analytical Results of Water Collected Offshore of Guam, with a Comparison to CCC and CMC Water Quality Values and a Deep Ocean Reference

Analyte	Fraction	Units	Station ID		GO-2	GO-2	GO-2	GO-2	GO-5	GO-5	GO-5	GO-5	GO-7	GO-7	GO-7	GO-7	CCC[1]	CMC[2]	Seawater Reference[3]
			Depth Category		Surface	Therm.	Mid	Bottom	Surface	Therm.	Mid	Bottom	Surface	Therm.	Mid	Bottom			
			Depth (m)		51	115	1199	2240	50	143	992	2147	50	157	1299	2385			
			MDL	RL															
Fluorene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Indeno[1,2,3-c,d]pyrene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Naphthalene	Total	ng/L	1	5	5.6	7	10.8	6.3	4.5J	8.5	7	8.5	5.1	14.4	6.7	<1	-	2350000	-
Perylene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	3.4J	<1	3.6J	<1	<1	-	-	-
Phenanthrene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	4600	7700	-
Pyrene	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	300000	-
Chlorinated Pesticides																			
2,4'-DDD	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	
2,4'-DDE	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2,4'-DDT	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
4,4'-DDD	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
4,4'-DDE	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
4,4'-DDT	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	4.8J	0.5	65	-
Aldrin	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
BHC-alpha	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
BHC-beta	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
BHC-delta	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
BHC-gamma	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Chlordane-alpha	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Chlordane-gamma	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
DCPA (Dacthal)	Total	ng/L	5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-
Dicofol	Total	ng/L	50	100	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	-	-	-
Dieldrin	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.95	355	-
Endosulfan Sulfate	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Endosulfan-I	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Endosulfan-II	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Endrin	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.15	18.5	-
Endrin Aldehyde	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Endrin Ketone	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Heptachlor	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.8	26.5	-
Heptachlor Epoxide	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.8	26.5	-
Methoxychlor	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	30	-	-
Mirex	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	-	-
Oxychlordane	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Perthane	Total	ng/L	5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-
Toxaphene	Total	ng/L	10	50	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.2	21	-
cis-Nonachlor	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
trans-Nonachlor	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Total Chlordane	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	45	-
Endosulfan (I + II)	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	4.35	17	-
BHC	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	340	-
Polychlorinated Biphenyls (PCBs) Congeners																			
PCB003	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1			-
PCB008	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1			-
PCB018	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1			-
PCB028	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB031	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB033	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB037	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-

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			Depth Category		Surface	Therm.	Mid	Bottom	Surface	Therm.	Mid	Bottom	Surface	Therm.	Mid	Bottom			
			Depth (m)		51	115	1199	2240	50	143	992	2147	50	157	1299	2385			
			MDL	RL															
PCB044	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB049	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB052	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB056/060	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB066	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB070	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB074	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB077	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB081	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB087	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB095	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB097	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB099	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB101	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB105	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB110	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB114	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB118	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB119	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB123	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB126	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB128	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB138	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB141	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB149	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB151	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB153	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB156	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB157	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB158	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB167	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB168+132	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB169	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB170	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB174	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB177	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB180	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB183	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB187	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB189	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB194	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB195	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB200	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB201	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB206	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB209	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Total PCBs	Total	ng/L	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	30	10000	-

Table 14. Summary of Conventional and Chemistry Analytical Results of Water Collected Offshore of Guam, with a Comparison to CCC and CMC Water Quality Values and a Deep Ocean Reference

Analyte	Fraction	Units	Station ID		GO-2	GO-2	GO-2	GO-2	GO-5	GO-5	GO-5	GO-5	GO-7	GO-7	GO-7	GO-7	CCC[1]	CMC[2]	Seawater Reference[3]
			Depth Category		Surface	Therm.	Mid	Bottom	Surface	Therm.	Mid	Bottom	Surface	Therm.	Mid	Bottom			
			Depth (m)		51	115	1199	2240	50	143	992	2147	50	157	1299	2385			
			MDL	RL															
Aroclor PCBs																			
Aroclor 1016	Total	ng/L	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1221	Total	ng/L	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1232	Total	ng/L	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1242	Total	ng/L	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1248	Total	ng/L	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1254	Total	ng/L	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1260	Total	ng/L	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-

J = estimated value above the MDL and below the RL

[1]CCC = Criteria Continuous Concentration, synonymous with "chronic." Based on EPA Ambient Water Quality Criteria (AWQC)

[2]CMC = Criteria Maximum Concentration, synonymous with "acute." Based on EPA Ambient Water Quality Criteria (AWQC)

[3]Seawater Reference = laboratory seawater collected at 400m in the San Pedro Channel, off the coast of Southern California

Conventional Parameters

Ammonia, dissolved orthophosphate, nitrate, nitrite and TOC were measured to determine typical nutrient levels in samples collected offshore of Guam. Seasonal current patterns, uptake by marine plants (phytoplankton), and upwelling may alter nutrient levels in marine ecosystems. However, these changes are also due to biogeochemical processes and regeneration due to decomposition of sinking particulate matter.

North Alternative

With the exception of nitrite which was not detected in any of the depth specific samples at Station 2, nutrients tended to have an increasing trend with depth whereas TOC tended to have a decreasing trend with depth (Figure 27 and Figure 28). Ammonia ranged from non-detect at the surface to 0.03 mg/L in the near bottom sample (Table 14). Dissolved orthophosphate concentrations ranged from non-detect at the surface to 0.08 mg/L in the near bottom sample. Nitrate concentrations ranged from non-detect in the surface sample to 0.5 mg/L in the near bottom sample, having a maximum concentration in the mid-water column sample of 0.84 mg/L. TOC concentrations ranged from 0.6 mg/L in the surface sample to an estimated value of 0.1 mg/L in the near bottom sample. The Dixon's Test for extreme values was utilized to determine the homogeneity of nutrient values throughout the water column. There were no significant differences in nutrient levels between samples collected at each of the four different water depths at Station 2 in the North Alternative area.

Northwest Alternative

With the exception of nitrite which was not detected in any of the depth specific samples at Station 7, nutrients tended to have an increasing trend with depth whereas TOC tended to have a decreasing trend with depth (Figure 27 and Figure 28). Ammonia ranged from non-detect at the surface to 0.04 mg/L in the mid-water column sample; ammonia was not detected in the near bottom sample (Table 14). Dissolved orthophosphate concentrations ranged from non-detect at the surface to 0.06 mg/L in the near bottom sample. Nitrate concentrations ranged from non-detect in the surface sample to 0.51 mg/L in the near bottom sample. TOC concentrations ranged from 0.4 mg/L in the surface sample to an estimated value of 0.1 mg/L in the near bottom sample. The Dixon's Test for extreme values was utilized to determine the homogeneity of nutrient values throughout the water column. There were no significant differences in nutrient levels between samples collected at each of the four different water depths at Station 7 in the Northwest Alternative area.

Inshore/Proposed Reference Site

At the proposed reference site, ammonia and nitrite were not detected in any of the depth specific samples. Dissolved orthophosphate, nitrate and TOC exhibited similar trends with depth as the North and Northwest Alternative areas (Figure 27 and Figure 28). Dissolved orthophosphate concentrations ranged from non-detect at the surface and mid-column water samples to to 0.08 and 0.07 mg/L in the thermocline and near bottom samples, respectively (Table 14). Nitrate concentrations ranged from non-detect in the surface and mid-column water samples to 0.54 and 0.33 mg/L in the thermocline and near bottom samples, respectively. TOC concentrations ranged from 0.4 mg/L in the surface and mid-column water samples to non-detect in the thermocline sample; TOC had an estimated concentration of 0.1 mg/L in the near bottom sample. The Dixon's Test for extreme values was utilized to determine the homogeneity of nutrient values throughout the water column. There were no significant differences in nutrient levels between samples collected at each of the four different water depths at Station 5, the proposed reference site.

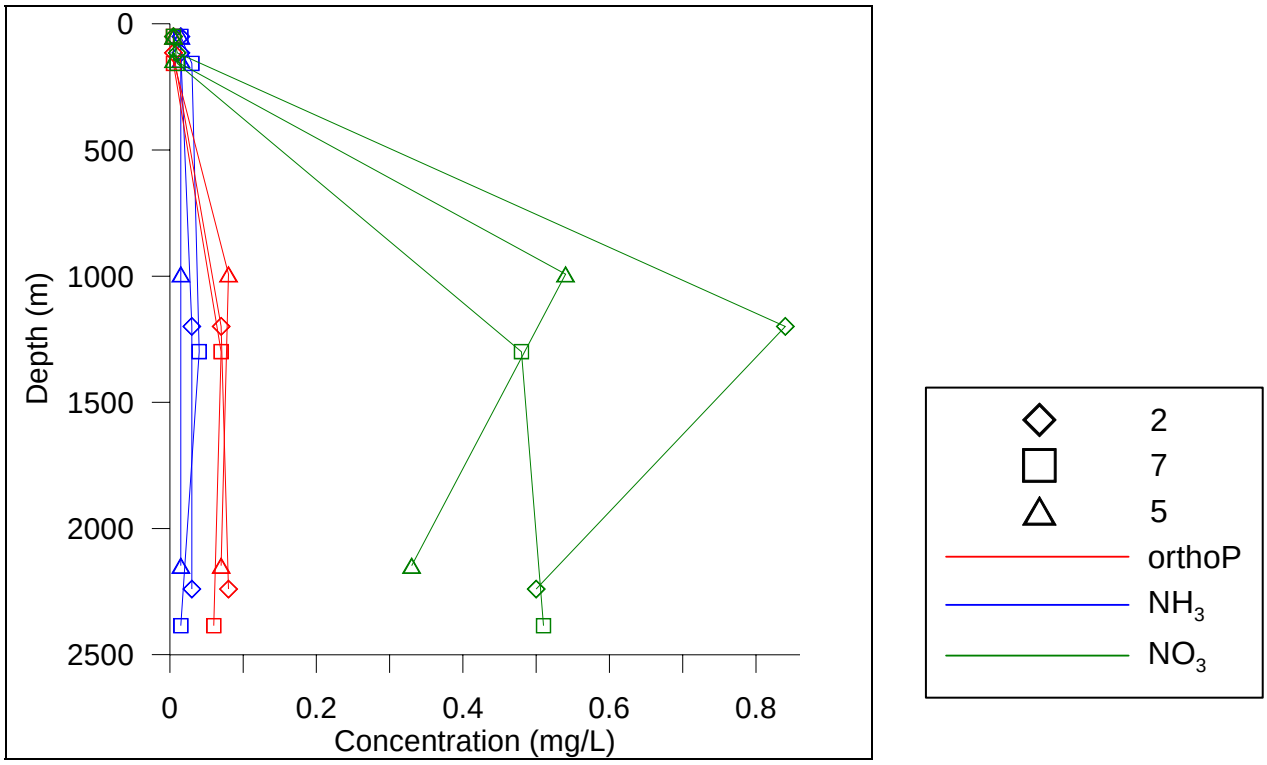

Figure 27. Nutrient Concentrations with Depth in the North Alternative, Northwest Alternative and Proposed Reference Areas

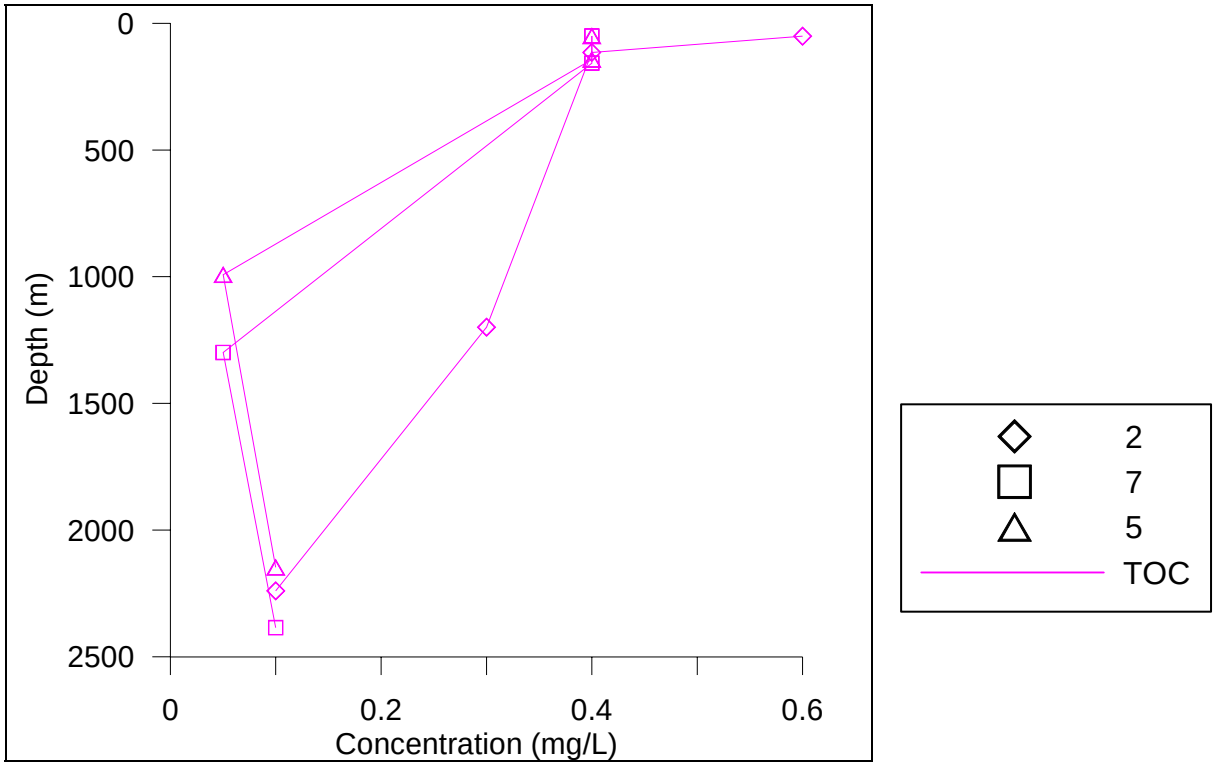

Figure 28. Total Organic Carbon Concentrations with Depth in the North Alternative, Northwest Alternative and Proposed Reference Areas

Trace Metals

North Alternative

In the North Alternative area, samples were collected from four distinct depths at Station 2. In the dissolved form, all trace metals were detected above the method detection limit (MDL) in the four samples with the exception of aluminum, beryllium, iron, mercury and tin (Table 14). Throughout the water column, dissolved metals concentrations were consistent with other deep ocean reference samples (Brown *et al.* 1989) and had the following ranges: antimony (0.11 to 0.17 µg/L); arsenic (1.63 to 2.04 µg/L); cadmium (0.007 [estimated] to 0.073 µg/L); chromium (0.179 to 0.273 µg/L); cobalt (0.114 to 0.258 µg/L); copper (0.25 to 2.09 µg/L); lead (0.005 [estimated] to 0.03 µg/L); manganese (0.12 to 0.22 µg/L); molybdenum (5.79 to 6.45 µg/L); nickel (0.243 to 0.608 µg/L); selenium (non-detect to 0.07 µg/L); silver (0.04 to 0.06 µg/L); thallium (0.008 [estimated] to 0.01 µg/L); titanium (non-detect to 0.063 [estimated] µg/L); vanadium (1.93 to 2.23 µg/L); and zinc (7.11 to 10.7 µg/L). All of the dissolved metals concentrations were one to three orders below their respective criteria continuous concentration (CCC) values. Figure 29 illustrates metals concentrations with depth for those analytes having corresponding CCC and criteria maximum concentration (CMC) values.

Using the Dixon's Test for detecting extreme values, it was determined that all four depths had similar concentrations for each metal with the exception of manganese and zinc. The dissolved manganese concentration was slightly higher in the bottom sample compared to the other three depths and the dissolved zinc concentration was slightly lower in the sample collected from the thermocline than the other three depths. Although these outliers were identified and due to the relatively low concentrations of these metals in the water samples, the metals concentrations were averaged across depths for subsequent comparison between alternative areas.

Northwest Alternative

In the Northwest Alternative area, samples were collected from four distinct depths at Station 7. In the dissolved form, all trace metals were detected above the MDL in the four samples with the exception of aluminum, beryllium, iron, mercury and tin (Table 14). Throughout the water column, dissolved metals concentrations were consistent with other deep ocean reference samples (Brown *et al.* 1989) and had the following ranges: antimony (0.13 to 0.15 µg/L); arsenic (1.50 to 2.10 µg/L); cadmium (0.008 [estimated] to 0.085 µg/L); chromium (0.181 to 0.253 µg/L); cobalt (0.103 to 0.126 µg/L); copper (non-detect to 0.70 µg/L); lead (non-detect to 0.008 [estimated] µg/L); manganese (0.11 to 0.28 µg/L); molybdenum (6.08 to 6.37 µg/L); nickel (0.242 to 0.567 µg/L); selenium (non-detect to 0.07 µg/L); silver (0.03 [estimated] to 0.04 µg/L); thallium (0.009 [estimated] µg/L); titanium (non-detect to 0.04 [estimated] µg/L); vanadium (1.94 to 2.20 µg/L); and zinc (0.819 to 9.51 µg/L). All of the dissolved metals concentrations were one to three orders below their respective CCC values. Figure 29 illustrates metals concentrations with depth for those analytes having corresponding CCC and CMC values.

Using the Dixon's Test for detecting extreme values, it was determined that all four depths had similar concentrations for each metal with the exception of manganese and molybedeum. The dissolved manganese concentration was slightly higher in the bottom sample compared to the other three depths and the dissolved molybdenum concentration was slightly higher in the sample collected from the surface than the other three depths. Although these outliers were identified and due to the relatively low concentrations of these metals in the water samples, the metals concentrations were averaged across depths for subsequent comparison between alternative areas.

Inshore/Proposed Reference Site

At the proposed reference site, samples were collected from four distinct depths at Station 5. In the dissolved form, all trace metals were detected above the MDL in the four samples with the exception of beryllium, iron, mercury and tin (Table 14). Throughout the water column, dissolved metals

concentrations were consistent with other deep ocean reference samples (Brown *et al*. 1989) and had the following ranges: aluminum (non-detect to 3.3 [estimated] µg/L); antimony (0.13 to 0.16 µg/L); arsenic (1.67 to 2.20 µg/L); cadmium (0.005 [estimated] to 0.079 µg/L); chromium (0.175 to 0.263 µg/L); cobalt (0.089 to 0.101 µg/L); copper (0.03 to 0.44 µg/L); lead (non-detect to 0.006 [estimated] µg/L); manganese (0.08 to 0.16 µg/L); molybdenum (5.90 to 6.20 µg/L); nickel (0.216 to 0.565 µg/L); selenium (non-detect to 0.07 µg/L); silver (0.03 [estimated] to 0.04 µg/L); thallium (0.009 [estimated] to 0.01 µg/L); titanium (non-detect to 0.049 [estimated] µg/L); vanadium (2.00 to 2.23 µg/L); and zinc (6.37 to 8.06 µg/L). All of the dissolved metals concentrations were one to three orders below their respective CCC values. Figure 29 illustrates metals concentrations with depth for those analytes having corresponding CCC and CMC values.

Using the Dixon's Test for detecting extreme values, it was determined that all four depths had similar concentrations for each metal; therefore, the metals concentrations were averaged across depths for subsequent comparison between alternative areas.

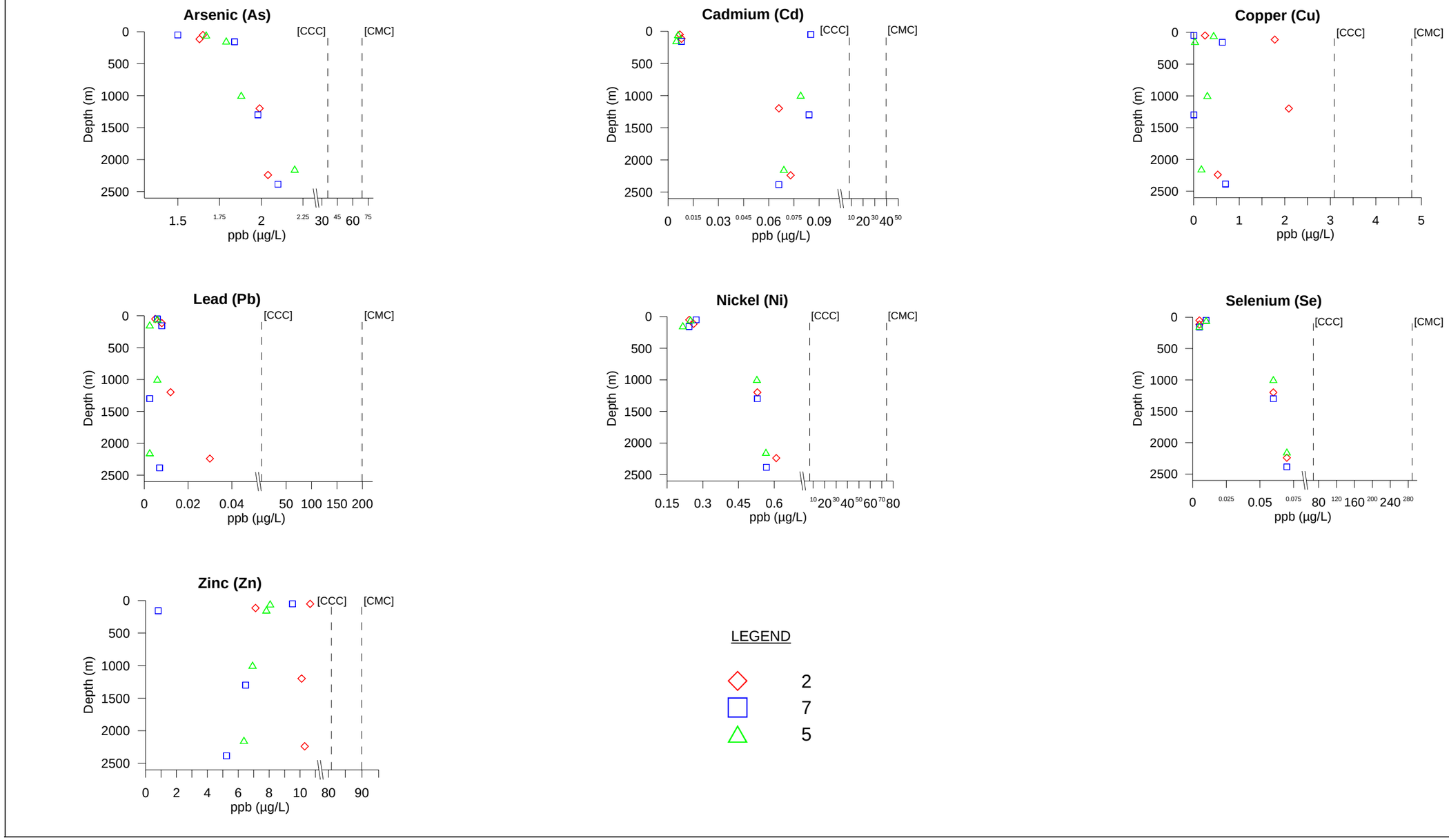

Figure 29. Dissolved Metals Concentrations with Depth in the North Alternative, Northwest Alternative and Proposed Reference Areas with a Comparison to CCC and CMC Water Quality Guidelines

Polycyclic Aromatic Hydrocarbons

North Alternative

At Station 2 in the North Alternative area, PAHs analyzed from water samples collected at four distinct depths were below the MDL (1 ng/L) with the exception of 1-methynaphthalene, 2-methylnaphthalene and naphthalene (Table 14). The analyte 1-methynapthalene was estimated at a concentration (1.5 ng/L) below the MRL (5 ng/L) in the surface sample (taken at 170 ft [51 m] depth) and 2-methylnapthalene was estimated at a concentration (1.9 ng/L) below the MRL in the bottom sample (taken at 2,240 m depth). Napthalene was detected above the MRL in all four water samples collected at Station 2, ranging from 5.6 to 10.8 ng/L, five orders of magnitude below the CMC for naphthalene. The presence of 1-methylnaphthalene, 2-methylnaphthalene and naphthalene in these samples may have been attributable to the proximity of the designated smoking area on board the *R/V Melville* to the deployment and retrieval area of the water samplers. Regardless, the concentrations observed in samples from Station 2 were well below CMC values and considered not biologically significant. There were no significant differences in PAH concentrations between samples collected at each of the four different water depths at Station 2 in the North Alternative area.

Northwest Alternative

At Station 7 in the Northwest Alternative area, PAHs analyzed from water samples collected at four distinct depths were below the MDL (1 ng/L) with the exception of 2-methylnaphthalene, naphthalene and perylene (Table 14). The analyte 2-methylnapthalene was estimated at a concentration (1.3 ng/L) below the MRL (5 ng/L) in the sample collected at the top of the thermocline (taken at 515 ft [157 m] depth). Napthalene was detected above the MRL in three water samples collected at Station 7, ranging from 5.1 to 14.4 ng/L, five orders of magnitude below the CMC for naphthalene; naphthalene was not detected in the bottom sample. Perylene was estimated at a concentration (3.6 ng/L) below the MRL (5 ng/L) in the sample collected at the top of the thermocline. Similarly, cross-contamination of the sample may have caused the 2-methylnaphthalene and naphthalene detections. There were no significant differences in PAH concentrations between samples collected at each of the four different water depths at Station 7 in the Northwest Alternative area.

Inshore/Proposed Reference Site

At Station 5, the proposed reference site, PAHs analyzed from water samples collected at four distinct depths were below the MDL (1 ng/L) with the exception of naphthalene and perylene (Table 14). Napthalene was detected in all four water samples collected at Station 5, ranging from 4.5 ng/L in the surface sample to 8.5 ng/L in the mid-column and near bottom samples, six orders of magnitude below the CMC for naphthalene. Perylene was estimated at a concentration (3.4 ng/L) below the MRL (5 ng/L) in the sample collected at the top of the thermocline. Similarly, cross-contamination of the sample may have caused the naphthalene detections. There were no significant differences in PAH concentrations between samples collected at each of the four different water depths at Station 5 at the proposed reference site.

Organochlorine Pesticides/PCBs

North Alternative

Concentrations of all chlorinated pesticides, including PCBs (both Aroclors and individual congeners), were below the MDL (1 ng/L) at each depth interval at each of the three stations in the North Alternative area (Stations 1-3; Table 14). There were no significant differences in chlorinated pesticide concentrations between samples collected at each of the four different water depths at Station 2 in the North Alternative area.

Northwest Alternative

Concentrations of all chlorinated pesticides, including PCBs (both Aroclors and individual congeners), were below the MDL (1 ng/L) at each depth interval at each of the three stations in the Northwest Alternative area (Stations 6-8) with the exception of 4,4'-DDT (estimated at a concentration [4.8 ng/L] below the MRL [5.0 ng/L]) in the bottom water sample (7,825 ft [2,385 m] depth) collected at Station 7 (Table 14). There were no significant differences in chlorinated pesticide concentrations between samples collected at each of the four different water depths at Station 7 in the Northwest Alternative area.

Inshore/Proposed Reference Site

Concentrations of all chlorinated pesticides, including PCBs (both Aroclors and individual congeners), were below the MDL (1 ng/L) at each depth interval at each of the three stations inshore of the two alternative areas (Stations 4, 5 and 9; Table 14). There were no significant differences in chlorinated pesticide concentrations between samples collected at each of the four different water depths at Station 5 at the proposed reference site.

Regional Summary

The conventional and chemical characteristics of water collected from stations located in the North and Northwest Alternative ODMDS study areas were similar. For the most part, nutrients tended to increase in concentration with increasing water depth whereas TOC tended to decrease in concentration with increasing water depth. Metals concentrations were relatively low compared to CCC and CMC values and were within the same order of magnitude of other deep ocean reference site water samples (Brown *et al*. 1989). Very few PAH or chlorinated pesticides were detected in any of the water samples.

As mentioned previously, a few metals were identified as outliers using the Dixon's Test for extreme values, however due to the relatively low concentrations of these metals in the water samples, these metals concentrations were used calculating an average value for a station in order to compare results from the North and Northwest Alternative areas to each other and the proposed reference site. Figure 30 and Figure 31 show that the mean value for each analyte at a particular station falls within one standard deviation of the mean for that analyte at another station. In other words, no significant differences were observed in water quality between the North and Northwest Alternative areas as well as the proposed reference site.

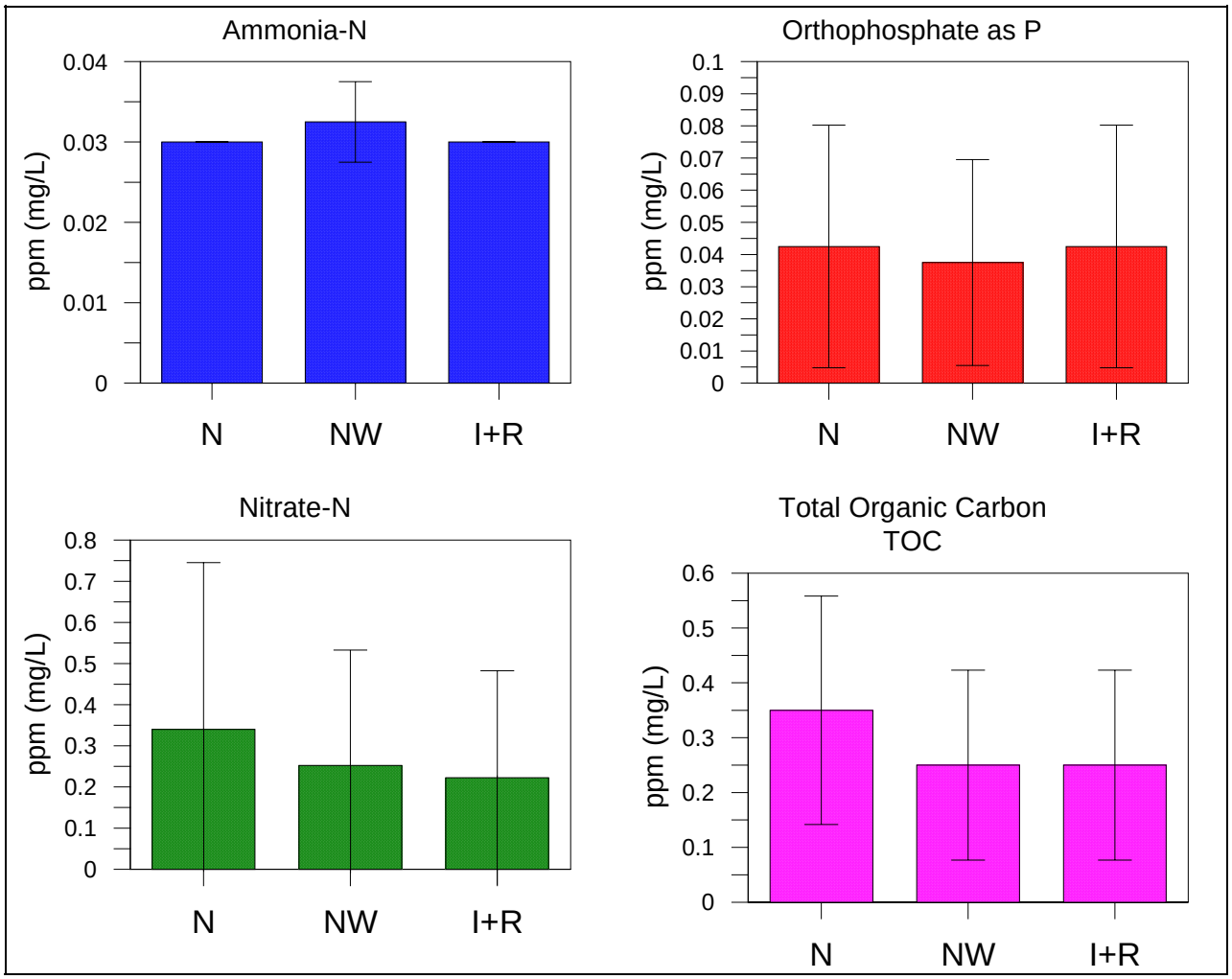

Figure 30. Mean and Standard Deviation of Selected Conventional Chemistry Constituents of Water Samples Collected Offshore of Guam, Showing Comparison of Alternative Areas (N and NW) to Each Other and Proposed Reference (I+R)

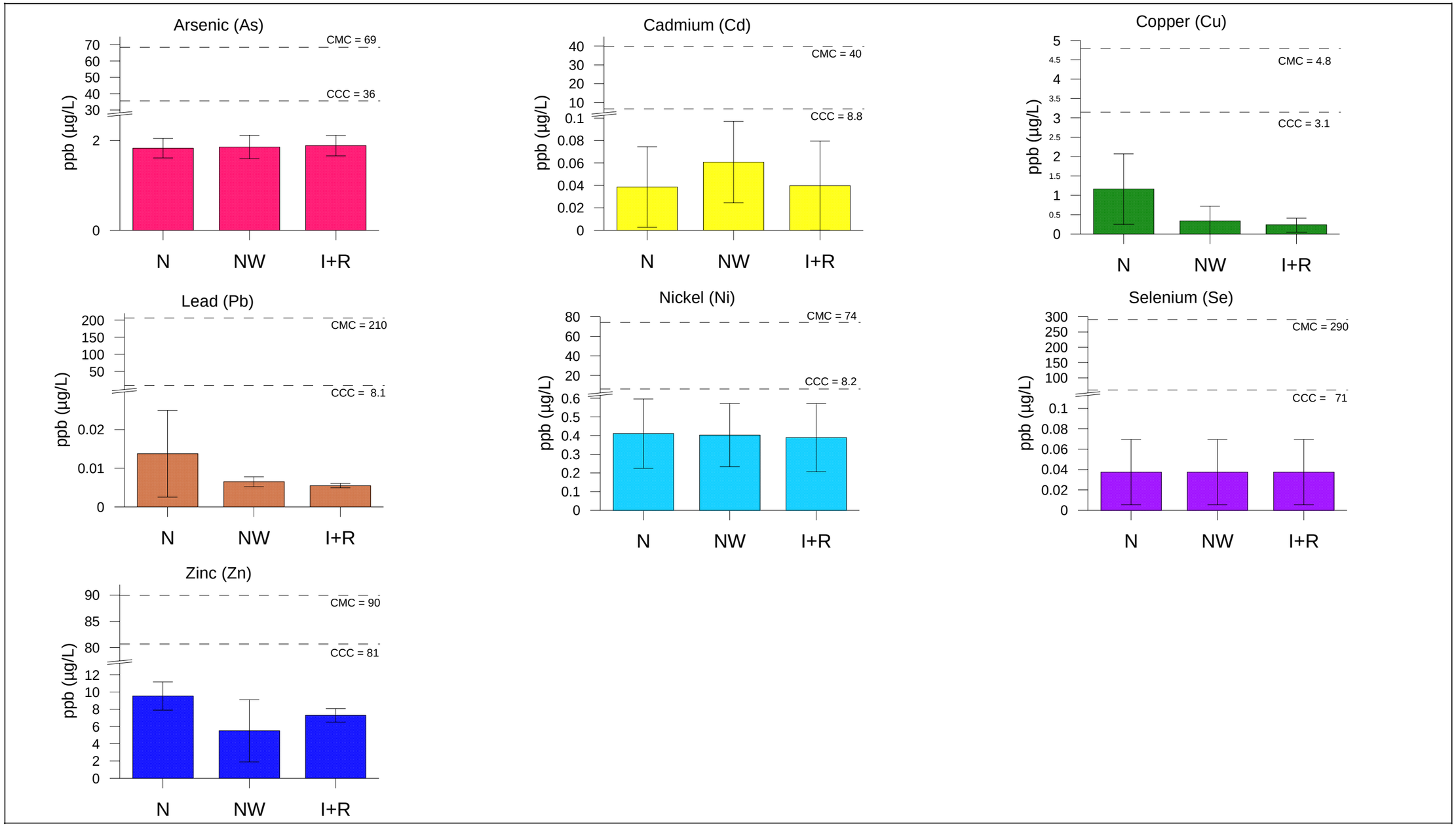

Figure 31. Mean and Standard Deviation of Selected Metals Showing Comparison of Alternative Areas (N and NW) to Each Other, Proposed Reference (I+R) and CMC and CCC Values

4.1.3 Regional Geology

Located in the western Pacific Ocean, Guam is the largest and southernmost of the Mariana Islands, located at 13° 28' North latitude, 144° 45' East longitude. The Marianas Islands are part of the Marianas Ridge, a complex island-arc system which is located west and on the concave side of the Mariana Trench (Figure 32). The Marianas Ridge was formed from the subduction of the oceanic Pacific Plate under the oceanic Philippine Plate. To the east, generally uniform underwater slopes descend from Guam at a rate of about 4° into this subduction zone area, otherwise known as the Marianas Trench, approximately 70 mi (113 km) away (Emery, 1962) and having depths greater than 36,000 ft (11,000 m). To the west, more complex slopes descend rapidly from Guam at a rate up to 14° to about 6,000 ft (1,830 m) into two depressions, interpreted by Tracey et al., (1964) as collapse or grabenlike features, and identified as the northwest and southwest collapse areas. These depressions are bounded by normal faults with two seamounts, likely underwater volcanoes, occurring to their west, approximately 15 nm (28 km) from the island of Guam. Further west, water depths increase to over 12,000 ft (3,600 m) in the East Mariana Basin of the Philippine Sea (Emery, 1962; Tracey et al., 1964).

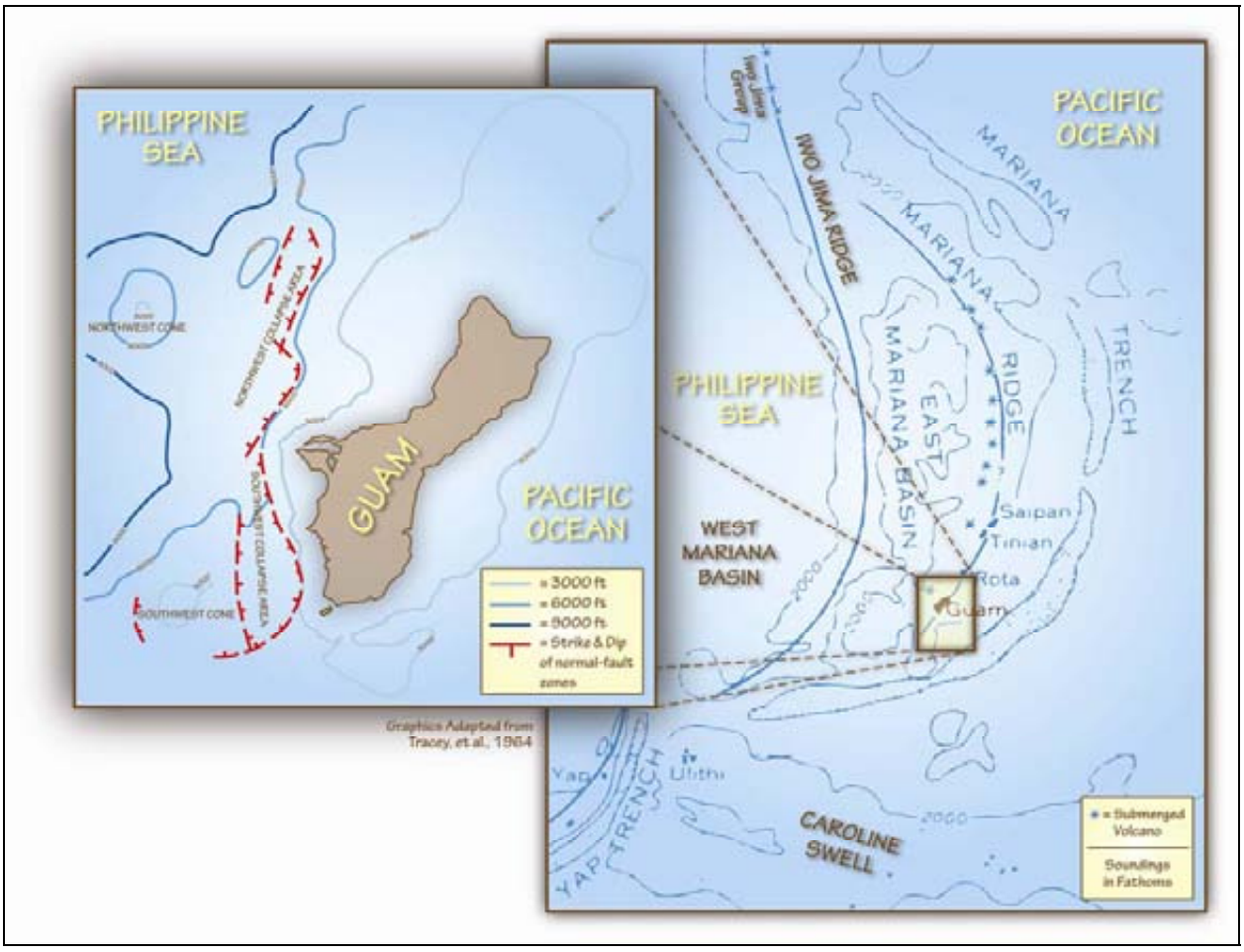

Figure 32. Marine Geology Offshore of Guam and Surrounding Vicinity

The island itself was formed through a combination of geologic processes; two volcanoes (identified in Tracey et al. [1964] as the Eocene and Miocene volcanoes) to the west of present day Guam collapsed and the related faulting with this event resulted in uplift of submerged areas, eventually creating the island of Guam. Today, the island is characterized by two distinct terrain features, a limestone plateau in the

northern half and volcanic uplands in the southern half. The northern plateau, bounded by steep cliffs, is approximately 600 ft (183 m) in elevation in the north and gently slopes to about 200 ft (60 m) in the central portion of Guam. The southern uplands are distinguished by a ridge of mountains trending parallel to the long axis of the island with elevations above 1000 ft (305 m) and a maximum of 1334 ft (406 m) at Mount Lamlam. An interior basin area characterized by rolling lowlands and karst occurs in the south central portion of Guam. Coastal lowland features are predominant along the coast in the southern half and sporadic in the north. Fringing reefs occur around the majority of the island. Guam is approximately 30 mi (48.3 km) in length, trending northeast-southwest in the northern half and trending north-south in the southern half. Guam ranges from 4 to 11 mi (6.4 to 17.7 km) wide and has a total land area of about 212 sq. mi (549 sq. km; Tracey et al., 1964).

Several underwater terraces have been observed around Guam and adjacent underwater banks such as Santa Rosa Reef and Galvez Bank. These terraces occur in relatively shallow water, with mean depths of 55 ft (17 m), 105 ft (32 m), 195 ft (59 m) and 315 ft (96 m). These terraces may likely be indicative of historical sea levels (Emery, 1962).

4.1.3.1 Study Region Bathymetry

The Guam ODMDS regional study area is located northwest of the island of Guam, approximately 5 nm (9 km) to 15 nm (28 km) offshore. During the 2008 Site Characterization Survey, a bathymetric survey of the region and surrounding area was conducted using a multibeam hydrographic survey system. Figure 33 shows the results of this survey. Water depths increase rapidly offshore of Orote Point, Guam to 6,550 ft (2,000 m). Several underwater canyons are apparent in the slope. The center of the study area is bisected by a broad shelf extending west from the base of the slope at depths of approximately 7,220 ft (2,200 m). South and southwest of this shelf, water depths continue to increase to 12,470 ft (3,800 m) into the East Mariana Basin. To the west, the shelf connects with a large conical seamount (identified in Figure 32 as the Northwest Cone), which rises to depths of only 2,625 ft (800 m). A ridge extends from the northeast to the shelf, separating the northern half of the study into two sections. The eastern section consists of a depression between the island slope to the east, the shelf-like feature to the south and ridge to the west. The western section consists of increasing water depths to 11,150 ft (3,400 m) into the East Mariana Basin.

North Alternative Area Bathymetry

The North Alternative Area, as determined through the ZSF process, is trapezoidal in shape and is predominantly located across a depression, identified in the previous section as the northwest collapse area of an ancient volcano (Figure 34). This depression is bounded by increasing slopes on all sides except to the north. The eastern portion of the North Alternative Area is located over slopes declining towards the northwest at 9°. The easternmost boundary is located in approximately 5,900 ft (1,800 m). A narrow canyon bisects this slope. The central and western portion of this area is located over a relatively flat region, with a <1° slope slightly declining towards the north. A ridge of seamounts bounds the extreme western portion of this region, with depths rising to about 6,550 ft (2,000 m) in the southwest and 5,575 ft (1,700 m) in the northwest corner. To the north of the North Alternative Area, a canyon trending towards the northwest bisects the ridge of seamounts, extending to depths of 11,150 ft (3,400 m).

Northwest Alternative Area Bathymetry

The Northwest Alternative Area, as determined through the ZSF process, is triangular in shape and is predominantly located across the southeastern flank of the Northwest Cone, a conical seamount approximately 15 nm (28 km) northwest of Apra Harbor, Guam (Figure 35). The northwest extent of this alternative area arcs across the tip of the seamount at only 2,625 ft (800 m) depth. The bathymetry slopes down off the seamount at approximately 7° to depths of approximately 8,200 ft (2,500 m) in the eastern portion of this area and 8,860 ft (2,700 m) in the southern portion.

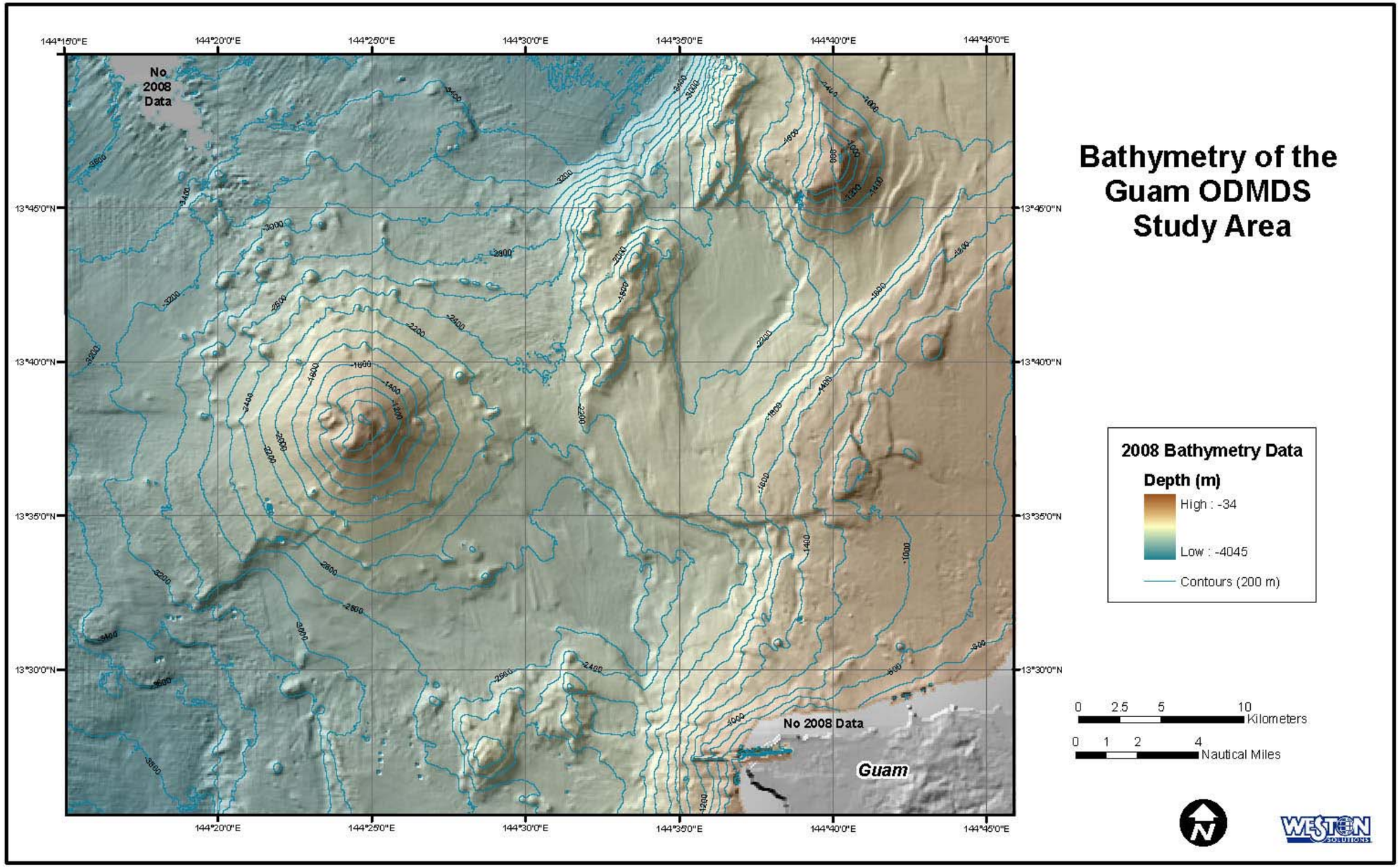

Figure 33. Regional Bathymetry

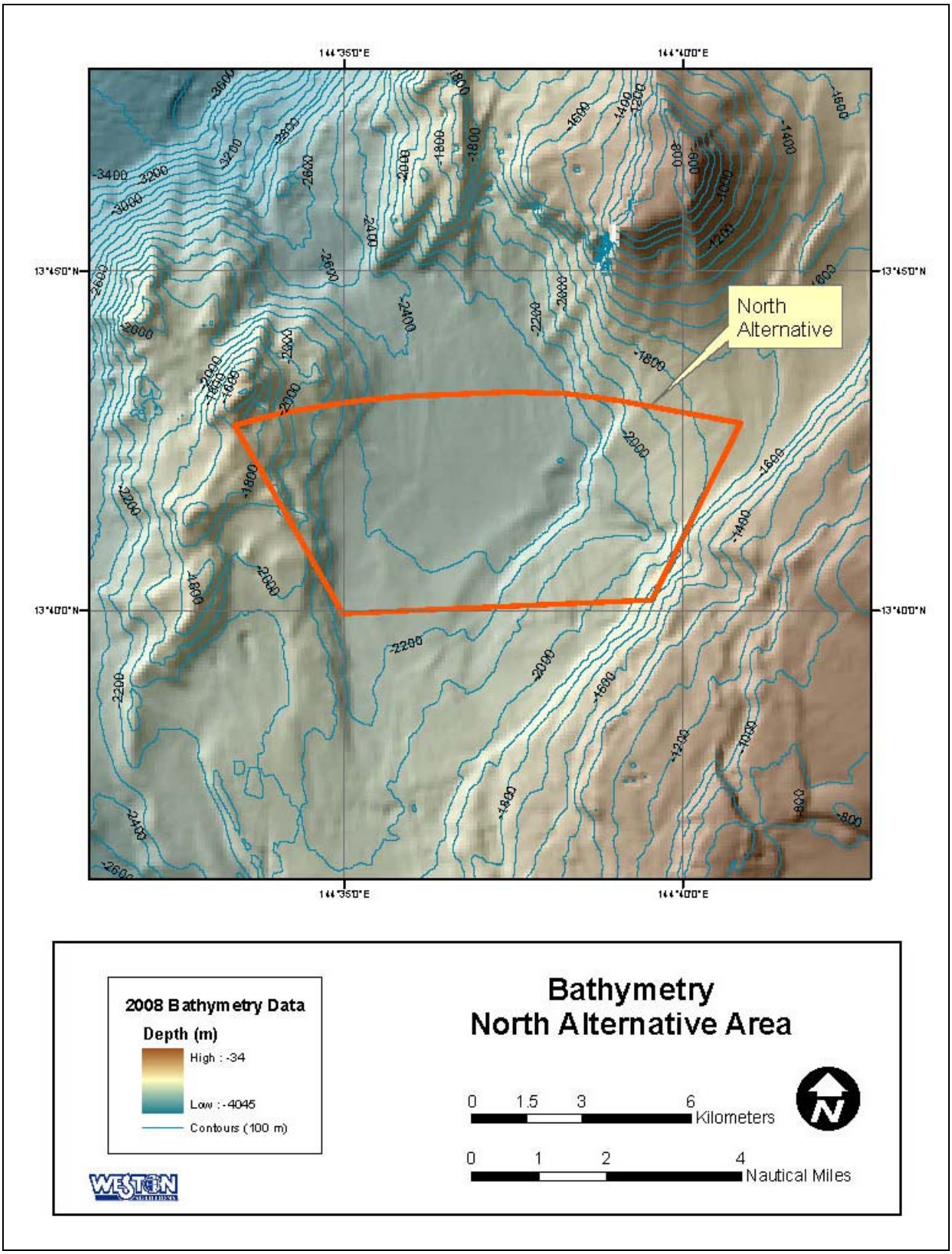

Figure 34. North Alternative Area Bathymetry

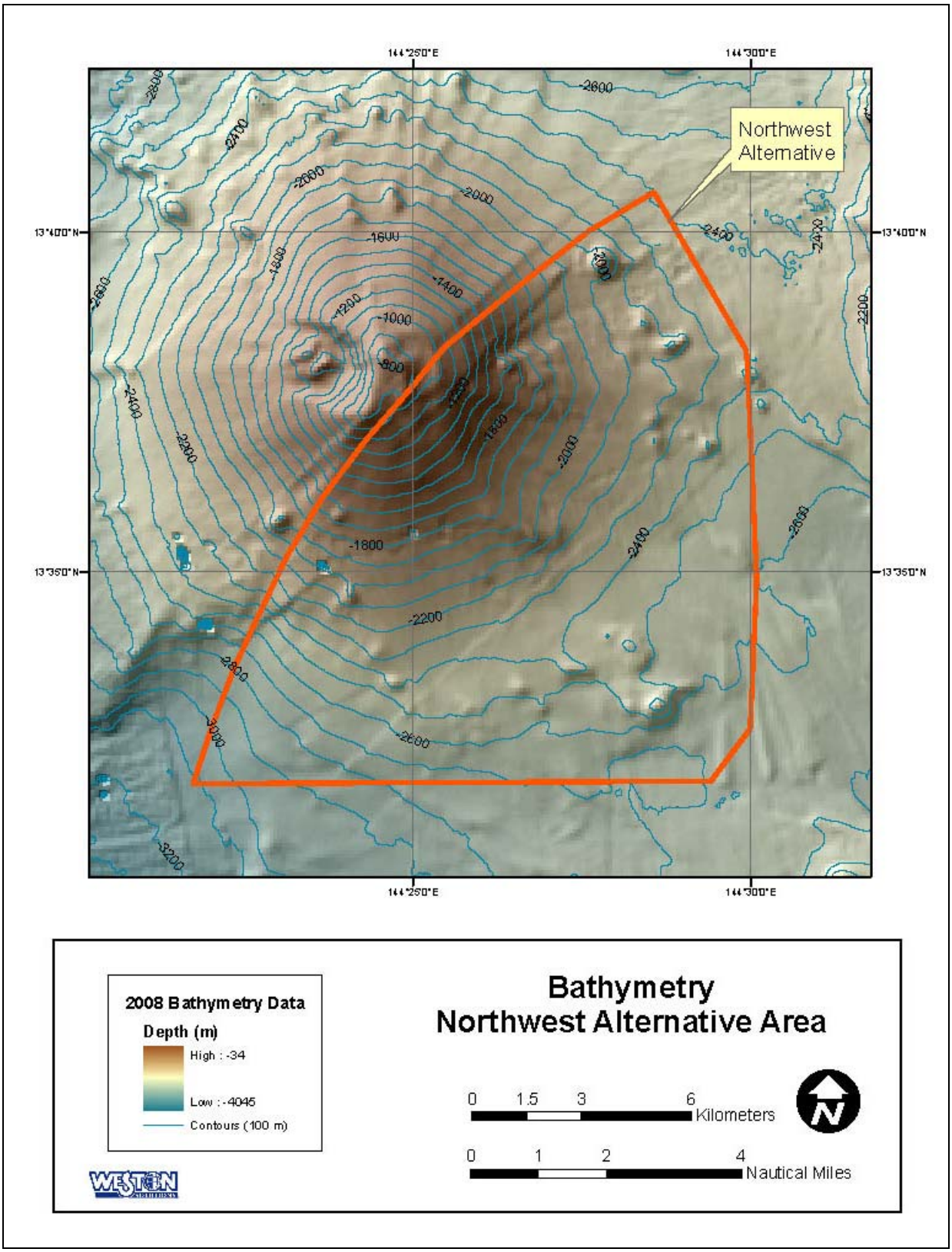

Figure 35. Northwest Alternative Area Bathymetry

4.1.4 Sediment Characteristics

Physical, conventional, chemical and radiological sediment characteristics examined in this study include grain size, carbon (TOC), nitrogen (ammonia, TKN, TON), sulfides, solids, trace metals, Acid volatile sulfides simultaneously extracted metals (AVS-SEM), persistent organic pollutants (PAHs, chlorinated pesticides/PCBs, organotins, dioxins/furans) and gross alpha/beta.

4.1.4.1 Physical Analyses

Grain size is the most essential physical characteristics of sediment. Information on sediment grain size is employed in determining trends of kinetic reactions, surface processes related to the dynamics of transportation and deposition, sample permeability/stability under load, affinities of contaminants to fine-grained particles and movement of subsurface fluids (Blatt et al., 1972; McCave and Syvitski, 1991). Grain size measurements were analyzed in sediments from nine stations in this study and presented in Figure 36 and Table 15. Complete laboratory analytical results for physical analyses are presented in Appendix C.2.

North Alternative
Sediment samples collected from Stations 1, 2 and 3 located in the North Alternative study area are primarily sand with some silt and clay. The dominant sand fraction had an average of 69.82 %, with a range of 58.93 % at Station 1 to 80.10 % at Station 2. The lesser silt fraction averaged 25.17 %, with a range of 16.14 % at Station 2 to 35.47 % at Station 1. The minor clay fraction averaged 5.01 %, with a range of 3.76 % at Station 2 to 5.68 % at Station 3. Results indicate that there was no gravel fraction detected in sediments from the North Alternative ODMDS study area.

Northwest Alternative
Sediment samples collected from Stations 6, 7 and 8 located in the Northwest Alternative study area were primarily sand and silt with some clay. The major sand fraction had an average of 52.05 %, with a range of 42.57 % at Station 8 to 63.44 % at Station 6. The minor silt fraction averaged 39.48 %, with a range of 30.33 % at Station 6 to 47.79 % at Station 8. The lesser clay fraction averaged 8.47 %, with a range of 6.22 % at Station 6 to 9.64 % at Station 8. Results indicate that there was no gravel fraction detected in sediments from the Northwest Alternative ODMDS study area.

Inshore/Proposed Reference Site
Sediment samples collected from Stations 4 and 9 located inshore of the two alternative areas, including the proposed reference site located at Station 5, were primarily sand with some silt and clay. The dominant sand fraction had an average of 65.11 %, with a range of 57.30 % at Station 5 to 72.38 % at Station 9. The lesser silt fraction averaged 27.73 %, with a range of 27.31 % at Station 4 to 33.96 % at Station 5. The minor clay fraction averaged 7.16 %, with a range of 5.69 % at Station 9 to 8.75 % at Station 5. Results indicate that there was no gravel fraction detected in sediments from the Inshore study area including the proposed upstream reference site

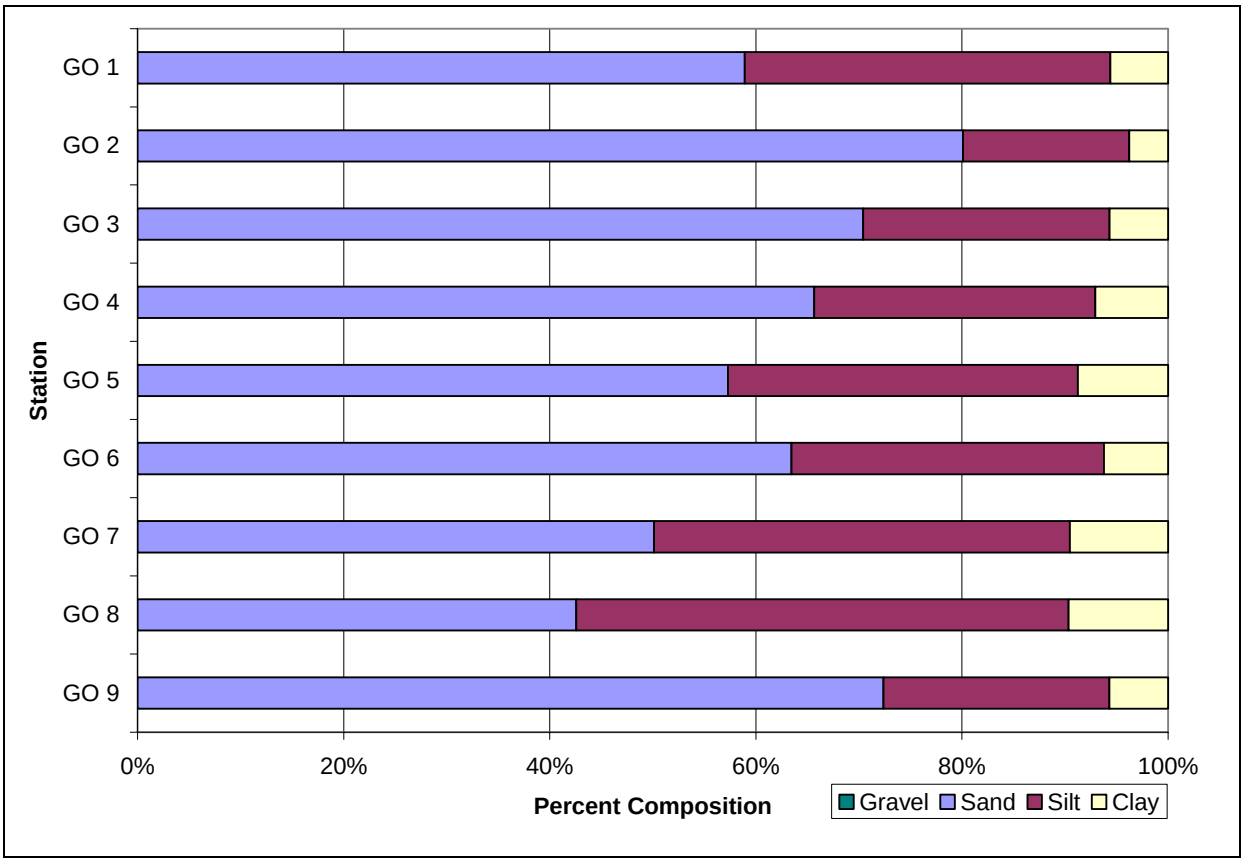

Figure 36. Grain Size Distribution by Size Class (Gravel, Sand, Silt, Clay) of Seafloor Sediment Samples Collected in the Guam ODMDS Study Area, April, 2008

Table 15. Summary of Chemistry Analytical Results and Physical Measurements of Sediments Collected Offshore of Guam, with a Comparison to ER-L and ER-M Sediment Quality Values and Oceanic Crustal Abundance Concentrations

Analyte	Units	MDL	RL	Station ID									ER-L	ER-M	Oceanic Crustal Abundance[3]
				GO_1	GO_2	GO_3	GO_4	GO_5	GO_6	GO_7	GO_8	GO_9			
Grain Size															
Gravel	%	-	-	0	0	0	0	0	0	0	0	0	-	-	-
Sand	%	-	-	58.93	80.10	70.42	65.65	57.30	63.44	50.13	42.57	72.38	-	-	-
Silt	%	-	-	35.47	16.14	23.90	27.31	33.96	30.33	40.33	47.79	21.94	-	-	-
Clay	%	-	-	5.60	3.76	5.68	7.05	8.75	6.22	9.54	9.64	5.69	-	-	-
Silt-Clay	%	-	-	41.07	19.90	29.58	34.35	42.70	36.56	49.87	57.43	27.62	-	-	-
General Chemistry															
Total Organics Carbob (TOC)	Percent	0.01	0.02	0.3	0.2	0.2	0.2	0.8	0.2	0.3	0.4	1.1	-	-	-
Total Organic Nitrogen (TON)[1]	mg/dry kg	-											-	-	-
Total Kjeldahl Nitrogen (TKN)		7.6	10	170	140	220	220	220	180	190	140	140	-	-	-
Ammonia-N	mg/dry kg	0.03	0.03	0.32	0.27	0.26	0.25	0.5	0.2	0.24	0.29	0.16	-	-	-
Total Sulfides	mg/dry kg	0.2	0.4	0.5	0.87	0.6	0.51	0.78	0.51	0.53	0.56	0.47	-	-	-
Percent Solids	Percent	0.1	0.1	53.7	54.8	54.5	54.9	53.3	53.8	51.5	52.2	62	-	-	-
Trace Metals															
Aluminum (Al)	µg/dry g	1	5	20640	19770	21060	26210	26720	21460	23380	17280	23850	-	-	-
Antimony (Sb)	µg/dry g	0.025	0.05	0.147	0.175	0.14	0.151	0.152	0.168	0.156	0.2	0.19	-	-	-
Arsenic (As)	µg/dry g	0.025	0.05	5.114	5.249	4.938	5.688	6.012	5.954	6.092	5.639	5.491	8.20	70.00	-
Barium (Ba)	µg/dry g	0.025	0.05	205	113.4	194.3	215.7	176.4	223.4	387.5	368.4	141.8	-	-	1497
Beryllium (Be)	µg/dry g	0.025	0.05	0.156	0.163	0.161	0.179	0.154	0.172	0.183	0.131	0.169	-	-	-
Cadmium (Cd)	µg/dry g	0.025	0.05	0.115	0.158	0.143	0.124	0.11	0.139	0.136	0.159	0.132	1.20	9.60	-
Chromium (Cr)	µg/dry g	0.025	0.05	43.74	40.18	42.81	53.61	61.2	45.7	48.62	31.38	44.51	81.00	370.00	17
Cobalt (Co)	µg/dry g	0.025	0.05	13.06	13.64	14.35	15.33	13.81	15.82	14.94	14.06	15.93	-	-	6324
Copper (Cu)	µg/dry g	0.025	0.05	41.19	39.37	40.44	45.22	39.02	49.55	52.83	43.99	44.96	34.00	270.00	799
Iron (Fe)	µg/dry g	1	5	22480	22770	23270	28160	26310	26070	27010	20990	27470	-	-	-
Lead (Pb)	µg/dry g	0.025	0.05	5.083	5.292	4.578	4.625	3.05	6.047	5.564	7.572	5.431	46.70	218.00	874
Manganese (Mn)	µg/dry g	0.025	0.05	701.3	919.2	784.3	685.4	487.5	1191	1068	1420	1110	-	-	-
Mercury (Hg)	µg/dry g	0.01	0.02	0.05	0.03	0.04	0.04	0.06	0.05	0.06	0.04	0.03	0.15	0.71	-
Molybdenum (Mo)	µg/dry g	0.025	0.05	0.424	0.572	0.455	0.404	0.402	0.667	0.56	0.59	0.561	-	-	-
Nickel (Ni)	µg/dry g	0.025	0.05	39.16	45.01	40.9	48.9	46.36	51.53	47.2	38.31	48.94	20.90	51.60	4960
Selenium (Se)	µg/dry g	0.025	0.05	0.098	0.052	0.073	0.082	0.111	0.062	0.089	0.053	0.05	-	-	-
Silver (Ag)	µg/dry g	0.025	0.05	0.081	0.091	0.082	0.104	0.111	0.103	0.095	0.118	0.113	1.00	3.70	-
Strontium (Sr)	µg/dry g	0.025	0.05	1025	1156	1395	1591	2531	1437	1440	1167	1280	-	-	1253
Thallium (Tl)	µg/dry g	0.025	0.05	0.075	0.113	0.079	0.051	0.038J	0.187	0.121	0.175	0.144	-	-	-
Tin (Sn)	µg/dry g	0.025	0.05	0.342	0.272	0.255	0.31	0.345	0.278	0.345	0.211	0.265	-	-	-
Titanium (Ti)	µg/dry g	0.025	0.05	607.6	686.1	644.1	727.1	688.9	644.6	668.7	586.2	834.1	-	-	-
Vanadium (V)	µg/dry g	0.025	0.05	62.92	67.39	68.72	74.58	70.85	67.76	74.58	58.11	82.05	-	-	600
Zinc (Zn)	µg/dry g	0.025	0.05	36.2	36.88	35.18	41.7	35.97	41.31	41.58	34.89	40.77	150.00	410.00	654
Acid Volatile Sulfides-Simultaneously Extracted Metals (AVS-SEM)															
Acid Volatile Sulfides (AVS)	mg/dry kg	0.05	0.1	1.46	1.37	1.09	0.9	2.01	1.03	1.16	1.52	1.01	-	-	-
Cadmium (Cd) - SEM	µmol/dry g	0.0018	0.0036	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	-	-	-
Copper (Cu) - SEM	µmol/dry g	0.0062	0.0124	0.0825	0.0378	0.0217	<0.0062	0.0569	0.0435	0.0745	0.113	0.0416	-	-	-
Lead (Pb) - SEM	µmol/dry g	0.0002	0.0004	0.0007	<0.0002	<0.0002	<0.0002	0.0003J	<0.0002	0.0002J	0.0013	<0.0002	-	-	-
Nickel (Ni) - SEM	µmol/dry g	0.0033	0.0066	0.0106	0.0097	0.0066	0.0049J	0.0126	0.008	0.0077	0.0107	0.0076	-	-	-
Silver (Ag) - SEM	µmol/dry g	0.0047	0.0094	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	-	-	-
Zinc (Zn) - SEM	µmol/dry g	0.0015	0.003	0.0696	0.0494	0.0379	0.0256	0.0533	0.0557	0.058	0.0841	0.0423	-	-	-

Table 15. Summary of Chemistry Analytical Results and Physical Measurements of Sediments Collected Offshore of Guam, with a Comparison to ER-L and ER-M Sediment Quality Values and Oceanic Crustal Abundance Concentrations

Analyte	Units	MDL	RL	Station ID									ER-L	ER-M	Oceanic Crustal Abundance[3]
				GO_1	GO_2	GO_3	GO_4	GO_5	GO_6	GO_7	GO_8	GO_9			
Polynuclear Aromatic Hydrocarbons (PAHs)															
1-Methylnaphthalene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
1-Methylphenanthrene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2,3,5-Trimethylnaphthalene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2,6-Dimethylnaphthalene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2-Methylnaphthalene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	70	670	-
Acenaphthene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	16	500	-
Acenaphthylene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	44	640	-
Anthracene	ng/dry g	1	5	<1	<1	1.6J	<1	<1	<1	<1	<1	<1	85.3	1100	-
Benz[a]anthracene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	261	1600	-
Benzo[a]pyrene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	430	1600	-
Benzo[b]fluoranthene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Benzo[e]pyrene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Benzo[g,h,i]perylene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Benzo[k]fluoranthene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Biphenyl	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Chrysene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	384	2800	-
Dibenz[a,h]anthracene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	63.4	260	-
Dibenzothiophene	ng/dry g	1	5	<1	<1	<1	2.1J	<1	<1	<1	<1	<1	-	-	-
Fluoranthene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	600	5100	-
Fluorene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	19	540	-
Indeno[1,2,3-c,d]pyrene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Naphthalene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	160	2100	-
Perylene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Phenanthrene	ng/dry g	1	5	<1	<1	1.2J	<1	<1	<1	<1	<1	<1	240	1500	-
Pyrene	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	665	2600	-
Chlorinated Pesticides															
2,4'-DDD	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2,4'-DDE	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
2,4'-DDT	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
4,4'-DDD	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	20	-
4,4'-DDE	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.2	27	-
4,4'-DDT	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	7	-
Aldrin	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
BHC-alpha	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
BHC-beta	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
BHC-delta	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
BHC-gamma	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Chlordane-alpha	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Chlordane-gamma	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
DCPA (Dacthal)	ng/dry g	5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-
Dicofol	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Dieldrin	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.02	8	-
Endosulfan Sulfate	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Endosulfan-I	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-

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Analyte	Units	MDL	RL	Station ID									ER-L	ER-M	Oceanic Crustal Abundance[3]
				GO_1	GO_2	GO_3	GO_4	GO_5	GO_6	GO_7	GO_8	GO_9			
Endosulfan-II	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Endrin	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Endrin Aldehyde	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Endrin Ketone	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Heptachlor	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Heptachlor Epoxide	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Methoxychlor	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Mirex	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Oxychlordane	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Perthane	ng/dry g	5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-
Toxaphene	ng/dry g	10	50	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
cis-Nonachlor	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
trans-Nonachlor	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Total Chlordane	ng/dry g	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.5	6	-
Polychlorinated Biphenyls (PCBs) Congeners															
PCB003	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB008	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB018	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB028	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB031	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB033	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB037	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB044	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB049	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB052	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB056/060	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB066	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB070	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB074	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB077	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB081	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB087	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB095	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB097	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB099	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB101	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB105	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB110	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB114	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB118	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB119	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB123	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB126	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB128	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB138	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-

Table 15. Summary of Chemistry Analytical Results and Physical Measurements of Sediments Collected Offshore of Guam, with a Comparison to ER-L and ER-M Sediment Quality Values and Oceanic Crustal Abundance Concentrations

Analyte	Units	MDL	RL	Station ID									ER-L	ER-M	Oceanic Crustal Abundance[3]
				GO_1	GO_2	GO_3	GO_4	GO_5	GO_6	GO_7	GO_8	GO_9			
PCB141	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB149	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB151	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB153	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB156	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB157	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB158	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB167	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB168+132	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB169	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB170	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB174	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB177	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB180	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB183	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB187	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB189	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB194	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB195	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB200	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB201	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB206	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
PCB209	ng/dry g	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Total PCBs	ng/dry g	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	22.7	180	-
Aroclor PCBs															
Aroclor 1016	ng/dry g	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1221	ng/dry g	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1232	ng/dry g	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1242	ng/dry g	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1248	ng/dry g	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1254	ng/dry g	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Aroclor 1260	ng/dry g	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-
Organotins															
Dibutyltin	ng/dry g	1	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Monobutyltin	ng/dry g	1	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Tetrabutyltin	ng/dry g	1	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Tributyltin	ng/dry g	1	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
Dioxins/Furans[2]															
2,3,7,8-Tetra CDD	pg/g	2.00	10	< 0.12	< 0.10	< 0.11	< 0.15	< 0.13	< 0.10	< 0.12	< 0.12	< 0.09	-	-	-
1,2,3,7,8-Penta CDD	pg/g	2.00	10	< 0.11	< 0.15	< 0.13	< 0.15	< 0.13	< 0.10	< 0.12	< 0.11	< 0.096	-	-	-
1,2,3,4,7,8-Hexa CDD	pg/g	2.00	10	< 0.22	< 0.12	< 0.15	< 0.18	< 0.16	< 0.17	< 0.13	< 0.14	< 0.15	-	-	-
1,2,3,6,7,8-Hexa CDD	pg/g	2.00	10	< 0.17	< 0.093	< 0.12	< 0.14	< 0.13	< 0.14	0.17 J	< 0.11	< 0.12	-	-	-
1,2,3,7,8,9-Hexa CDD	pg/g	3.00	10	< 0.18	< 0.10	< 0.13	< 0.15	< 0.16 (1)	< 0.15	< 0.19 (1)	< 0.12	< 0.13	-	-	-
1,2,3,4,6,7,8-Hepta CDD	pg/g	3.00	10	1.19 J	0.80 J	1.02 J	1.04 J	< 1.4 (1)	1.07 J	0.76 J	< 0.44 (1)	0.751 J	-	-	-
Octa CDD	pg/g	5.00	100	13.8	11.3	11.1	11.9	20.1	12.6	15.8	11.4	13.2	-	-	-

Table 15. Summary of Chemistry Analytical Results and Physical Measurements of Sediments Collected Offshore of Guam, with a Comparison to ER-L and ER-M Sediment Quality Values and Oceanic Crustal Abundance Concentrations

Analyte	Units	MDL	RL	Station ID									ER-L	ER-M	Oceanic Crustal Abundance[3]
				GO_1	GO_2	GO_3	GO_4	GO_5	GO_6	GO_7	GO_8	GO_9			
Total Tetra CDD	pg/g	-	-	< 0.30 (1)	0.2	< 0.27 (1)	0.34	< 0.33 (1)	< 0.34 (1)	0.3	< 0.12	< 0.092	-	-	-
Total Penta CDD	pg/g	-	-	4.92	2.18	3.46	2.21	2.67	3.25	1.47	2.4	2.56	-	-	-
Total Hexa CDD	pg/g	-	-	0.85	< 2.1 (1)	< 2.0 (1)	< 1.9 (1)	< 2.4 (1)	0.95	0.17	< 1.8 (1)	0.27	-	-	-
Total Hepta CDD	pg/g	-	-	2.62	1.73	2.14	2.3	1.48	2.33	1.6	0.47	1.61	-	-	-
2,3,7,8-Tetra CDF	pg/g	2.00	10	< 0.17 (1)	0.27 J	0.24 J	0.26 J	0.30 J	0.20 J	0.23 J	0.22 J	0.25 J	-	-	-
1,2,3,7,8-Penta CDF	pg/g	2.00	10	< 0.14	< 0.11	< 0.11	< 0.13	< 0.18	< 0.12	< 0.12	< 0.11	< 0.11	-	-	-
2,3,4,7,8-Penta CDF	pg/g	2.00	10	< 0.14	< 0.11	< 0.11	< 0.19 (1)	< 0.19	< 0.13	< 0.25 (1)	< 0.12	< 0.12	-	-	-
1,2,3,4,7,8-Hexa CDF	pg/g	2.00	10	< 0.20	0.20 J	0.2	< 0.17	< 0.13	< 0.19 (1)	< 0.12	< 0.12 (1)	< 0.23 (1)	-	-	-
1,2,3,6,7,8-Hexa CDF	pg/g	2.00	10	< 0.19	< 0.12	< 0.11	< 0.17	< 0.12	0.16 J	< 0.11	< 0.11	< 0.10	-	-	-
2,3,4,6,7,8-Hexa CDF	pg/g	2.00	10	< 0.22	< 0.14	< 0.13	< 0.20	< 0.14	< 0.13	< 0.13	< 0.13	< 0.12	-	-	-
1,2,3,7,8,9-Hexa CDF	pg/g	2.00	10	< 0.26	< 0.16	< 0.15	< 0.23	< 0.17	< 0.15	< 0.15	< 0.15	< 0.14	-	-	-
1,2,3,4,6,7,8-Hepta CDF	pg/g	3.00	10	< 1.2 (1)	< 0.48 (1)	< 0.54 (1)	< 0.87 (1)	< 1.9 (1)	< 0.71 (1)	< 0.26 (1)	< 0.20 (1)	< 0.54 (1)	-	-	-
1,2,3,4,7,8,9-Hepta CDF	pg/g	2.00	10	< 0.18	< 0.21	< 0.16	< 0.15	< 0.14	< 0.16	< 0.14	< 0.11	< 0.12	-	-	-
Octa CDF	pg/g	5.00	100	1.19 J	0.66 J	0.65 J	0.71 J	1.55 J	0.64 J	0.63 J	0.35 J	0.57 J	-	-	-
Total Tetra CDF	pg/g	-	-	0.34	0.45	0.43	0.52	0.69	0.42	0.52	0.39	0.25	-	-	-
Total Penta CDF	pg/g	-	-	< 0.90 (1)	< 0.23 (1)	< 0.18 (1)	< 0.24 (1)	< 0.41 (1)	< 1.2 (1)	< 0.25 (1)	< 0.11	< 0.14 (1)	-	-	-
Total Hexa CDF	pg/g	-	-	< 0.22	0.2	0.2	< 0.19	0.55	0.68	0.13	< 0.12 (1)	< 0.23 (1)	-	-	-
Total Hepta CDF	pg/g	-	-	0.84	< 0.48 (1)	< 0.54 (1)	< 0.87 (1)	< 1.9 (1)	< 0.71 (1)	< 0.26 (1)	< 0.20 (1)	0.28	-	-	-
Gross Alpha/Beta															
Gross Alpha	pCi/g	3	-	12.4	9.69	7.02	9.68	6.45	12.1	10.8	11.6	12.4	-	-	-
Gross Beta	pCi/g	2.3	-	6.19	7.78	0.9	3.67	2.17	5.86	2.46	1.61	2.75	-	-	-

J = estimated value above the MDL and below the RL

[1] TON = TKN - Ammonia

[2] dioxin/furan results reported down to sample-specific laboratory EDL instead of MDL

(1) EMPC / NDR - Peak detected does not meet ratio criteria and has resulted in an elevated detection limit.

[3] Wen *et al*., 1997

4.1.4.2 Chemical Analyses

Complete laboratory analytical results for sediment chemistry are presented in Appendix C.3.

Conventional Parameters

Concentrations of carbon (TOC), nitrogen (ammonia, TKN, TON), sulfides and solids were analyzed in sediments from this study and presented in Table 15 and Figure 37.

North Alternative

Conventional parameters analyzed in sediment samples from Stations 1, 2 and 3 located in the North Alternative study area were detected in low concentrations. Percent solid content had an average of 54.3 % with a range of 53.7 % at Station 1 to 54.8 % at Station 2. TOC had an average of 0.22 % with a range of 0.17 % at Station 3 to 0.29 % at Station 1. TON had an average of 95.69 mg/dry kg with a range of 76.45 mg/dry kg at Station 2 to 119.64 mg/dry kg at Station 3. Ammonia-N had an average of 0.28 mg/dry kg with a range of 0.26 mg/dry kg at Station 3 to 0.32 mg/dry kg at Station 1. These ammonia-N averages were approximately 2 orders of magnitude lower than biologically toxic concentrations (30 ppm) and were supported by toxicity test results conducted on project sediments (Section 4.3). TKN had an average of 177 mg/wet kg with a range of 140 mg/wet kg at Station 2 to 220 mg/wet kg at Station 3. Total sulfides had an average of 0.66 mg/dry kg with a range of 0.50 mg/dry kg at Station 1 to 0.87 mg/dry kg at Station 2. Analysis of conventional parameters using the Dixon's Test established no relative difference in carbon (TOC), nitrogen (ammonia, TKN, TON), sulfides and solids content of sediment between stations located in the North Alternative study area. The homogeneity of conventional parameters measured across Stations 1, 2 and 3 in the North Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Northwest Alternative

Conventional parameters analyzed in sediment samples from Stations 6, 7 and 8 located in the Northwest Alternative study area were detected in low concentrations. Percent solid content had an average of 52.5 % with a range of 51.5 % at Station 7 to 53.8 % at Station 6. TOC had an average of 0.28 % with a range of 0.19 % at Station 6 to 0.39 % at Station 8. TON had an average of 89.01 mg/dry kg with a range of 72.79 mg/dry kg at Station 8 to 97.61 mg/dry kg at Station 7. Ammonia-N had an average of 0.24 mg/dry kg with a range of 0.20 mg/dry kg at Station 6 to 0.29 mg/dry kg at Station 8. These ammonia-N averages were approximately 2 orders of magnitude lower than biologically toxic concentrations (30 ppm) and were supported by toxicity test results conducted on project sediments (Section 4.3). TKN had an average of 170 mg/wet kg with a range of 140 mg/wet kg at Station 8 to 190 mg/wet kg at Station 7. Total sulfides had an average of 0.53 mg/dry kg with a range of 0.51 mg/dry kg at Station 6 to 0.56 mg/dry kg at Station 8. Analysis of conventional parameters using the Dixon's Test established no relative difference in TOC, ammonia-N, TKN, sulfides and solids content of sediment in the Northwest Alternative study area. TON concentration was slightly lower at Station 8 (72.79 mg/dry kg) than Stations 6 (96.64 mg/dry kg) and 7 (97.61 mg/dry kg). The homogeneity of conventional parameters measured across Stations 6, 7 and 8 in the Northwest Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Inshore/Proposed Reference Site

Conventional parameters analyzed in sediment samples from Stations 4 and 9 located inshore of the two alternative areas, as well as the proposed reference site located at Station 5, were detected in low concentrations. Percent solid content had an average 56.7 % with a range of 53.3 % at Station 5 to 62.0 % at Station 9. TOC content had an average of 0.71 % with a range of 0.22 % at Station 4 to 1.07 % at Station 9. TON had an average of 107.98 mg/dry kg with a range of 86.64 mg/dry kg at Station 9 to 120.53 mg/dry kg at Station 4. Ammonia-N had an average of 0.30 mg/dry kg with a range of 0.16 mg/dry kg at Station 9 to 0.50 mg/dry kg at Station 5. These ammonia-N averages were approximately 2 orders of magnitude lower than biologically toxic concentrations (30 ppm) and were supported by toxicity

test results conducted on project sediments (Section 4.3). TKN had an average of 193 mg/wet kg with a range of 140 mg/wet kg at Station 9 to 220 mg/wet kg at Stations 4 and 5. Total sulfides had an average of 0.59 mg/dry kg with a range of 0.47 mg/dry kg at Station 9 to 0.78 mg/dry kg at Station 5. Analysis of conventional parameters using the Dixon's Test established no relative difference in TOC, TON, ammonia-N, sulfides and solids content of sediment in the inshore study area including the proposed reference site. TKN concentration was slightly lower at Station 9 (140 mg/wet kg) than Stations 4 (220 mg/wet kg) and 5 (220 mg/dry kg). The homogeneity of conventional parameters measured at Station 5 as compared to other stations inshore of the two alternative areas, suggest this would be an appropriate reference site.

Trace Metals

Although many metals are biologically essential in trace amounts (e.g. chromium, copper, and zinc), excessive quantities can interfere with integral physiological processes in organisms from yeast to humans. Metals are introduced in marine systems as a result of the weathering of soils and rocks, from volcanic eruptions, and from a variety of human activities involving the mining, processing, or use of metals and/or substances that contain metals. Both localized and dispersed metal pollutants such as cadmium, lead, mercury, and silver are not biodegradable, toxic in solution, and subject to biomagnifications in the tissues of marine organisms causing adverse environmental impacts (Lau et al., 1998). Trace metal concentrations in sediments are typically orders of magnitude greater than concentrations in overlying water and constitute an enriched pool of metal (Luoma, 1989). A portion of its biologically available form is generally chemically fixed and largely unavailable to organisms without chemical changes in the sediment. The equilibrium state for metals depends on the chemical state of the water and sediment, particularly the pH and oxidation-reduction conditions. Concentrations of 23 metals were analyzed in sediments from this study and presented in Table 15 and Figure 38. For comparison, available ER-L/ER-M values and data for central Pacific Ocean sediments collected at comparable depth with similar bathymetric features are also presented in Table 15.

North Alternative

Average metal concentrations in sediment samples from Stations 1, 2 and 3 located in the North Alternative study area were as follows: aluminum (20,490 µg/dry g); antimony (0.154 µg/dry g); arsenic (5.100 µg/dry g); barium (170.9 µg/dry g); beryllium (0.160 µg/dry g); cadmium (0.139 µg/dry g); chromium (42.24 µg/dry g); cobalt (13.68 µg/dry g); copper (40.33 µg/dry g); iron (22840 µg/dry g); lead (4.984 µg/dry g); manganese (801.6 µg/dry g); mercury (0.04 µg/dry g); molybdenum (0.484 µg/dry g); nickel (41.69 µg/dry g); selenium (0.074 µg/dry g); silver (0.085 µg/dry g); strontium (1192 µg/dry g); thalium (0.089 µg/dry g); tin (0.290 µg/dry g); titanium (645.9 µg/dry g); vanadium (66.34 µg/dry g); zinc (36.09 µg/dry g). Analysis of metals using the Dixon's Test established no relative difference in metal content of sediment between stations located in the North Alternative ODMDS study area.

Cadmium, zinc, mercury, arsenic, chromium, lead and silver concentrations in the North Alternative study area were below ER-L levels. Average copper concentrations slightly exceeded the ER-L (34 µg/dry g) but at concentrations well below the ER-M (270 µg/dry g). Average nickel concentrations were approximately two times the ER-L (20.9 µg/dry g) and slightly less than the ER-M (51.6 µg/dry g). As a point of comparison, trace metal concentrations measured during baseline studies for the SF-DODS designation show chromium and nickel exceeding the ER-L or ER-M, respectively, at all alternative locations and copper exceeding the ER-L at one location (USEPA 1993).

Sediment metal levels in the North Alternative study area were below average oceanic crustal abundances available for barium, cobalt, copper, iron, lead, manganese, nickel, strontium, titanium, vanadium and zinc. Average aluminum concentrations were an order of magnitude greater than, while average chromium concentrations were more than double the oceanic crustal abundance values measured in the central Pacific Ocean (Wen et al., 1997).

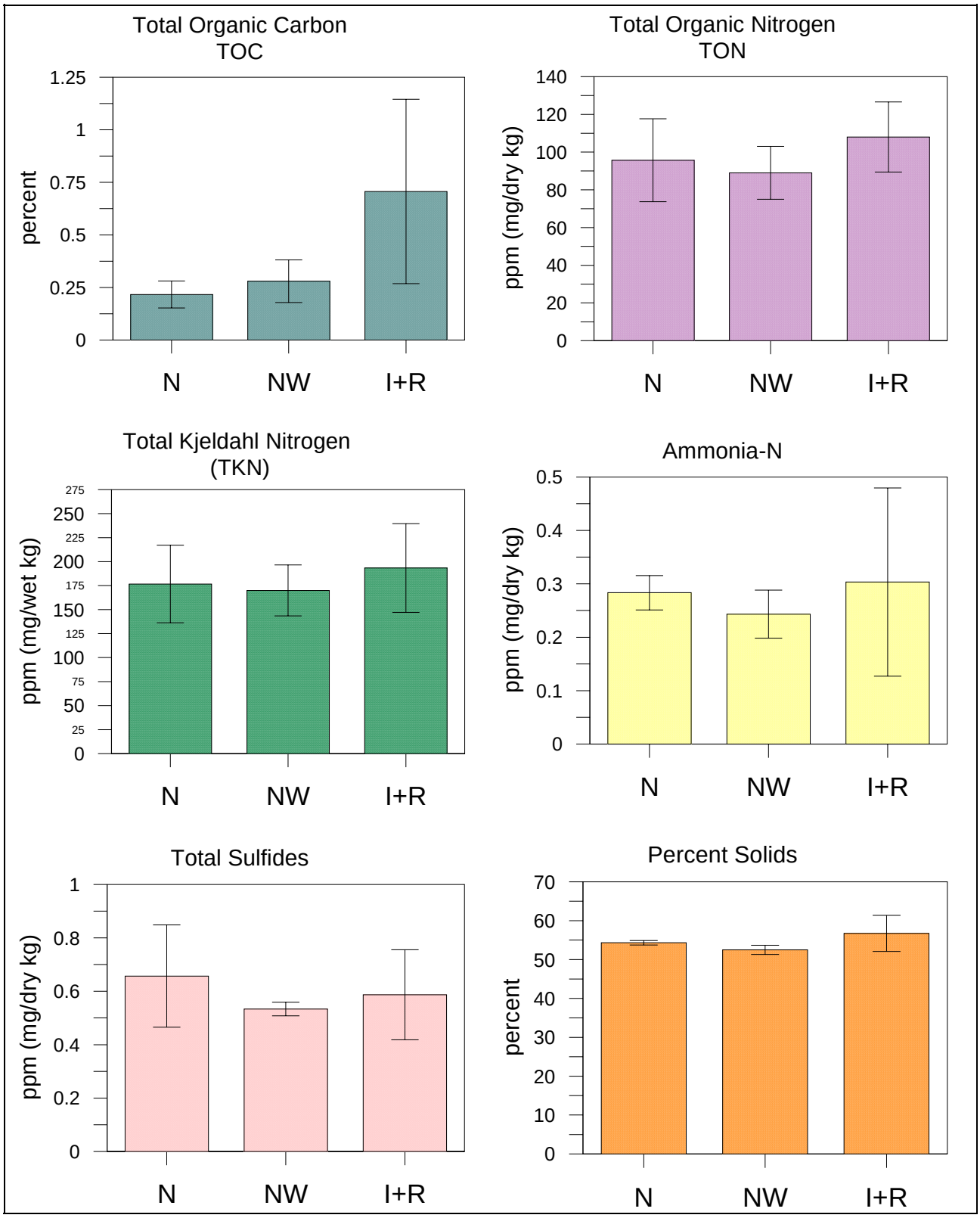

Figure 37. Mean and Standard Deviation of Selected Conventional Chemistry Constituents Showing Comparison of Alternative Areas to Each Other and Proposed Reference

The homogeneity of trace metals measured across Stations 1, 2 and 3 in the North Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Northwest Alternative

Average metal concentrations in sediment samples from Station 6, 7 and 8 located in the Northwest Alternative study area were as follows: aluminum (20707 µg/dry g); antimony (0.175 µg/dry g); arsenic (5.895 µg/dry g); barium (326.4 µg/dry g); beryllium (0.162 µg/dry g); cadmium (0.145 µg/dry g); chromium (41.90 µg/dry g); cobalt (14.94 µg/dry g); copper (48.79 µg/dry g); iron (24690 µg/dry g); lead (6.394 µg/dry g); manganese (1226 µg/dry g); mercury (0.05 µg/dry g); molybdenum (0.61 µg/dry g); nickel (45.68 µg/dry g); selenium (0.068 µg/dry g); silver (0.105 µg/dry g); strontium (1348 µg/dry g); thalium (0.161 µg/dry g); tin (0.278 µg/dry g); titanium (633.2 µg/dry g); vanadium (66.82 µg/dry g); zinc (39.26 µg/dry g). Analysis of metals using the Dixon's Test established no relative difference in all but two metals between stations located in the Northwest Alternative study area. Strontium concentrations were lower at Station 8 (1167 µg/dry g) than Stations 6 (1437 µg/dry g) and 7 (1440 µg/dry g). Zinc concentrations were also slightly lower at Station 8 (34.89 µg/dry g) than Stations 6 (41.31 µg/dry g) and 7 (41.58 µg/dry g).

Cadmium, zinc, mercury, arsenic, chromium, lead and silver concentrations in the Northwest Alternative study area were below ER-L levels. Average copper concentrations slightly exceeded the ER-L (34 µg/dry g) but at concentrations well below the ER-M (270 µg/dry g). Average nickel concentrations were more than 2 times the ER-L (20.9 µg/dry g) and slightly less than the ER-M (51.6 µg/dry g).

Sediment metal levels in the Northwest Alternative study area were below average oceanic crustal abundances available for barium, cobalt, copper, iron, lead, manganese, nickel, titanium, vanadium and zinc. Average aluminum concentrations were an order of magnitude greater than, while average chromium concentrations were more than double the oceanic crustal abundance values. Average strontium only slightly exceeds the oceanic crustal abundance values measured in the central Pacific Ocean (Wen et al., 1997).

The homogeneity of trace metals measured across Stations 6, 7 and 8 in the Northwest Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Inshore/Proposed Reference Site

Average metal concentrations in sediment samples from Stations 4 and 9 located inshore of the two alternative areas, as well as the proposed reference site located at Station 5, were as follows: aluminum (25593 µg/dry g); antimony (0.164 µg/dry g); arsenic (5.730 µg/dry g); barium (178.0 µg/dry g); beryllium (0.167 µg/dry g); cadmium (0.122 µg/dry g); chromium (53.11 µg/dry g); cobalt (15.02 µg/dry g); copper (43.07 µg/dry g); iron (27313 µg/dry g); lead (4.369 µg/dry g); manganese (761.0 µg/dry g); mercury (0.04 µg/dry g); molybdenum (0.456 µg/dry g); nickel (48.07 µg/dry g); selenium (0.081 µg/dry g); silver (0.109 µg/dry g); strontium (1801 µg/dry g); thalium (0.078 µg/dry g); tin (0.307 µg/dry g); titanium (750.0 µg/dry g); vanadium (75.83 µg/dry g); zinc (39.48 µg/dry g). Analysis of metals using the Dixon's Test established no relative difference in all but three metals between stations in the inshore study area including the proposed reference site. Copper concentrations were lower at Station 5 (30.02 µg/dry g) than Stations 4 (45.22 µg/dry g) and 9 (44.96 µg/dry g). Nickel concentrations were also slightly lower at Station 5 (46.36 µg/dry g) than Stations 4 (48.90 µg/dry g) and 9 (48.94 µg/dry g). In contrast, antimony concentrations were slightly greater at Station 9 (0.190 µg/dry g) than Stations 4 (0.151 µg/dry g) and 5 (0.152 µg/dry g).

Cadmium, zinc, mercury, arsenic, chromium, lead and silver concentrations in the inshore study area including the proposed upstream reference site were below ER-L levels. Average copper concentrations slightly exceeded the ER-L (34 µg/dry g) but at concentrations well below the ER-M (270 µg/dry g).

Average nickel concentrations were more than two times the ER-L (20.9 µg/dry g) and slightly lower than the ER-M (51.6 µg/dry g).

Sediment metal levels in the inshore study area including the proposed upstream reference site were below average oceanic crustal abundances available for barium, cobalt, copper, iron, lead, manganese, nickel, titanium, vanadium and zinc. Average aluminum concentrations were an order of magnitude greater than, while average chromium concentrations were more than double the oceanic crustal abundance values. Average strontium only slightly exceeds the oceanic crustal abundance values measured in the central Pacific Ocean (Wen et al., 1997).

The homogeneity of trace metals measured at Station 5 as compared to other inshore stations in this study, suggest that this would be an appropriate reference site.

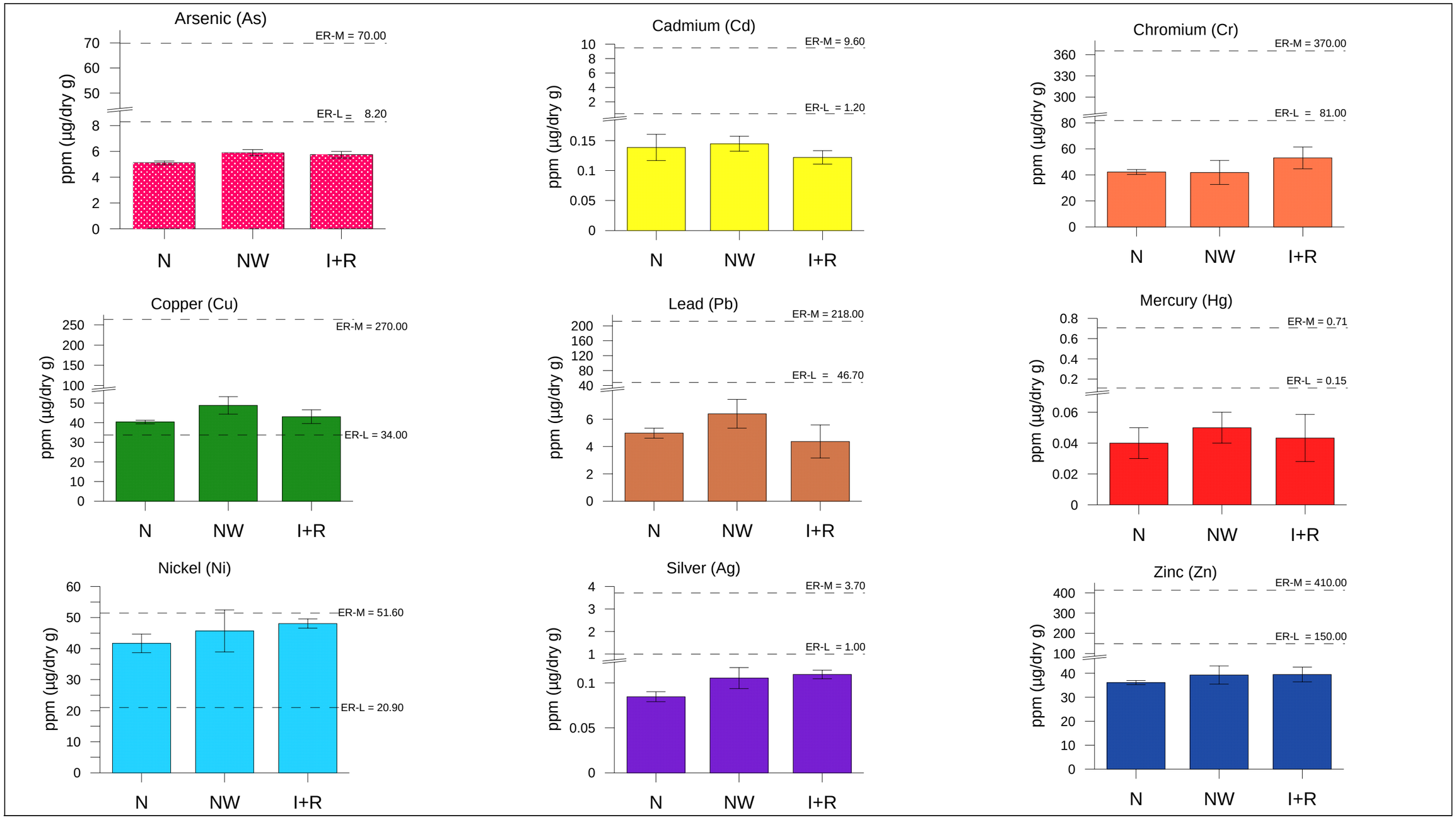

Figure 38. Mean and Standard Deviation of Selected Metals Showing Comparison of Alternative Areas to Each Other, Proposed Reference and ER-L and ER-M Values

Acid volatile sulfides/simultaneously extracted metals AVS-SEM

In anoxic sediments, there is commonly a substantial reservoir of sulfide in the form of solid FeS, referred to as acid volatile sulfide (AVS). The availability of metals such as Cd, Cu, Ni, Pb, Zn, and Ag is thought to be controlled in part by its precipitation as insoluble sulfides complexes, because the stability constants for most metal-sulfide associates are very high, and exchange from metal sulfides to water is low. This property allows the presence of excess AVS to influences the toxicity potential of these metals to benthic organisms by acting as a sink for and immobilizing its biologically available, ionic form (Ankley et al., 1996). AVS is operationally defined as the amount of sulphides that can be volatilized during a cold acid extraction. The AVS-bound metals are extracted at the same time and are referred to as simultaneously extracted metals (SEM). Laboratory and field experiments have shown that if the ratio of SEM:AVS is less than one, there are likely to be no biologically available metals in solution. This ratio approach can be used to predict the lack of toxicity but not the onset of toxicity (Di Toro et al., 2001). AVS are naturally produced by the bacterial breakdown of organic material and cannot exist in the presence of oxygen, therefore have no utility in aerobic sediment or terrestrial environments. Table 15 presents the SEM results for six metals (Cd, Cu, Pb, Ni, Ag, and Zn) that are likely to bind to AVS and the concentration of AVS for each sample. Table 16 calculates the ratio of ∑SEM:AVS and highlights Stations in this study with a ratio greater than one.

North Alternative

AVS and SEM analyzed in sediment samples from Stations 1, 2 and 3 located in the North Alternative study area were detected in low concentrations. AVS had an average of 0.041 µmol/dry g with a range of 0.034 µmol/dry g at Station 3 to 0.046 µmol/dry g at Station 1. Combined SEM had and average of 0.111 µmol/dry g with a range of 0.068 µmol/dry g at Station 3 to 0.165 µmol/dry g at Station 1. The calculated ∑SEM:AVS had an average of 2.66 with a range of 2.01 at Station 3 to 3.63 at Station 1. While this implies the potential for toxicity due to metal bioavailability, studies suggest that a ∑SEM:AVS ratio of greater than 40 is required for certainty of metal toxicity predictions (Di Toro et al., 2001). Analysis of SEM:AVS using the Dixon's Test established no relative difference in the SEM:AVS ratio of sediment between stations located in the North Alternative ODMDS study area. The homogeneity of SEM:AVS measured across Stations 1, 2 and 3 in the North Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Northwest Alternative

AVS and SEM analyzed in sediment samples from Stations 6, 7 and 8 located in the Northwest Alternative study area were detected in low concentrations. AVS had an average of 0.039 µmol/dry g with a range of 0.032 µmol/dry g at Station 6 to 0.047 µmol/dry g at Station 8. Combined SEM had and average of 0.154 µmol/dry g with a range of 0.109 µmol/dry g at Station 6 to 0.211 µmol/dry g at Station 8. The calculated ∑SEM:AVS had an average of 3.93 with a range of 3.40 at Station 6 to 4.45 at Station 8. While this implies the potential for toxicity due to metal bioavailability, studies suggest that a ∑SEM:AVS ratio of greater than 40 is required for certainty of metal toxicity predictions (Di Toro et al., 2001). Analysis of SEM:AVS using the Dixon's Test established no relative difference in the SEM:AVS ratio of sediment between stations located in the Northwest Alternative ODMDS study area. The homogeneity of SEM:AVS measured across Stations 6, 7 and 8 in the Northwest Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Inshore/Proposed Reference Site

AVS and SEM analyzed in sediment samples from Stations 4 and 9 located inshore of the two alternative areas, as well as the proposed reference site located at Station 5, were detected in low concentrations. AVS had an average of 0.041 µmol/dry g with a range of 0.028 µmol/dry g at Station 4 to 0.063 µmol/dry g at Station 5. Combined SEM had and average of 0.085 µmol/dry g with a range of 0.036 µmol/dry g at Station 4 to 0.125 µmol/dry g at Station 5. The calculated ∑SEM:AVS had an average of 2.08 with a range of 1.27 at Station 4 to 2.97 at Station 9. While this implies the potential for toxicity due to metal bioavailability, studies suggest that a ∑SEM:AVS ratio of greater than 40 is required for certainty of

metal toxicity predictions (Di Toro et al., 2001). Analysis of SEM:AVS content using the Dixon's Test established no relative difference in the SEM:AVS ratio between stations in the inshore study area including the proposed reference site. The homogeneity of SEM:AVS measured at Station 5 as compared to other Inshore stations in this study, suggest that this would be an appropriate reference site.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are one of the most widespread organic pollutants due to its collective natural and manufactured origins. They are a group of over 100 different chemicals that occur naturally in oil, coal, tar deposits and are formed during the incomplete combustion of petroleum products, garbage, and tobacco and even charbroiled meat. Different types of incineration yield unique distributions of PAHs in both relative amounts of discrete PAHs and in which isomers are produced, making these compounds potentially useful as source markers. PAHs are also manufactured in its pure form and used in medicines or to make dyes and plastics. Because of its lipophilic properties, PAHs in the marine environment are found primarily in the sediment. A total of 25 individual PAHs were analyzed in sediments from this study and presented in Table 15.

North Alternative

PAHs analyzed in sediment samples from Stations 1, 2 and 3 located in the North Alternative study area were non-detectable below the MDL of 1 ng/dry g, with the exception of one station. Station 3 had detectable concentrations of two low molecular weight PAHs at estimated results below the laboratory reporting limit for anthracene (1.6 ng/dry g) and phenanthrene (1.2 ng/dry g). The homogeneity of PAHs measured across Stations 1, 2 and 3 in the North Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Northwest Alternative

PAHs analyzed in sediment samples from Stations 6, 7 and 8 located in the Northwest Alternative study area were non-detectable below the MDL of 1 ng/dry g. The homogeneity of PAHs measured across Stations 6, 7 and 8 in the Northwest Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Inshore/Proposed Reference Site

PAHs analyzed in sediment samples from Stations 4 and 9 located inshore of the two alternative areas, as well as the proposed reference site located at Station 5, were non-detectable below the MDL of 1 ng/dry g, with the exception of one station. Station 4 had detectable concentrations of low molecular weight PAHs at estimated results below the laboratory reporting limit for dibenzothiophene (2.1 ng/dry g). The homogeneity of PAHs measured at Station 5 as compared to other inshore stations in this study, suggest that this would be an appropriate reference site.

Table 16. Simultaneously Extracted Metals/Acid Volatile Sulfides Results and ∑SEM:AVS for Seafloor Sediment Samples Collected in the Guam ODMDS Study Area, April, 2008

Analyte	Units	MDL	RL	Station ID								
				GO 1	GO 2	GO 3	GO 4	GO 5	GO 6	GO 7	GO 8	GO 9
Cadmium (Cd) - SEM	µmol/dry g	0.0018	0.0036	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018	<0.0018
Copper (Cu) - SEM	µmol/dry g	0.0062	0.0124	0.0825	0.0378	0.0217	<0.0062	0.0569	0.0435	0.0745	0.113	0.0416
Lead (Pb) - SEM	µmol/dry g	0.0002	0.0004	0.0007	<0.0002	<0.0002	<0.0002	0.0003J	<0.0002	0.0002J	0.0013	<0.0002
Nickel (Ni) - SEM	µmol/dry g	0.0033	0.0066	0.0106	0.0097	0.0066	0.0049J	0.0126	0.008	0.0077	0.0107	0.0076
Silver (Ag) - SEM	µmol/dry g	0.0047	0.0094	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047	<0.0047
Zinc (Zn) - SEM	µmol/dry g	0.0015	0.003	0.0696	0.0494	0.0379	0.0256	0.0533	0.0557	0.058	0.0841	0.0423
∑SEM[1]	µmol/dry g	-	-	0.165	0.099	0.068	0.036	0.125	0.109	0.142	0.211	0.094
Acid Volatile Sulfides	mg/dry kg	0.05	0.1	1.46	1.37	1.09	0.9	2.01	1.03	1.16	1.52	1.01
Acid Volatile Sulfides	µmol/dry g	0.002	0.003	0.046	0.043	0.034	0.028	0.063	0.032	0.036	0.047	0.031
∑SEM:AVS	ratio	-	-	3.63	2.32	2.01	1.27	2.00	3.40	3.94	4.45	2.97

[1] ∑SEM = sum (Cd + Cu + Pb + Ni + (Ag/2) + Zn): if ND, then 1/2 MDL used

∑SEM:AVS = >1, indicating potential for metal toxicity due to presense of unbound, ionized metal

Organochlorine Pesticides/PCBs

Unlike PAHs, organochlorine pesticides and polychlorinated biphenyls (PCBs) are solely anthropogenic in origin. Dichlorodiphenyltrichloroethane (DDT) is the first and one of the most renowned chlorinated organic insecticides. Dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyldichloroethane (DDD) are the major metabolites and breakdown products of DDT in the environment. In the 1970s and 1980s, applications of DDT were banned in most developed countries although its limited use in disease vector control continues in certain parts of the world where malaria persist (Larson, 2007). While the DDT family is the best known organochlorine pesticide, it is only one of a large number of related compounds used for a variety of pest control needs.

Due to their chemical stability and nonflammable properties, PCBs are valuable as coolants and insulating fluids for transformers and capacitors, stabilizing additives in flexible PVC coatings of electrical wiring and electronic components, pesticide extenders, cutting oils, flame retardants, hydraulic fluids, sealants, adhesives, wood finishes, paints, aspirating agents, and in carbonless copy paper. There are theoretically 209 different PCB congeners, although only about 130 of these were found in commercial PCB mixtures. Aroclor is the trade name of commercial PCB mixture marketed in the USA and UK from the 1930s until its ban in the 1970s. Commercial PCBs are known to be contaminated with levels of other significantly toxic compounds such as dioxins and furans through partial oxidation. Concentrations of 31 individual organochlorine pesticides, 53 PCB congeners and 7 unique Aroclor PCB mixtures were analyzed in sediments from this study and presented in Table 15.

North Alternative
Chlorinated pesticides and PCBs analyzed in sediment samples from Stations 1, 2 and 3 located in the North Alternative study area were non-detectable below the laboratory MDL. The homogeneity of chlorinated pesticides and PCBs measured across Stations 1, 2 and 3 in the North Alternative area suggests that any of these locations would be suitable for the placement of an ODMDS.

Northwest Alternative
Chlorinated pesticides and PCBs analyzed in sediment samples from Stations 6, 7 and 8 located in the Northwest Alternative study area were non-detectable below the laboratory MDL. The homogeneity of chlorinated pesticides and PCBs measured across Stations 6, 7 and 8 in the Northwest Alternative area suggest that any of these locations would be suitable for the placement of an ODMDS.

Inshore/Proposed eference Sites
Chlorinated pesticides and PCBs analyzed sediment samples from Stations 4 and 9 located inshore of the two alternative areas, as well as the proposed reference site located at Station 5, were non-detectable below the laboratory MDL. The homogeneity of chlorinated pesticides and PCBs measured at Station 5 as compared to other inshore stations in this study, suggests that this would be an appropriate reference site.

Organotins

Organotin compounds or stannanes have no known natural sources and therefore have exclusively anthropogenic origins. These compounds are used in plastics manufacturing, as wood preservatives, slimicides, and disinfectants. Organotins are also potent biocides for cooling systems, power station cooling towers, pulp and paper mills, breweries, leather processing, textile mills and marine antifouling paints. The environmentally toxic biocidal properties of organotins are unique to tributyltin (TBT). The monobutyl- and dibutyltins do not exhibit these properties. Tetrabutyltins are very stable molecules that are also unusable as biocides, but can be metabolized into TBT compounds by microorganisms. Controls on the use of TBT in antifouling paints were introduced in 1986 when the sale of TBT-based paints was banned. In 1987, the use of TBT-based paints on boats under 25 meters and mariculture equipment was also prohibited. These measures have reduced the potential routes of entry into the marine environment

and successfully reduced environmental concentrations (Waite et al., 1991). Organotins have a low water solubility and a strong tendency to adsorb strongly to suspended materials and sediments (Laughlin et al., 1986). Organotins were analyzed in sediments from this study and presented in Table 15.

North Alternative
Organotins analyzed in sediment samples from Stations 1, 2 and 3 located in the North Alternative study area were non-detectable below the laboratory MDL of 1 ng/dry g. The homogeneity of organotins measured across Stations 1, 2 and 3 in the North Alternative area suggests that any of these locations would be suitable for the placement of an ODMDS.

Northwest Alternative
Organotins analyzed in sediment samples from Stations 6, 7 and 8 located in the Northwest Alternative study area were non-detectable below the laboratory MDL of 1 ng/dry g. The homogeneity of organotins measured across Stations 6, 7 and 8 in the Northwest Alternative area suggests that any of these locations would be suitable for the placement of an ODMDS.

Inshore/Proposed Reference Site
Organotins analyzed in sediment samples from Stations 4 and 9 located inshore of the two alternative areas, as well as the proposed upstream reference site located at Station 5, were non-detectable below the laboratory MDL of 1 ng/dry g. The homogeneity of organotins measured at Station 5 as compared to other inshore stations in this study, suggests that this would be an appropriate reference site.

Dioxins/Furans
The general term 'dioxins' is often used for a family of 210 structurally and chemically related polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and even some PCBs. Dioxins and furans are chemical compounds inadvertently generated and released into the environment as by-products of various combustion and chemical processes involving chlorine including smelting, waste incineration, plastic production, pulp and paper bleaching, and the manufacturing of chemicals and pesticides such as PCBs. They can also result from natural processes such as volcanic eruptions and forest fires. Low levels of dioxins and furans are expected in the environment due to natural sources, or the dechlorination of chlorinated pesticides due to biological or abiotic processes (Gaus *et al*. 2002 and Holt *et al*. 2008). The most toxic chemical in the group is 2,3,7,8-tetrachlorodibenzo-para-dioxin (2,3,7,8-TCDD); it should be noted that 2,3,7,8-TCDD was estimated at values below the MDL in the sediment samples collected from both alternative ODMDS. Because it is the most toxic, 2,3,7,8-TCDD is the standard to which other dioxins are compared. Furans are about a tenth as toxic while 12 of the 209 congeners of PCBs are about one hundredth as toxic (Eisler, 1986). Although formation of dioxins is localized, environmental distribution is global due to its hydrophobic and lipophilic properties. The highest levels of dioxins are found in soil, sediment and the fatty tissues of animals, with much lower levels found in plants, water and air. Complex mixtures of 17 family member dioxin and furan compounds were analyzed in sediments from this study and presented in Table 15. For each analyte that was not detected, an Estimated Detection Limit (EDL) was calculated. The EDL is a sample specific, laboratory estimate of the minimum analyte concentration required to produce a signal with a peak height of at least 2.5 times the background noise signal level. Because of the toxicological significance of dioxins and furans, the EDL value is reported for non-detected analytes rather than simply reporting the respective MDLs.

North Alternative
Dioxins and furans analyzed in sediment samples from Stations 1, 2 and 3 located in the North Alternative study area were detected in low concentrations. The sum of all detectable dioxins had an average of 19.66 pg/g with a range of 17.51 pg/g at Station 2 to 22.49 pg/g at Station 1. The sum of all detectable furans had an average of 2.50 pg/g with a range of 2.00 pg/g at Station 3 to 3.49 pg/g at Station 1 (Table 17 and Figure 39). Analysis of dioxins and furans using the Dixon's Test established no relative

difference in the dioxin concentration of sediment between stations located in the North Alternative ODMDS study area. Furan concentration was slightly higher at Station 1 (3.49 pg/g) than Stations 2 (2.02 pg/g) and 3 (2.00 pg/g). The homogeneity of dioxins and furans measured across Stations 1, 2 and 3 in the North Alternative area suggests that any of these locations would be suitable for the placement of an ODMDS.

Northwest Alternative

Dioxins and furans analyzed in sediment samples from Stations 6, 7 and 8 located in the Northwest Alternative study area were detected in low concentrations. The sum of all detectable dioxins had an average of 18.33 pg/g with a range of 16.19 pg/g at Station8 to 19.47 pg/g at Station 6 (Table 17 and Figure 39). The sum of all detectable furans had an average of 2.20 pg/g with a range of 1.17 pg/g at Station 8 to 3.65 pg/g at Station 6. Analysis of dioxins and furans using the Dixon's Test established no relative difference in the furan concentration of sediment between stations located in the Northwest Alternative ODMDS study area. Dioxin concentration was slightly lower at Station 8 (16.19 pg/g) than Stations 6 (19.47 pg/g) and 7 (19.34 pg/g). The homogeneity of dioxins and furans measured across Stations 6, 7 and 8 in the Northwest Alternative area suggests that any of these locations would be suitable for the placement of an ODMDS.

Inshore/Proposed Reference Site

Dioxins and furans analyzed in samples from Stations 4 and 9 located inshore of the two alternative areas, as well as the proposed upstream reference site located at Station 5, were detected in low concentrations. The sum of all detectable dioxins had an average of 21.12 pg/g with a range of 17.73 pg/g at Station 9 to 26.98 pg/g at Station 5 (Table 17 and Figure 39). The sum of all detectable furans had an average of 3.03 pg/g with a range of 1.47 pg/g at Station 9 to 5.10 pg/g at Station 5. Analysis of dioxins and furans using the Dixon's Test established no relative difference in the dioxin and furan concentration of sediment between stations located in inshore study area including the proposed upstream reference site. The homogeneity of dioxins and furans measured at Station 5 as compared to other inshore stations in this study, suggests that this would be an appropriate reference site.

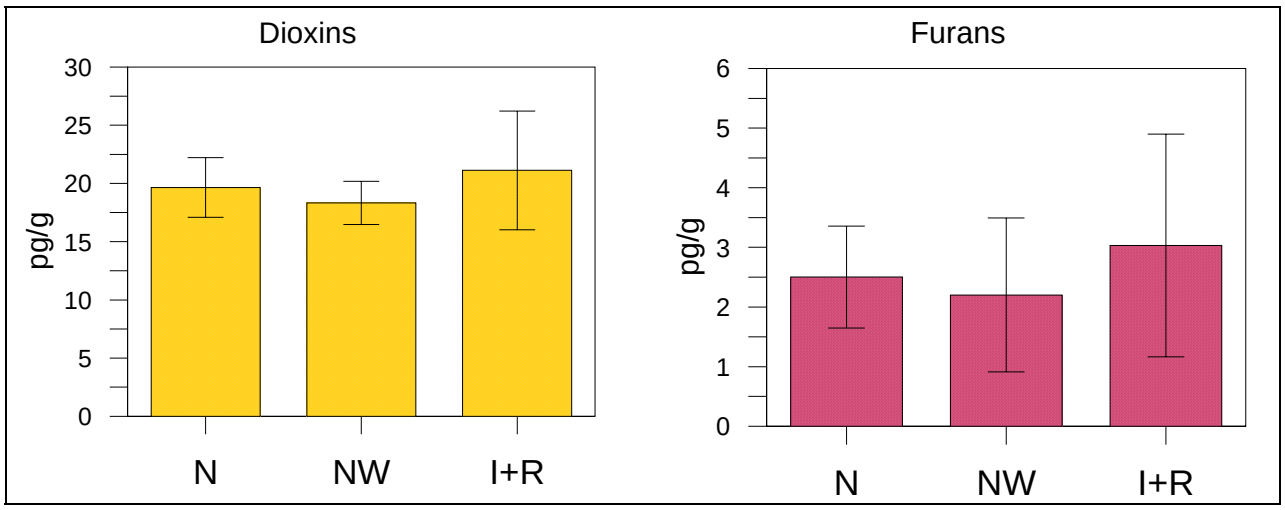

Figure 39. Mean and Standard Deviation of Dioxins and Furans Showing Comparison of Alternative Areas to Each Other and Proposed Reference

Table 17. Calculated Sum Total Dioxins (CDD) and Furans (CDF) for Sediment Samples Collected Offshore of Guam

Analyte	Units	MDL	RL	Station ID								
				GO 1	GO 2	GO 3	GO 4	GO 5	GO 6	GO 7	GO 8	GO 9
Total Tetra CDD	pg/g	-	-	< 0.30 (1)	0.2	< 0.27 (1)	0.34	< 0.33 (1)	< 0.34 (1)	0.3	< 0.12	< 0.092
Total Penta CDD	pg/g	-	-	4.92	2.18	3.46	2.21	2.67	3.25	1.47	2.4	2.56
Total Hexa CDD	pg/g	-	-	0.85	< 2.1 (1)	< 2.0 (1)	< 1.9 (1)	< 2.4 (1)	0.95	0.17	< 1.8 (1)	0.27
Total Hepta CDD	pg/g	-	-	2.62	1.73	2.14	2.3	1.48	2.33	1.6	0.47	1.61
Octa CDD	pg/g	5.00	100	13.8	11.3	11.1	11.9	20.1	12.6	15.8	11.4	13.2
∑CDD[1]	pg/g			22.49	17.51	18.97	18.65	26.98	19.47	19.34	16.19	17.73
Total Tetra CDF	pg/g	-	-	0.34	0.45	0.43	0.52	0.69	0.42	0.52	0.39	0.25
Total Penta CDF	pg/g	-	-	< 0.90 (1)	< 0.23 (1)	< 0.18 (1)	< 0.24 (1)	< 0.41 (1)	< 1.2 (1)	< 0.25 (1)	< 0.11	< 0.14 (1)
Total Hexa CDF	pg/g	-	-	< 0.22	0.2	0.2	< 0.19	0.55	0.68	0.13	< 0.12 (1)	< 0.23 (1)
Total Hepta CDF	pg/g	-	-	0.84	< 0.48 (1)	< 0.54 (1)	< 0.87 (1)	< 1.9 (1)	< 0.71 (1)	< 0.26 (1)	< 0.20 (1)	0.28
Octa CDF	pg/g	5.00	100	1.19 J	0.66 J	0.65 J	0.71 J	1.55 J	0.64 J	0.63 J	0.35 J	0.57 J
∑CDF[2]	pg/g			3.49	2.02	2.00	2.53	5.10	3.65	1.79	1.17	1.47

[1] ∑CDD = sum (Total Tetra CDD + Total Penta CDD + Total Hexa CDD + Total Hepta CDD + Octa CDD) if ND, then sample-specific laboratory EDL used

[2] ∑CDD = sum (Total Tetra CDF + Total Penta CDF + Total Hexa CDF + Total Hepta CDF + Octa CDF) if ND, then sample-specific laboratory EDL used

J = estimated value above the MDL and below the RL

(1) EMPC / NDR - Peak detected does not meet ratio criteria and has resulted in an elevated detection limit.

Gross Alpha/Beta

Radioactive nuclei can emit several kinds of particles that can be classified into three primary types: alpha particles (α), beta particles (β), and photons that are either x rays or gamma rays (γ). For the purposes of this study, gross alpha- and beta-emitting radionuclides were characterized to screen samples for relative levels of radioactivity.

Several properties distinguish alpha and beta particles from one another. One is electric charge; alpha particles are emitted with a positive charge of two, beta particles are emitted with either one negative charge (electron) or one positive charge (positron). Another important property is penetration of the particles through matter. Alpha particles lose energy rapidly and travel relatively slowly due to their electric charge and large mass. Beta particles can travel several feet in open air but are easily stopped by solid materials. Alpha and beta emitters have anthropogenic sources and occur naturally in the environment, present in varying amounts in nearly all rocks, soils, and water. Gross alpha and gross beta radiation were analyzed in sediments from this study and presented in Table 15 and Figure 40.

North Alternative

Alpha and beta particle activity analyzed in sediment samples from Stations 1, 2 and 3 located in the North Alternative study area were detected in low concentrations. Gross alpha had an average of 9.70 pCi/g with a range of 7.02 pCi/g at Station 3 to 12.4 pCi/g at Station 1. Gross beta had an average of 4.96 pCi/g with a range of 0.90 pCi/g at Station 3 to 6.19 pCi/g at Station 1. Analysis of gross alpha and beta using the Dixon's Test established no relative difference in alpha and beta-particle activity of sediment between Stations located in the North Alternative study area. The homogeneity of gross alpha and beta measured across Stations 1, 2 and 3 in the North Alternative area suggests that any of these locations would be suitable for the placement of an ODMDS.

Northwest Alternative

Alpha and beta particle activity analyzed in sediment samples from Stations 6, 7 and 8 located in the Northwest Alternative study area were detected in low concentrations. Gross alpha had an average of 11.5 pCi/g with a range of 10.8 pCi/g at Station 7 to 12.10 pCi/g at Station 6. Gross beta had an average of 3.31 pCi/g with a range of 1.61 pCi/g at Station 8 to 5.86 pCi/g at Station 6. Analysis of gross alpha and beta using the Dixon's Test established no relative difference in alpha and beta-particle activity of sediment between stations located in the Northwest Alternative ODMDS study area. The homogeneity of gross alpha and beta measured across Stations 6, 7 and 8 in the Northwest Alternative area suggests that any of these locations would be suitable for the placement of an ODMDS.

Inshore/Proposed Reference Site

Alpha and beta particle activity analyzed in samples from Stations 4 and 9, located inshore of the two alternative areas, as well as the proposed upstream reference site located at Station 5, were detected in low concentrations. Gross alpha had an average of 9.51 pCi/g with a range of 6.45 pCi/g at Station 5 to 12.4 pCi/g at Station 9. Gross beta had an average of 2.86 pCi/g with a range of 2.17 pCi/g at Station 5 to 3.67 pCi/g at Station 4. Analysis of gross alpha and beta using the Dixon's Test established no relative difference in alpha and beta-particle activity of sediment between stations located in inshore study area including the proposed upstream reference site. The homogeneity of gross alpha and beta measured at Station 5 as compared to other inshore stations in this study, suggests that this would be an appropriate reference site.

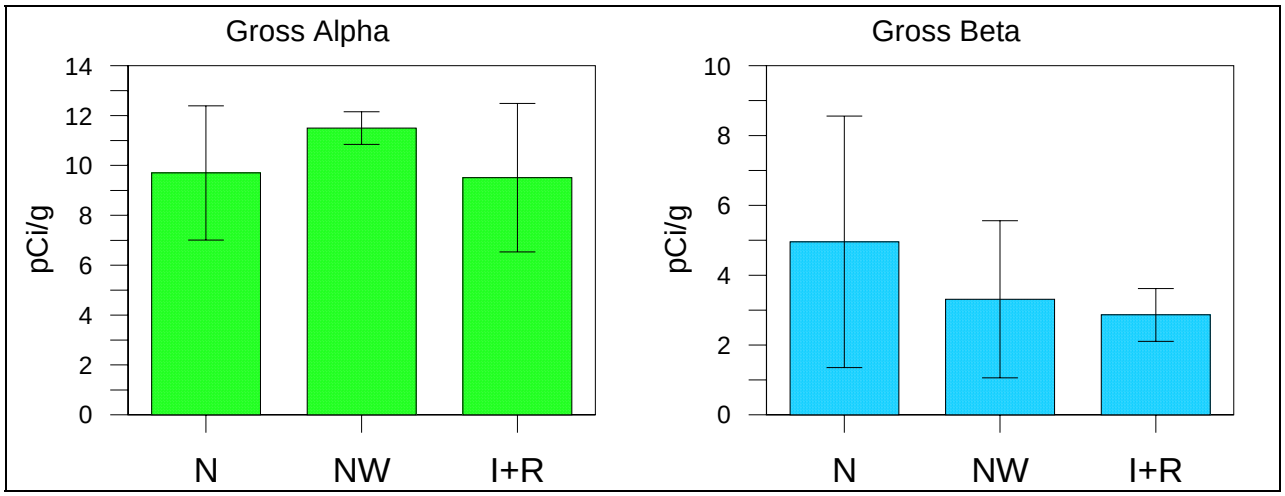

Figure 40. Mean and Standard Deviation of Gross Alpha and Gross Beta Showing Comparison of Alternative Areas to Each Other and Proposed Reference

Sediment Characteristics Summary

In general, the physical, conventional, chemical, and radiological characteristics of sediments collected from stations located in the North and Northwest Alternative ODMDS study areas are similar with the exception of grain size and few trace metals. Sediment samples from Stations 6, 7 and 8, located in the Northwest Alternative area, were finer than those from Stations 1, 2 and 3 located in the North Alternative area. The foremost reason for this difference in grain size can be attributed to the contrast in seafloor location of these study areas. Bathymetry charts show that stations in the Northwest Alternative area are located on the southeastern slope of a seamount whereas stations in the North Alternative area are located in a depression between seamounts. Mean concentrations of cadmium, chromium, mercury, nickel, and zinc were similar in both ODMDS alternative areas. While slightly higher mean concentrations of silver, arsenic, copper, and lead were measured in sediment samples from Stations 6, 7 and 8 located in the Northwest Alternative. Most persistent organic pollutants were non-detectable below the laboratory MDL.

4.2 Biological Environment

4.2.1 Invertebrate Community

4.2.1.1 Macrofauna

Benthic macroinfauna are small invertebrates that live within sediments and can be retained on a 0.5-mm sieve. They are important marine ecological community members because they burrow within and oxygenate sediments, can filter large volumes of water, contribute organics, and serve as food for bottom-feeding fish and other invertebrates.

Benthic infauna data from each of the study areas were assessed using various indices common to ecological community structure evaluations, including composition (species present), density (number of individuals/m^2), species richness (number of species) and the Shannon-Wiener species diversity index (number of different species relative to the total number of individuals; weighted for evenness of species composition). A cluster analysis was also performed to determine similarities between species assemblages of invertebrate macroinfauna among stations. The benthic infaunal communities were characterized for the North Alternative ODMDS (Stations 1, 2, and 3), Northwest Alternative ODMDS (Stations 6, 7, and 8), and the sample stations located inshore of the two alternative areas (Stations 4 and 9), including the proposed reference site (Station 5) Three replicate samples were taken at each of the stations within a study area. Table 18 presents species and abundance data by station. It should be noted that large quantities of foraminifera (both living specimens and empty shells) were present in all of the samples.

Table 18. Macrofaunal Species List and Abundance with Respect to Sampling Station, Offshore of Guam

Species	Station 1			Station 2			Station 3			Station 4			Station 5			Station 6			Station 7			Station 8			Station 9		
	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3
Arthropoda																											
Anthuridae sp GU1		1																									
Apseuromorpha sp GU1											1		1	2													
Calanoida																			1		1						
Corophioidea sp GU1								1																			
Eurycopidae															1												
Gammaridea sp GU1														1													
Harpactocoida								2							1												
Insecta																		1								1	
Lysianassidae sp GU4				1																							
Mysidacea																			1								
Paramunnidae sp GU1																1											
Tanaidacea																					2	1					
Tanaidacea sp GU1			1											1													
Tanaidacea sp GU2										1									1								
Tanaidacea sp GU3								1						1													
Tanaidacea sp GU4														1													
Tanaidacea sp GU5															1												
Tanaidacea sp GU6															1												
Tanaidacea sp GU7																	1										
Tanaidacea sp GU8																							1				
Tanaidacea sp GU9																					1						
Zoea/Megalopa																	2		1								
Arthropoda Total		1	1	1				4		1	1		1	6	4	1	3	1	4		4	1	1			1	
Chordata																											
Ascidiacea, cf Molgula sp			1																								
Chordata Total			1																								
Cnidaria																											
Bougainvilliidae (Hydrozoa)				1																							
Cnidaria Total				1																							
Echiura																											
Echiura											1																
Echiura Total											1																
Ectoprocta																											
Ectoprocta												1															
Ectoprocta Total												1															
Mollusca																											
Ledellina sp GU1								1																			
Nuculanoidea			1																								

Species	Station 1			Station 2			Station 3			Station 4			Station 5			Station 6			Station 7			Station 8			Station 9		
	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3
Odostomia sp				1																							
Ostreidae				1																							
Pelecypoda													1														
Mollusca Total			1	2				1					1														
Nematoda																											
Nematoda			6	5	2	2	1		1	1	1			1	1	3	3	2		3	6	1	1		1		2
Nematoda Total			6	5	2	2	1		1	1	1			1	1	3	3	2		3	6	1	1		1		2
Nemertea																											
Nemertea											1													2			
Nemertea Total											1													2			
Phorona																											
Phoronida					2																						
Phorona Total					2																						
Polychaeta																											
?Glycinde sp	2	1	1		1																						
?Notomastus sp														1							1					1	1
?Sabellidae															4												
?Serpula sp																									1		
?Spiochaetopterus sp																			1								
Ampharetidae				1	1	1	1		2				1		3	1		1	2		1			1		1	
Ampharetidae sp 1									1		1			1										1			
Aricidea (Acmira) nr. rubra	2																										
Aricidea sp																							1				
Capitellidae										1									1						1		
Caulleriella sp																											1
Cirratulidae										1							1	1				1			1	1	
Eteone sp		1			1						1																
Euclymeninae					1					1			1	1	1			1									
Exogone sp 1							1									1						1					
Glycera sp					1											1									1		
Goniada sp	1																1	1	1			1				1	1
Hesionidae			1				1																				
Hesiosyllis sp																	1										
Longisomatidae																			1	1							
Lumbrineridae		1							1										1								
Lumbrineris sp										1																	
Magelona sp																							1				
Maldanidae											1			2		1			1	1	1						
Mediomastus sp	1																										
Melinna sp	1																										
Neomediomastus sp	1																										
Nereididae		1																					1				

Species	Station 1			Station 2			Station 3			Station 4			Station 5			Station 6			Station 7			Station 8			Station 9		
	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3	REP 1	REP 2	REP 3
Oligochaeta	1																										
Opheliidae							1																				
Oweniidae				1					1								1									1	
Paradiopatra sp 1	1	1			2	1							1			1			1	1			1	1			2
Paradoneis sp		1	1												1												
Paraonidae				1											1	1											
Poecilochaetus sp						1								1													
Sabidius sp 1							1				1																
Spionidae		2	1							1				2				1									1
Sthenolopis sp 1			1								1			1						1							
Travisia sp 1		2	2				2		1	2			3	6	3	1	2	3							2	1	
Polychaeta Total	10	10	7	3	7	3	7		6	7	5		6	15	13	7	6	8	9	4	3	3	4	3	7	5	6
Sipuncula																											
Nephasoma sp				2		1				1				8											1		
Sipuncula									1		1																
Sipuncula Total				2		1			1	1	1			8											1		
Total Abundance	10	11	16	14	11	6	8	5	8	10	10	1	8	30	18	11	12	11	13	7	13	5	6	5	9	6	8

North Alternative

At Station 1, the density per replicate ranged from 16 individuals/m^2 in Rep 1 to 26 individuals/m^2 in Rep 3 (Table 19). Species richness ranged from 8 species in Rep 1 to 10 species in Rep 3. The Shannon-Wiener species diversity ranged from 2.01 in Rep 3 to 2.15 in Rep 2.

At Station 2, the density per replicate ranged from 10 individuals/m^2 in Rep 3 to 22 individuals/m^2 in Rep 1 (Table 19). Species richness ranged from 5 species in Rep 3 to 9 species in Rep 1. The Shannon-Wiener species diversity ranged from 1.56 in Rep 3 to 2.02 in Rep 2.

At Station 3, the density per replicate ranged from 8 individuals/m^2 in Rep 2 to 13 individuals/m^2 in Reps 1 and 3 (Table 19). Species richness ranged from 4 species in Rep 2 to 7 species in Reps 1 and 3. The Shannon-Wiener species diversity ranged from 1.33 in Rep 2 to 1.91 in Reps 1 and 3.

In summary, a total of 37 different species were collected in the North Alternative area. Station 3 had the lowest density of organisms and diversity while Station 1 had the highest. Polychaetes dominated the benthic populations at Stations 1 and 3 while Station 2 was comprised of a mix of polychaetes and miscellaneous phyla (Table 19). Overall, crustaceans and molluscs were in low abundance. Echinoderms were absent at all of the stations.

Table 19. Macrofauna Community Composition in the North Alternative Area

Parameter	North Alternative Site											
	Station GO1				Station GO2				Station GO3			
	Rep 1	Rep 2	Rep 3	Mean	Rep 1	Rep 2	Rep 3	Mean	Rep 1	Rep 2	Rep 3	Mean
Density (number/m^2)	16	18	26	20	22	18	10	17	13	8	13	11
Species Richness (# of species)	8	9	10	9	9	8	5	7	7	4	7	6
Shannon-Wiener diversity	2.03	2.15	2.01	2.06	1.97	2.02	1.56	1.85	1.91	1.33	1.91	1.72
% Polychaetes	100	91	44		22	64	50		88	0	75	
% Crustaceans	0	9	6		7	0	0		0	80	0	
% Molluscs	0	0	6		14	0	0		0	20	0	
% Echinoderms	0	0	0		0	0	0		0	0	0	
% Misc. Phyla	0	0	44		57	36	50		12	0	25	

Northwest Alternative

At Station 6, the density per replicate ranged from 18-19 individuals/m^2 and species richness ranged from 8-9 species in each of the replicates (Table 20). The Shannon-Wiener species diversity ranged from 1.97 in Rep 3 to 2.10 in Rep 1.

At Station 7, the density per replicate ranged from 11 individuals/m^2 in Rep 2 to 21 individuals/m^2 in Reps 1 and 3 (Table 20). Species richness ranged from 5 species in Rep 2 to 12 species in Rep 1. The Shannon-Wiener species diversity ranged from 1.48 in Rep 2 to 2.46 in Rep 1.

At Station 8, the density per replicate ranged from 8-10 individuals/m^2 and species richness ranged from 4-6 species in each of the replicates (Table 20). The Shannon-Wiener species diversity ranged from 1.33 in Rep 3 to 1.79 in Rep 2.

In summary, a total of 30 different species were collected in the Northwest Alternative area. Station 8 had the lowest densities of organisms and diversity. Stations 6 and 7 had similar values. At all of the stations, the majority of the benthic populations were comprised of polychaetes (Table 20). There were no molluscs or echinoderms present in any of the stations.

Table 20. Macrofauna Community Composition in the Northwest Alternative Area

Parameter	Northwest Alternative Site											
	Station GO6				Station GO7				Station GO8			
	Rep 1	Rep 2	Rep 3	Mean	Rep 1	Rep 2	Rep 3	Mean	Rep 1	Rep 2	Rep 3	Mean
Density (number/m^2)	18	19	18	18	21	11	21	18	8	10	8	9
Species Richness (# of species)	9	8	8	8	12	5	7	8	5	6	4	5
Shannon-Wiener diversity	2.10	1.98	1.97	2.02	2.46	1.48	1.63	1.86	1.61	1.79	1.33	1.58
% Polychaetes	64	50	73		69	57	23		60	67	60	
% Crustaceans	9	25	9		31	0	31		20	17	0	
% Molluscs	0	0	0		0	0	0		0	0	0	
% Echinoderms	0	0	0		0	0	0		0	0	0	
% Misc. Phyla	27	25	18		0	43	46		20	16	40	

Inshore/Proposed Reference Site

At Station 4, the density per replicate ranged from 2 individuals/m^2 in Rep 3 to 16 individuals/m^2 in Reps 1 and 2 (Table 21). Species richness ranged from 1 species in Rep 3 to 10 species in Rep 2. The Shannon-Wiener species diversity ranged from 0 in Rep 3 to 2.30 in Rep 2.

At Station 9, the density per replicate ranged from 10 individuals/m^2 in Rep 2 to 14 individuals/m^2 in Rep 1 (Table 21). Species richness ranged from 6-8 species in each of the replicates. The Shannon-Wiener species diversity ranged from 1.73 in Rep 3 to 2.04 in Rep 1.

At Station 5, the proposed reference site, the density per replicate ranged from 13 individuals/m^2 in Rep 1 to 48 individuals/m^2 in Rep 2 (Table 21). Species richness ranged from 6 species in Rep 1 to 15 species in Rep 2. The Shannon-Wiener species diversity ranged from 1.67 in Rep 1 to 2.35 in Rep 2.

In summary, a total of 35 different species were collected in the stations located inshore of the two alternative areas, including the proposed reference site. Stations 4 and 9 had similar organism densities and species richness; however, Station 4 had a slightly lower diversity than Station 9. Station 5, the proposed reference site, had the highest organism density and species diversity with a mean value of 30 and 2.08, respectively. Polychaetes comprised the majority of species at all of the stations (Table 21). No molluscs were present at Station 4 or 9 and only one Pelecypoda was found at Station 5. Echinoderms were absent from all of the stations from this study area.

Table 21. Macrofauna Community Composition at the Inshore and Proposed Reference Site Stations

Parameter	Inshore/Proposed Reference Site											
	Station GO4				Station GO5				Station GO9			
	Rep 1	Rep 2	Rep 3	Mean	Rep 1	Rep 2	Rep 3	Mean	Rep 1	Rep 2	Rep 3	Mean
Density (number/m^2)	16	16	2	11	13	48	29	30	14	10	13	12
Species Richness (# of species)	9	10	1	7	6	15	11	32	8	6	6	7
Shannon-Wiener diversity	2.16	2.30	0.00	1.49	1.67	2.35	2.22	2.08	2.04	1.79	1.73	1.85
% Polychaetes	70	50	0		75	50	72		78	83	75	
% Crustaceans	10	10	0		13	20	22		0	17	0	
% Molluscs	0	0	0		12	0	0		0	0	0	
% Echinoderms	0	0	0		0	0	0		0	0	0	
% Misc. Phyla	20	40	100		0	30	6		22	0	25	

Regional Summary

Results of the cluster analysis, an assessment to determine the degree of similarity of macrofauna species assemblages amongst stations, indicate that there was no difference in species composition between the North and Northwest Alternative areas (Figure 41). Further, the results show the proposed reference site had similar macrofauna assemblages to the North and Northwest Alternative areas, suggesting that this is a suitable reference site.

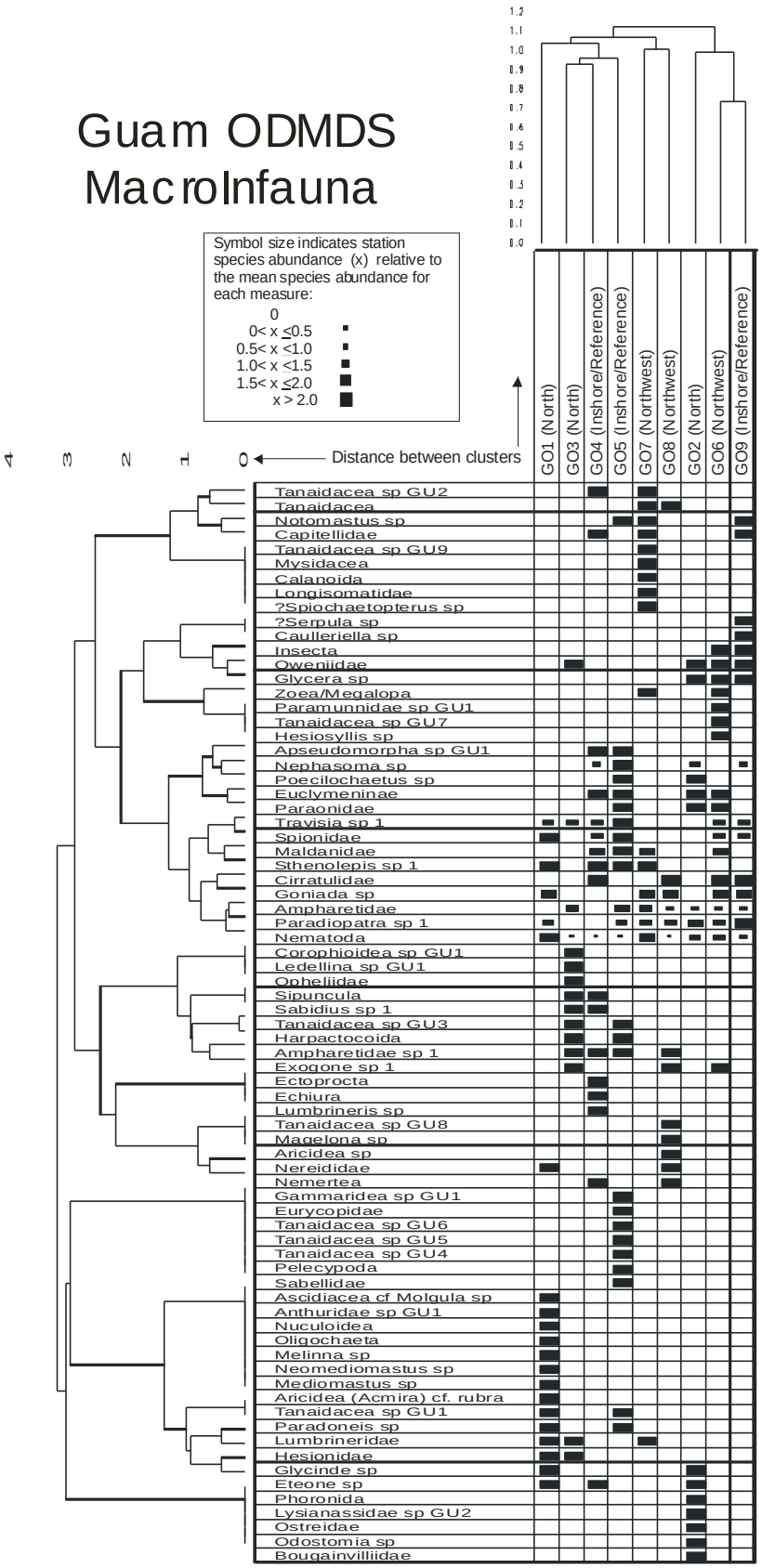

Figure 41. Results of Cluster Analysis Showing Similarities in Species Composition Among Stations within Alternative Areas.

4.2.1.2 Meiofauna

Benthic meiofauna are described as small organisms that live within the sediment and can be retained on a 63-µm sieve, but pass through a 0.5-mm sieve. Nematodes and harpactacoid copepods make up the majority of meiofauna; therefore, the presence of only these two taxa were accounted for in the samples. The benthic meiofauna communities were characterized for the North Alternative ODMDS (Stations 1, 2, and 3), Northwest Alternative ODMDS (Stations 6, 7, and 8), and the sample stations located inshore of the two alternative areas (Stations 4 and 9), including the proposed reference site (Station 5). Two replicate samples were taken at each of the stations within a study area.

North Alternative
At Station 1, Rep 3, one nematode was found. There were no harpactacoid copepods in the sediment sample collected at Station 1. No meiofaunal nematodes or harpactacoid copepods were present at Stations 2 or 3.

Northwest Alternative
No meiofaunal nematodes or harpactacoid copepods were present at Stations 6, 7, or 8.

Inshore/Proposed Reference Site
No meiofaunal nematodes or harpactacoid copepods were present at Stations 4, 5, or 9.

Regional Summary
Meiofaunal organisms were absent throughout all of the study areas, with the exception of Station 1 in the North Alternative study site. Only one nematode was found in this station. In addition to the absence of nematodes and harpactacoid copepods in the majority of the samples, it must be noted that when the samples were analyzed there were no other meiofaunal organisms present. Similar to the macroinfauna samples, there were large quantities of foraminifera (both living specimens and empty shells) present in all of the samples.

4.2.2 Fish Community

4.2.2.1 Deep-Sea Demersal Species

The demersal fish community in the deep offshore environment was assessed using three gear types: beam trawl, traps, and photography. All specimens collected by trawl and traps were retained for identification to species level by Scripps Institution of Oceanography scientists. Fish images in photographs and video were generally unable to be identified to an advanced taxonomic level. These typically fell into two morphological types that were referred to as Ophidiiform (e.g., cuskeels that are relatively short and "tadpole" shaped, often with a bulbous head) and Anguilliform (e.g., true eels that are long and slender). The following sections provide brief descriptions of the specimens collected during the Site Characterization Study conducted in April 2008. Copies of the field log sheets for collected fish specimens are located in Appendix A.4.

Bassogigas gillii
This specimen is a type of fish commonly called a cuskeel, although it is not a true eel. The dorsal and ventral fins are continuous with the caudal fin. It may reach a size of at least 33.5 in (85 cm) and the deepest recorded depth of capture is 7,050 ft (2,150 m), although the specimen caught in this study likely came from a depth of about 8,530 ft (2,600 m). It has been collected from all major oceans and is considered uncommon (Smith and Heemstra, 1986; Nielsen et al., 1999)

Bathypterois longipes
This species is in a group of fishes commonly called tripod fish, so named for the elongated extensions of the pelvic and caudal fin which form a tripod on which the fish rests on the seafloor. This particular specimen is known as the abyssal spiderfish. Tripod fish swim very little, and feed by facing into the current and waiting for small planktonic organisms to contact its outstretched (and also elongated) pectoral fins. Maximum recorded size is 9.8 in (24.9 cm) and the depth range is 8,580 – 18,400 ft (2,615-5,610 m; Merrett, 1990)

Cyclothone pallida
The genus *Cyclothone* is one of the most abundant of all types of fishes and is estimated to be the most abundant vertebrate genus in the world. The common name of bristlemouth is derived from the presence of numerous fine teeth. Its maximum size is about 3 in (75 mm) and has a very large mouth and several rows of photophores (bio-luminescent spots) along the body. *Cyclothone pallida* is found in all major oceans. *Cyclothone* typically live in the 1,300 – 3,300 ft (400-1,000 m) mesopelagic depth range, although they may be found much deeper. The specimens collected by beam trawl in this study were likely captured in the water column while the net was being deployed or retrieved, as opposed to while it was on the ocean floor (Smith & Heemstra, 1996; Gon, 1990)

Eptatretus carlhubbsi
The giant hagfish *Eptatretus carlhubbsi* is the largest known hagfish. In the order Myxiniforme, hagfish are primitive jawless fishes that are unique in that they have a cranium but lack a vertebral column. Colloquially known as "slime eels" the fish is known for its ability to produce copious amounts of slime when agitated. The largest recorded size for the species is 46 in (116 cm) and the deepest recorded depth is 5,160 ft (1,574 m; Fernholm, 1998). The largest specimen collected in this study was 50 in (127 cm) and two smaller specimens were collected at a depth of about 8,530 ft (2,600 m) at Station 6.

Tauredophidium hextii
This uncommon species of cuskeel is quite unique in that it has three long spines on the operculum, has no eyes, and is the only species in the genus *Tauredophidium*. The specimen collected was a gravid adult female near the maximum recorded size of 4 in (10.5 cm). The recorded depth range for the fish is from 4,920 – 8,725 ft (1,500-2,660 m), while the trawl depth in this study ranged from 8,740 – 8,900 ft (2,665-2,713 m; Nielsen et al., 1999)

North Alternative

Beam Trawl
Beam trawl sampling in the North Alternative area was performed at Station 2 and Station 3. The trawls collected a total of three fish, including one tripod fish (*Bathypterois longipes*) and one Stomiiforme that was too damaged to be identified further. The Stomiiforme is a mid-water column organism (Appendix A.4).

Fish Traps
The fish traps that were set in the North Alternative area were limited to Station 1. A total of two giant hagfish (*Eptatretus carlhubbsi*) were collected (Appendix A.4).

Photo Surveys
The stations in the North Alternative area had a total of five fish observed by camera, all of which were at Station 1. There were at least three different species observed, including three individual Ophidiiform (cuskeel) specimens, one Anguilliform (probably family Halosauridae: *Aldovandria* sp., deep sea spiny eel), and one specimen that was possibly a small shark or an Ophidiiform, with very large horizontally positioned pectoral fins.

Northwest Alternative

Beam Trawl

Beam trawl sampling in the Northwest Alternative area was performed at Station 6 and 8, and collected a total of five fish. At Station 6, one relatively large demersal cuskeel (*Bassogigas gillii*) was collected as well as three water column bristlemouths (*Cyclothone pallida*). At Station 8 one small Ophidiiform was collected (Appendix A.4).

Fish Traps

Fish traps in the Northwest Alternative area collected two hagfish. One was identified as a giant hagfish while the other was too immature and damaged to be identified beyond family Myxinidae (Appendix A.4).

Photo Surveys

The stations in the Northwest Alternative area had a total of five fish observed by camera. All specimens were fairly small Ophidiiforms, with one photographed at Station 6, one photographed at Station 7, and three photographed at Station 8.

Inshore/Proposed Reference Site

Beam Trawl

Beam trawl sampling at the inshore stations and proposed reference station was performed at Station 9 and 5, respectively. At Station 9, one individual cuskeel (*Tauredophidium hextii*) was collected. Two attempts were made at trawling at Station 5, but both times the gear snagged on bottom obstructions, the equipment was damaged, and no fish were collected.

Fish Traps

Fish traps were not deployed at either of the inshore or proposed reference stations.

Photo Surveys

The stations in the inshore and proposed reference area had a total of four fish observed by camera. Station 5 had two relatively large Anguilliforms (probable *Aldovandria* sp.) and one Ophidiiform specimen photographed. Station 9 had one small Ophidiiform specimen photographed.

4.3 Toxicology

Results of the solid phase toxicity testing and bioaccumulation potential testing are presented in the following sections.

4.3.1 Solid Phase Testing

SP bioassays were performed to estimate the potential impact of ocean disposal of dredged sediment on benthic organisms that attempt to re-colonize the area. Results from the three separate rounds of bioassay tests are presented below. As stated previously, the first round consisted of composited sediment from the proposed reference location (Station 5), sediment from three individual grabs that comprised the composite, and laboratory control sediment. The second and third rounds consisted solely of composited sediment from the proposed reference location (Station 5). Each round was conducted using separate batches of test organisms.

4.3.1.1 Ampelisca abdita – Round 1

Water quality parameters were within the appropriate limits for the 10 day SP bioassay test using the amphipod, *Ampelisca abdita* (Table 22). Survival of *A. abdita* in the control treatment was 94 %, which met the 90 % minimum acceptable control survival criterion (Table 23). The survival of *A. abdita* in tests

using sediment from Areas G05-Comp, G05-Grab 7, GS0-Grab 11, and G05-Grab 14 was 92 %, 95 %, 89% and 89 %, respectively. The survivorship in all test sediments was within 20% of the control survival. None of the sediments were significantly different from the control based on the results of a one-way ANOVA and Dunnett's Multiple-Comparison Test. Detailed test results are presented in Appendix D.

The LC_{50} was 0.858 mg Cd^{2+}/L in the cadmium chloride reference toxicant test, using a control and nominal concentrations of 0.125, 0.250, 0.500, 1.00 and 2.00 mg Cd^{2+}/L. This value was within one standard deviation (± 0.251 mg Cd^{2+}/L) of the laboratory mean of 0.697 mg Cd^{2+}/L, indicating that the sensitivity of *A. abdita* used in test sediments fell within the normal range.

In the ammonium chloride reference toxicant test, LC_{50} values of 68.2 mg total NH_3/L and 2.50 mg un-ionized NH_3/L were determined from survivorship using a control and measured concentrations of 27.0, 52.5, 103, 202, and 365 mg total NH_3/L, and calculated unionized concentrations of 1.11, 2.15, 3.40, 3.32 and 3.83 mg un-ionized NH_3/L. The no observed effect concentration (NOEC) values (52.5 mg total NH_3/L and 2.15 mg un-ionized NH_3/L) were higher than interstitial and overlying ammonia concentrations measured in the SP test, indicating that ammonia was not expected to have contributed to any toxicity found in test area samples.

Table 22. Round 1 Test Conditions and Water Quality Results for the 10 Day Solid Phase Bioassay Using *A. abdita*.

Test Conditions 10 Day SP Bioassay		
Sample Identification		G05-Comp, G05-Grab 7, G05-Grab 11, G05-Grab 14
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L G05-Comp, 20L G05-Grab 7, 11, 14
Test Species		*Ampelisca abdita*
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); USEPA (1994)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Aquatic Research Organisms, Hampton, NH
Date Acquired		May 17, 2008
Acclimation/Holding Time		3 days
Age Class / Size Class		Immature
Test Location		Weston Solutions, Carlsbad, lab room 3, 20ºC
Test Dates		May 20 - 30, 2008
Actual Water Quality Measurements	Temperature	19.6º - 21.0ºC
	Salinity	27.1 - 29.9 ppt
	Dissolved Oxygen	6.4 - 8.5 mg/L
	pH	7.5 - 8.3
	Overlying Total Ammonia	< 0.5 - 0.73 mg/L
	Overlying Un-ionized Ammonia	< 0.007 - 0.030 mg/L
	Interstitial Total Ammonia	< 0.5 - 5.47 mg/L
	Interstitial Un-ionized Ammonia	0.004 - <0.011
Deviations from Test Protocol		None

Table 23. Round 1 Summary of Solid Phase Test Results.

Composite Area ID	Amphipod (*Ampelisca abdita*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	0.725	<0.5	5.47	0.586	94.0
G05-Comp	<0.5	<0.5	<0.5	<0.5	92.0
G05-Grab 7	<0.5	<0.5	<0.5	<0.5	95.0
G05-Grab 11	<0.5	<0.5	<0.5	<0.5	89.0
G05-Grab 14	<0.5	<0.5	<0.5	<0.5	89.0

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	100	0.858
	0.125	93.3	
	0.250	80.0	
	0.50	90.0	
	1.00	36.7	
	2.00	3.3	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC50 (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	96.7	68.2	52.5	2.50	2.15
	27.0	1.11	100				
	52.5	2.15	80.0				
	103	3.40	6.7				
	202	3.32	0				
	365	3.83	0				

4.3.1.2 Ampelisca abdita – Round 2

Water quality parameters were within the appropriate limits for the 10 day SP bioassay test using the amphipod, *A. abdita* (Table 24). Survival of *A. abdita* in the control treatment was 93%, which met the 90% minimum acceptable control survival criterion (Table 25). The survival of *A. abdita* in a test using sediment from Area G05-Comp was 96%, which was within 20% of the control survival. Detailed test results are presented in Appendix D.

Table 24. Round 2 Test Conditions and Water Quality Results for the 10 Day Solid Phase Bioassay Using *A. abdita*.

Test Conditions 10 Day SP Bioassay		
Sample Identification		G05-Comp
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L
Test Species		*Ampelisca abdita*
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); USEPA (1994)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Aquatic Research Organisms, Hampton, NH
Date Acquired		May 21, 2008
Acclimation/Holding Time		2 days
Age Class / Size Class		Immature
Test Location		Weston Solutions, Carlsbad, lab room 3, 20ºC
Test Dates		May 23 - June 2, 2008
Actual Water Quality Measurements	Temperature	19.5º - 20.6ºC
	Salinity	27.2 - 29.8 ppt
	Dissolved Oxygen	6.8 - 8.0 mg/L
	pH	8.0 - 8.3
	Overlying Total Ammonia	< 0.5 - 3.15 mg/L
	Overlying Un-ionized Ammonia	< 0.020 - 0.105 mg/L
	Interstitial Total Ammonia	< 0.5 - 3.70 mg/L
	Interstitial Un-ionized Ammonia	<0.003 - 0.073 mg/L
Deviations from Test Protocol		None

The LC_{50} was 0.563 mg Cd^{2+}/L in the cadmium chloride reference toxicant test, using a control and nominal concentrations of 0.125, 0.250, 0.500, 1.00 and 2.00 mg Cd^{2+}/L. This value was within one standard deviation (± 0.230 mg Cd^{2+}/L) of the laboratory mean of 0.669 mg Cd^{2+}/L, indicating that the sensitivity of *A. abdita* used in test sediments fell within the normal range.

In the ammonium chloride reference toxicant test, LC_{50} values of 42.5 mg total NH_3/L and 1.32 mg un-ionized NH_3/L were determined from survivorship using a measured concentrations of 24.1, 41.5, 88.1, 162, 321 mg total NH_3/L and a control, and calculated unionized concentrations of 0.947, 1.30, 2.20, 2.57, 3.22 mg un-ionized NH_3/L and a control. The NOEC values (24.1 mg total NH_3/L and 0.947 mg un-ionized NH_3/L) were higher than interstitial and overlying ammonia concentrations measured in the solid phase test, indicating that ammonia was not expected to have contributed to any toxicity found in test area samples.

Table 25. Round 2 Summary of Solid Phase Test Results.

Composite Area ID	Amphipod (*Ampelisca abdita*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	0.970	3.15	8.74	3.70	93.0
G05-Comp	<0.5	<0.5	<0.5	<0.5	96.0

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	93.3	0.563
	0.125	93.3	
	0.250	90.0	
	0.500	60.0	
	1.00	3.3	
	2.00	0	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC50 (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	100	42.5	24.1	1.32	0.947
	24.1	0.947	93.3				
	41.5	1.30	53.3				
	88.1	2.20	0				
	162	2.57	0				
	321	3.22	0				

4.3.1.3 Ampelisca abdita – Round 3

Water quality parameters were within the appropriate limits for the 10 day SP bioassay test using the amphipod, *A. abdita* (Table 26), with one exception; one extra animal was added to Replicate 1 of the 15.6 mg/L concentration of the ammonia reference toxicant test. This deviation should not affect the test results. Survival of *A. abdita* in the control treatment was 99%, which met the 90% minimum acceptable control survival criterion (Table 27). The survival of *A. abdita* in a test using sediment from Area G05-Comp was 97%, which was within 20% of the control survival. The Area G05-Comp sediment was not significantly different from the control, based on the results of a Two-Sample Kolmogorov-Smirnov Test. Detailed test results are presented in Appendix D.

The LC_{50} was 0.672 mg Cd^{2+}/L in the cadmium chloride reference toxicant test nominal concentrations of 0.125, 0.250, 0.500, 1.00 and 2.00 mg Cd^{2+}/L and a control. This value was within one standard deviation (± 0.194 mg Cd^{2+}/L) of the laboratory mean of 0.656 mg Cd^{2+}/L, indicating that the sensitivity of *A. abdita* used in test sediments fell within the normal range.

In the ammonium chloride reference toxicant test, LC_{50} values of 48.1 mg total NH_3/L and 1.82 mg un-ionized NH_3/L were determined from survivorship using a measured concentrations of 23.1, 49.1, 89.5, 169, 319 mg total NH_3/L and a control, and calculated unionized concentrations of 0.927, 1.97, 2.89, 3.51, 4.20 mg un-ionized NH_3/L and a control. The NOEC values (23.1 mg total NH_3/L and 0.927 mg un-ionized NH_3/L) were higher than interstitial and overlying ammonia concentrations measured in the SP test, indicating that ammonia was not expected to have contributed to any toxicity found in test area samples.

Table 26. Round 3 Test Conditions and Water Quality Results for the 10 Day Solid Phase Bioassay Using *A. abdita*.

Test Conditions		
10 Day SP Bioassay		
Sample Identification		G05-Comp
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L
Test Species		*Ampelisca abdita*
Test Procedures		ITM (USEPA/USACE, 1998); OTM (USEPA/USACE, 1991); USEPA (1994)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Aquatic Research Organisms, Hampton, NH
Date Acquired		June 28, 2008
Acclimation/Holding Time		3 days
Age Class / Size Class		Immature
Test Location		Weston Solutions, Carlsbad, lab room 3, 20ºC
Test Dates		July 1 - 11, 2008
Actual Water Quality Measurements	Temperature	19.7º - 20.7ºC
	Salinity	26.1 - 29.0 ppt
	Dissolved Oxygen	6.8 - 7.8 mg/L
	pH	7.1 - 8.4
	Overlying Total Ammonia	< 0.500 - 5.74 mg/L
	Overlying Un-ionized Ammonia	< 0.009 - 0.061 mg/L
	Interstitial Total Ammonia	< 0.500 - 9.92 mg/L
	Interstitial Un-ionized Ammonia	< 0.013 - 0.212 mg/L
Deviations from Test Protocol		One extra animal was added to Replicate 1 of the 15.625 mg/L concentration of the ammonia reference toxicant test. This deviation should not affect the test results.

Table 27. Round 3 Summary of Solid Phase Test Results.

Composite Area ID	Amphipod (*Ampelisca abdita*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	<0.500	5.74	<0.500	<0.500	99.0
G05-Comp	1.19	<0.500	9.92	9.21	97.0

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	96.7	0.672
	0.125	83.3	
	0.250	80.0	
	0.500	63.3	
	1.00	36.7	
	2.00	6.7	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC50 (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	86.7	48.1	23.1	1.82	0.927
	23.1	0.927	90.3				
	49.1	1.97	46.7				
	89.5	2.89	0				
	169	3.51	0				
	319	4.20	0				

4.3.1.4 Eohaustorius estuarius – Round 1

In Round 1, survival in the control of the *Eohaustoriou estuarius* 10-day SP test did not meet the control acceptability criterion of ≥90%, as a consequence of poor health of the organisms received. However, because the health of the organisms was affected similarly across all tests, survival in sediment from the individual grabs (G05-Grab 7, G05-Grab 11, and G05-Grab 14) was still compared to that in the G05-Composite. Results of a one-way ANOVA and Dunnett's Multiple-Comparison Test indicated that there was no significant difference in survival of amphipods in any of the individual samples which comprised of the composite sample vs. that of the composite (G05-Comp) sample ($p>0.05$). These results are plotted in Figure 42 below.

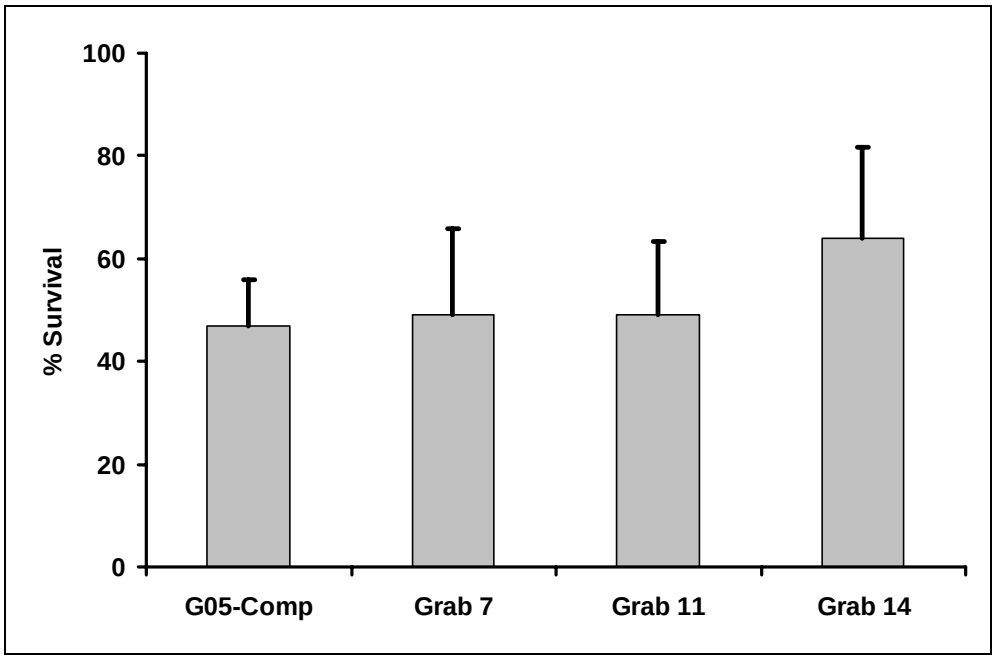

Figure 42. Survival of *Eohaustorius estuarius* in Individual Grab Samples (Grab 7, 11, and 14) and the Composite Sample (G05-Comp). Error bars indicate ± 1 standard deviation.

Because the control acceptability criterion was not met, this test was rerun only for the G05-Comp sediment sample.

4.3.1.5 Eohaustorius estuarius – Round 1, Rerun

Water quality parameters were within appropriate limits for the 10 day SP bioassay test using *E. estuarius* (Table 28), however, ammonia measurements were not taken. This deviation should not affect the test results. The survival of *E. estuarius* in the G05-Comp test sediment was 71% (Table 29). Survival of the *E. estuarius* in control sediment was 90% and met the minimum acceptable control survival criterion of ≥90%. Survival of *E. estuarius* in the G05-Comp test sediment was within 20% of the control survival. Results of a Student's T-Test indicate that there was a statistically significant difference in survival in the control and G05-Comp. Detailed test results are presented in Appendix D.

The cadmium chloride reference toxicant test resulted in a LC_{50} of 7.30 mg Cd^{2+}/L using concentrations of 2.5, 5.0, 10.0, 20.0, 40.0 mg Cd^{2+}/L and a control. This value was within one standard deviation (± 1.51 mg Cd^{2+}/L) of the laboratory mean of 6.32 mg Cd^{2+}/L, indicating that the sensitivity of *E. estuarius* used in the assessment of the test sediments fell within normal range.

The ammonium chloride reference toxicant test resulted in LC_{50} values of 197 mg total NH_3/L and 2.10 mg un-ionized NH_3/L and measured total ammonia concentrations of 25.6, 43.2, 95.9, 190, 325 mg total NH_3/L and a control, and calculated un-ionized ammonia concentrations of 0.678, 0.919, 1.64, 2.09, 2.26 mg un-ionized NH_3/L and a control. The NOEC and LC_{50} values were 95.9 and 197 mg total NH_3/L, respectively, (1.64 and 2.10 mg unionized NH_3/L, respectively) were higher than interstitial and overlying ammonia concentrations that were measured during the testing period. Therefore, ammonia was not expected to contribute to toxicity, if any, in project test sediments.

Table 28. Round Rerun 1 Test Conditions and Water Quality Results for the 10 Day Solid Phase Bioassay Using *Eohaustorius estuarius.*

Test Conditions		
10 Day SP Bioassay		
Sample Identification		G05-Comp
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L G05-Comp
Test Species		*Eohaustorius estuarius*
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); USEPA (1994)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Northwestern Aquatic Sciences, Newport, OR
Date Acquired		June 18, 2008
Acclimation/Holding Time		2 days
Age Class / Size Class		3-5 mm
Test Location		Weston Solutions, Carlsbad, lab room 2, 15ºC
Test Dates		June 20 - 30, 2008
Actual Water Quality Measurements	Temperature	14.6º - 16.5ºC
	Salinity	20.0 - 21.6 ppt
	Dissolved Oxygen	7.4 - 8.8 mg/L
	pH	7.6 - 8.4
	Overlying Total Ammonia	< 0.500 mg/L
	Overlying Un-ionized Ammonia	< 0.025 - < 0.031 mg/L
	Interstitial Total Ammonia	< 0.500 mg/L
	Interstitial Un-ionized Ammonia	< 0.500 - < 0.013 mg/L
Deviations from Test Protocol		Initial overlying ammonias were not measured. This deviation should not affect the test results. Survival in Replicate 5 of the control was less than 80 percent.

Table 29. Round 1 Rerun Summary of Solid Phase Test Results.

Composite Area ID	Amphipod (*Eohaustorius estuarius*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	*	<0.5	<0.5	<0.5	90.0
G05-Comp	*	<0.5	<0.5	<0.5	71.0

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	93.3	7.30
	2.5	80.0	
	5.0	73.3	
	10.0	26.7	
	20.0	0	
	40.0	0	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC_{50} (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	93.3	197	95.9	2.10	1.64
	25.6	0.678	93.3				
	43.2	0.919	83.3				
	95.9	1.64	96.7				
	190	2.09	50.0				
	325	2.26	6.67				

4.3.1.6 Eohaustorius estuarius – Round 2

Water quality parameters were within appropriate limits for the 10 day SP bioassay test using *E. estuarius*, with one exception (Table 30); there were only 4 replicates of the 10 mg/L concentration in the cadmium chloride reference toxicant test due to technician error This deviation should not affect the test results. The survival of *E. estuarius* in the G5-Comp-05 test sediment was 87% (Table 31). Survival of the *E. estuarius* in control sediment was 96% and met the minimum acceptable control survival criterion of ≥90%. Survival of *E. estuarius* in the G5-Comp-05 test sediment was within 20% of the control survival. Based on the results of a Two-Sample Kolmogorov-Smirnov Test, there was no statistically significant difference between survival in the G5-Comp and the control. Detailed test results are presented in Appendix D.

The cadmium chloride reference toxicant test resulted in a LC_{50} of 5.01 mg Cd^{2+}/L using concentrations of 2.5, 5.0, 10.0, 20.0, 40.0 mg Cd^{2+}/L and a control. This value was within one standard deviation (± 2.06 mg Cd^{2+}/L) of the laboratory mean of 6.64 mg Cd^{2+}/L, indicating that the sensitivity of *E. estuarius* used in the assessment of the test sediments fell within normal range.

The ammonium chloride reference toxicant test resulted in LC_{50} values of 137 mg total NH_3/L and 1.64 mg un-ionized NH_3/L and measured total ammonia concentrations of 23.3, 46.1, 91.6, 177, 341 mg total NH_3/L and a control, and calculated un-ionized ammonia concentrations of 0.573, 0.912, 1.46, 1.77, 2.15 mg un-ionized NH_3/L and a control. The NOEC and LC_{50} values were 91.6 and 137 mg total NH_3/L, respectively, (1.46 and 1.64 mg unionized NH_3/L, respectively) were higher than interstitial and overlying ammonia concentrations that were measured during the testing period. Therefore, ammonia was not expected to contribute to toxicity, if any, in project test sediments.

Table 30. Round 2 Test Specifics and Water Quality for the 10-Day Solid Phase Bioassay with *Eohaustorius estuarius*

Test Conditions **10 Day SP Bioassay**		
Sample Identification		G05-Comp
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L
Test Species		*Eohaustorius estuarius*
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); USEPA (1994)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Northwestern Aquatic Sciences, Newport, OR
Date Acquired		May 21, 2008
Acclimation/Holding Time		2 days
Age Class / Size Class		3-5 mm
Test Location		Weston Solutions, Carlsbad, lab room 2, 15ºC
Test Dates		May 23 - June 2, 2008
Actual Water Quality Measurements	Temperature	13.9º - 16.1ºC
	Salinity	20.3 - 22.1 ppt
	Dissolved Oxygen	7.9 - 8.9 mg/L
	pH	7.6 - 8.3
	Overlying Total Ammonia	< 0.5 mg/L
	Overlying Un-ionized Ammonia	<0.006 - <0.024 mg/L
	Interstitial Total Ammonia	< 0.5 mg/L
	Interstitial Un-ionized Ammonia	<0.003 - <0.010 mg/L
Deviations from Test Protocol		Animals were not added to Replicate 2 of the 10 mg/L concentration in the cadmium chloride reference toxicant test. This deviation should not affect the test results.

Table 31. Round 2 Summary of Solid Phase Test Results.

Composite Area ID	Amphipod (*Eohaustorius estuarius*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	<0.5	<0.5	<0.5	<0.5	96.0
G05-Comp	<0.5	<0.5	<0.5	<0.5	87.0

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	100	5.01
	2.5	96.7	
	5.0	46.7	
	10.0	15.0	
	20.0	0	
	40.0	0	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC50 (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	96.7	137	91.6	1.64	1.46
	23.3	0.573	100				
	46.1	0.912	100				
	91.6	1.46	90.0				
	177	1.77	16.7				
	341	2.15	0				

4.3.1.7 Eohaustorius estuarius – Round 3

Water quality parameters were within the appropriate limits for the 10 day SP bioassay test using *E. estuarius* (Table 32). Survival in the control did not meet acceptability criteria. Survival of *E. estuarius* in the control treatment was 97 %, which met the 90% minimum acceptable control survival criterion (Table 33). The survival of *E. estuarius* in G05-Comp sediment was 68%. The survivorship in the G05 Comp test sediment was not within 20% of the control survival. Survival in the G05-Comp test sediment was significantly different from the control, based on the results of a Two-Sample Kolmogorov-Smirnov Test. Detailed test results are presented in Appendix D.

The LC_{50} was 8.33 mg Cd^{2+}/L in the cadmium chloride reference toxicant test, using a control and nominal concentrations of 2.5, 5.0, 10.0, 20.0, and 40.0 mg Cd^{2+}/L. This value was within two standard deviations (± 3.51 mg Cd^{2+}/L) of the laboratory mean of 6.48 mg Cd^{2+}/L, indicating that the sensitivity of *E. estuarius* used in test sediments fell within the normal range.

In the ammonium chloride reference toxicant test, LC_{50} values of 171 mg total NH_3/L and 160 mg un-ionized NH_3/L were determined from survivorship using a control and measured concentrations of 19.4, 34.3, 69.5, 155, and 291 mg total NH_3/L, and calculated unionized concentrations of 0.474, 0.844, 1.11, 1.56, and 1.88 mg un-ionized NH_3/L. The NOEC values (69.5 mg total NH_3/L and 1.11 mg un-ionized NH_3/L) were higher than interstitial and overlying ammonia concentrations (highest ammonia values of < 0.5 mg/L mg total NH_3/L and < 0.5 mg/L mg un-ionized NH_3/L) measured in the SP test, indicating that ammonia was not expected to have contributed to any toxicity found in test area samples.

Table 32. Round 3 Test Conditions and Water Quality Results for the 10 Day Solid Phase Bioassay Using *Eohaustorius estuarius*.

Test Conditions **10 Day SP Bioassay**		
Sample Identification		G05-Comp
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L G05-Comp
Test Species		*Eohaustorius estuarius*
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); USEPA (1994)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Northwestern Aquatic Sciences, Newport, OR
Date Acquired		May 24, 2008
Acclimation/Holding Time		3 days
Age Class / Size Class		3-5 mm
Test Location		Weston Solutions, Carlsbad, lab room 2, 15ºC
Test Dates		May 27 - June 6, 2008
Actual Water Quality Measurements	Temperature	15.0º - 16.6ºC
	Salinity	20.0 - 22.4 ppt
	Dissolved Oxygen	7.3 - 8.3 mg/L
	pH	7.6 - 8.3
	Overlying Total Ammonia	< 0.5 mg/L
	Overlying Un-ionized Ammonia	<0.010 - <0.020 mg/L
	Interstitial Total Ammonia	< 0.5 mg/L
	Interstitial Un-ionized Ammonia	<0.005 mg/L
Deviations from Test Protocol		None

Table 33. Round 3 Summary of Solid Phase Test Results.

Composite Area ID	Amphipod (*Eohaustorius estuarius*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	<0.5	<0.5	<0.5	<0.5	97.0
G05-Comp	<0.5	<0.5	<0.5	<0.5	68.0

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	100	8.33
	2.5	86.7	
	5.0	76.7	
	10.0	36.7	
	20.0	6.7	
	40.0	0	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC50 (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	86.7	171	69.5	1.60	1.11
	19.4	0.474	96.7				
	34.3	0.844	100				
	69.5	1.11	86.7				
	155	1.56	53.3				
	291	1.88	0				

4.3.1.8 Neanthes arenaceodentata – Round 1

Water quality parameters were within appropriate limits for the 10 day SP bioassay test using *Neanthes arenaceodentata* (Table 34). The survival of the polychaete worm, *N. arenaceodentata*, ranged from 98 to 100% across all test sediments (Table 35). Survival of the polychaete worm in control sediment was 96% and met the minimum acceptable control survival criterion of ≥90% (Table 35). Survival of *N. arenaceodentata* in all test sediments was within 10% of the control survival. Detailed test results for the control and reference toxicant tests using *N. arenaceodentata* are presented in Appendix D.

The cadmium chloride reference toxicant test resulted in a LC_{50} of 6.46 mg Cd^{2+}/L using concentrations of 3.75, 7.50, 15.0, 30.0, 60.0 mg Cd^{2+}/L and a control (Table 35). This value was within two standard deviations (± 6.61 mg Cd^{2+}/L) of the laboratory mean of 10.2 mg Cd^{2+}/L, indicating that the sensitivity of *N. arenaceodentata* used in the assessment of the test sediments fell within normal range.

The ammonium chloride reference toxicant test resulted in LC_{50} values of 142 mg total NH_3/L and 2.92 mg un-ionized NH_3/L and measured total ammonia concentrations of 16.3, 33.3, 66.2, 130, 239 mg total NH_3/L and a control, and calculated un-ionized ammonia concentrations of 0.54, 1.10, 1.76, 2.76, 3.18 mg un-ionized NH_3/L and a control (Table 35). The NOEC and LC_{50} values were 66.2 and 142 mg total NH_3/L, respectively, (1.76 and 2.92 mg unionized NH_3/L, respectively) were higher than interstitial and overlying ammonia concentrations that were measured during the testing period. Therefore, ammonia was not expected to contribute to toxicity, if any, in project test sediments.

Table 34. Round 1 Test Conditions and Water Quality Results for the 10 Day Solid Phase Bioassay Using *Neanthes arenaceodentata*.

Test Conditions 10 Day SP Bioassay		
Sample Identification		G05-Comp, G05-Grab 7, G05-Grab 11, G05-Grab 14
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L G05-Comp, 20L G05-Grab 7, 11, 14
Test Species		*Neanthes arenaceodentata*
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); ASTM E1611 (2006)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Dr. Donald Reish, Long Beach, CA
Date Acquired		May 19, 2008
Acclimation/Holding Time		1 day
Age Class / Size Class		2-3 weeks post-emergence
Test Location		Weston Solutions, Carlsbad, lab room 3, 20ºC
Test Dates		May 20 - 30, 2008
Actual Water Quality Measurements	Temperature	18.9º - 20.2ºC
	Salinity	28.2 - 30.2 ppt
	Dissolved Oxygen	6.6 - 8.2 mg/L
	pH	7.9 - 8.3
	Overlying Total Ammonia	< 0.5 mg/L
	Overlying Un-ionized Ammonia	< 0.024 - < 0.031 mg/L
	Interstitial Total Ammonia	< 0.5 mg/L
	Interstitial Un-ionized Ammonia	< 0.005 - < 0.013 mg/L
Deviations from Test Protocol		None

Table 35. Round 1 Summary of Solid Phase Bioassay Test Results Using *Neanthes arenaceodentata*.

Composite Area ID	Polychaete (*Neanthes arenaceodentata*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	<0.5	<0.5	<0.5	<0.5	96.0
G05-Comp	<0.5	<0.5	<0.5	<0.5	98.0
G05-Grab 7	<0.5	<0.5	<0.5	<0.5	100
G05-Grab 11	<0.5	<0.5	<0.5	<0.5	98.0
G05-Grab 14	<0.5	<0.5	<0.5	<0.5	98.0

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	86.7	6.46
	3.75	86.7	
	7.50	26.7	
	15.0	0	
	30.0	0	
	60.0	0	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC50 (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	100	142	66.2	2.92	1.76
	16.3	0.543	100				
	33.3	1.10	100				
	66.2	1.76	93.3				
	130	2.76	80.0				
	239	3.18	0				

4.3.1.9 Neanthes arenaceodentata – Round 2

Water quality parameters were within appropriate limits for the 10 day SP bioassay test using *N. arenaceodentata*, however, one additional animal was added to Replicate 1 of the 284 mg/L concentration of the ammonia reference toxicant test. This deviation should not affect test results (Table 36). The survival of the polychaete worm, *N. arenaceodentata*, was 100% for the G05-Comp sediment (Table 37). Survival of the polychaete worm in control sediment was also 100% and met the minimum acceptable control survival criterion of ≥90% (Table 37). Survival of *N. arenaceodentata* in G05-Comp sediment was also within 10% of the control survival. Detailed test results for the control and tests using *N. arenaceodentata* are presented in Appendix D.

The cadmium chloride reference toxicant test resulted in a LC_{50} of 6.09 mg Cd^{2+}/L concentrations of 3.75, 7.5, 15.0, 30.0, 60.0 mg Cd^{2+}/L and a control (Table 37). This value was within two standard deviations

(± 6.86 mg Cd^{2+}/L) of the laboratory mean of 9.99 mg Cd^{2+}/L, indicating that the sensitivity of *N. arenaceodentata* used in the assessment of the test sediments fell within normal range.

The ammonium chloride reference toxicant test resulted in LC_{50} values of 109 mg total NH_3/L and 2.34 mg un-ionized NH_3/L using measured total ammonia concentrations of 19.1, 37.9, 73.0, 146, 284 mg total NH_3/L and a control and calculated un-ionized ammonia concentrations of 0.740, 1.75, 1.79, 2.91, 3.58 mg un-ionized NH_3/L and a control (Table 37). The NOEC and LC_{50} values were 73.0 and 109 mg total NH_3/L, respectively, (1.79 and 2.34 mg unionized NH_3/L, respectively) were higher than interstitial and overlying ammonia concentrations that were measured during the testing period. Therefore, ammonia was not expected to contribute to toxicity, if any, in project test sediments.

Table 36. Round 2 Test Conditions and Water Quality Results for the 10 Day Solid Phase Bioassay Using *Neanthes arenaceodentata*.

Test Conditions 10 Day SP Bioassay		
Sample Identification		G05-Comp
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L
Test Species		*Neanthes arenaceodentata*
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); ASTM E1611 (2006)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Dr. Donald Reish, Long Beach, CA
Date Acquired		May 20, 2008
Acclimation/Holding Time		3 days
Age Class / Size Class		2-3 weeks post-emergence
Test Location		Weston Solutions, Carlsbad, lab room 3, 20ºC
Test Dates		May 23 - June 2, 2008
Actual Water Quality Measurements	Temperature	19.8º - 21.0ºC
	Salinity	28.1 - 29.7 ppth
	Dissolved Oxygen	6.7 - 8.0 mg/L
	pH	7.9 - 8.3
	Overlying Total Ammonia	< 0.5 mg/L
	Overlying Un-ionized Ammonia	< 0.020 - < 0.033 mg/L
	Interstitial Total Ammonia	< 0.5 mg/L
	Interstitial Un-ionized Ammonia	< 0.004 - < 0.017
Deviations from Test Protocol		One extra animal was added to Replicate 1 of the 284 mg/L concentration of the ammonia reference toxicant test. This deviation should not affect the test results.

Table 37. Round 2 Summary of Solid Phase Bioassay Test Results Using *Neanthes arenaceodentata*.

Composite Area ID	Polychaete (*Neanthes arenaceodentata*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	<0.5	<0.5	<0.5	<0.5	100
G05-Comp	<0.5	<0.5	<0.5	<0.5	100

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	100	6.09
	3.75	100	
	7.50	20.0	
	15.0	0	
	30.0	0	
	60.0	0	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC50 (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	100	109	73.0	2.34	1.79
	19.1	0.740	93.3				
	37.9	1.18	100				
	73.0	1.79	100				
	146	2.91	0				
	284	3.58	0				

4.3.1.10 Neanthes arenaceodentata – Round 3

Water quality parameters were within appropriate limits for the 10 day SP bioassay test using *N. arenaceodentata* with one exception; one additional animal was added to Replicate 1 of the G05-Comp sample at test initiation (Table 38). This deviation should not affect test results. The survival of the polychaete worm, *N. arenaceodentata*, was 100% for the G05-Comp sediment (Table 39). Survival of the polychaete worm in control sediment was also 98% and met the minimum acceptable control survival criterion of ≥90% (Table 39). Survival of *N. arenaceodentata* in the G05-Comp sediment was also within 10% of the control survival. Detailed test results for the control and reference toxicant tests using *N. arenaceodentata* are presented in Appendix D.

The cadmium chloride reference toxicant test resulted in a LC_{50} of 8.20 mg Cd^{2+}/L using concentrations of 3.75, 7.50, 15.0, 30.0, 60.0 mg Cd^{2+}/L and a control (Table 39). This value was within one standard deviation (± 3.73 mg Cd^{2+}/L) of the laboratory mean of 9.96 mg Cd^{2+}/L, indicating that the sensitivity of *N. arenaceodentata* used in the assessment of the test sediments fell within normal range.

The ammonium chloride reference toxicant test resulted in LC_{50} values of 84.5 mg total NH_3/L and 1.56 mg un-ionized NH_3/L using measured total ammonia concentrations of 12.0, 30.5, 64.1, 98.1, 218 mg total NH_3/L and calculated un-ionized ammonia concentrations of 0.402, 0.836, 1.38, 1.66 and 2.29 mg un-ionized NH_3/L and a control (Table 39). The NOEC and LC_{50} values were 64.1 and 84.5 mg total NH_3/L, respectively, (1.38 and 1.56 mg unionized NH_3/L, respectively) were higher than interstitial and overlying ammonia concentrations that were measured during the testing period. Therefore, ammonia was not expected to contribute to toxicity, if any, in project test sediments.

Table 38. Round 3 Test Conditions and Water Quality Results for the 10 Day Solid Phase Bioassay Using *Neanthes arenaceodentata*.

Test Conditions **10 Day SP Bioassay**		
Sample Identification		G05-Comp
Dates Sampled		May 2 and May 15, 2008
Date Received at Weston's Laboratory		May 16, 2008
Approximate Volume of Sediment Received		60L
Test Species		*Neanthes arenaceodentata*
Test Procedures		ITM (USEPA/USACE 1998); OTM (USEPA/USACE 1991); ASTM E1611 (2005b)
Test Type/Duration		Static - Acute SP/10 days
Supplier		Dr. Donald Reish, Long Beach, CA
Date Acquired		May 24, 2008
Acclimation/Holding Time		3 days
Age Class / Size Class		2-3 weeks post-emergence
Test Location		Weston Solutions, Carlsbad, lab room 3, 20ºC
Test Dates		May 27 - June 6, 2008
Actual Water Quality Measurements	Temperature	19.0º - 20.2ºC
	Salinity	27.0 - 29.5 ppt
	Dissolved Oxygen	7.0 - 7.9 mg/L
	pH	7.5 - 8.3
	Overlying Total Ammonia	< 0.5 mg/L
	Overlying Un-ionized Ammonia	< 0.019 - < 0.020 mg/L
	Interstitial Total Ammonia	< 0.5 - 5.31 mg/L
	Interstitial Un-ionized Ammonia	< 0.008 - 0.084 mg/L
Deviations from Test Protocol		One extra animal was added to Replicate 1 of the G05-Comp sample at test initiation. This deviation should not affect the test results.

Table 39. Round 3 Summary of Solid Phase Bioassay Test Results Using *Neanthes arenaceodentata*.

Composite Area ID	Polychaete (*Neanthes arenaceodentata*)				
	Overlying Total Ammonia Concentration (mg/L)		Interstitial Total Ammonia Concentration (mg/L)		% Survival
	Initial	Day 10	Initial	Day 10	
Control	<0.5	<0.5	5.31	<0.5	98.0
G05-Comp	<0.5	<0.5	<0.5	<0.5	100

	Concentration (mg/L)	% Survival	LC_{50} (mg/L)
Cadmium Chloride Reference Toxicant	Control	93.3	8.20
	3.75	100	
	7.50	53.3	
	15.0	0	
	30.0	0	
	60.0	0	

	Total NH_3	Un-ionized NH_3		Total NH_3		Un-ionized NH_3	
	Actual Concentration (mg/L)	Calculated Concentration (mg/L)	% Survival	LC_{50} (mg/L)	NOEC (mg/L)	LC50 (mg/L)	NOEC (mg/L)
Ammonium Chloride Reference Toxicant	Control	Control	100	84.5	64.1	1.56	1.38
	12.0	0.402	93.3				
	30.5	0.836	100				
	64.1	1.38	100				
	98.1	1.66	0				
	218	2.29	0				

4.3.2 Bioaccumulation Potential Tests

4.3.2.1 Water Quality

Water quality parameters were within appropriate limits for the 28-day bioaccumulation test using *Nephyts caecoides* and *Macoma. nasuta* with the exception of a single pH measurement observed on Day 20 in the GO 1-2-3 sample (composite of project sediment from Stations GO-1, GO-2 and GO-3 from the North Alternative area). The pH value of 7.2 was slightly below the recommended range of 7.8 ±0.5 units; this value was still well within the tolerance range of the test organisms (6 to 9 units) and did not impact the significance of the test results (Table 40). Detailed test results are presented in Appendix E.

4.3.2.2 Survival

At the end of 28 days, the test organisms were removed via a 1-mm screen, counted and placed in a flow-through chamber without sediment to purge gut contents for 24 hours.

Nephtys caecoides
Mean survival for the polychaete worm, *N. caecoides*, ranged from 91% to 96% in the project test sediments and was 93% in the control sediments (Table 41).

Macoma nasuta
Mean survival for the bivalve, *M. nasuta*, ranged from 98% to 99% in the project test sediments and was 98% in the control sediments (Table 41).

Table 40. Test Conditions and Water Quality Results for the 28-Day Flow-Through Bioaccumulation Test Using *Nephtys caecoides* and *Macoma nasuta*

Toxicity Test Experimental Design and Test Conditions 28-Day Bioaccumulation Study		
Sample Identification	GO 1-2-3 Comp, GO 5 Comp, GO 6-7-8 Comp, and Control	
Date sampled	2 May 2008	
Date received at NewFields	7 May 2008	
Approximate volume received	5 gallons per treatment	
Sample storage conditions	4°C, dark, minimal head space	
Weeks of holding	2 weeks	
Source of control sediment	Tomalas Bay, CA	
Test Species	***Macoma nasuta***	***Nephtys caecoides***
Supplier	Reed Gunstone, WA	John Brezina, CA
Date acquired	8 May 2008	13 May 2008
Acclimation/holding time	6 days	1 days
Age class	Adults	Adults
Test Procedures	ITM (USEPA/USACE 1998), OTM (USEPA/USACE 1991), USEPA (1993)	
Test location	NewFields Northwest Laboratory, Port Gamble, WA	
Test type/duration	28-day static with flow through	
Test dates	14 May – 11 June, 2008	
Control water	North Hood Canal, sand filtered to ~20µm	
Test temperature	Recommended: 15 ± 1 °C	Achieved: 14.1 – 15.9 °C
Test Salinity	Recommended: 32 ± 2 ppt	Achieved: 30 – 32 ppt
Test dissolved oxygen	Recommended: > 4.5 mg/L	Achieved: 6.5 – 9.9 mg/L
Test pH	Recommended: 7.8 ± 0.5	Achieved: 7.2 – 7.9
Test photoperiod	16 hours light: 8 hours dark	
Test chamber	Glass Aquaria (49.5 x 24.8 x 29.2 cm)	
Replicates/treatment	5	
Organisms/replicate	*M. nasuta* = 25, *N. caecoides* = 60	
Exposure Volume	4L sediment	
Feeding	None	
Water renewal	Flow-through 1.8 – 3.1 ml/sec	
Deviations from Test Protocol	Slight deviation in pH from recommended range on Day 20.	

Table 41. Summary of Bioaccumulation Test Survival Results for *Nephtys caecoides* and *Macoma nasuta*

Sample ID/Project Test Area	**% Survival**	
	Nephtys caecoides	***Macoma nasuta***
Control	93	98
GO 1-2-3 Comp	92	99
GO 5 Comp	96	98
GO 6-7-8 Comp	91	98

4.3.3 Bioaccumulation Tissue Chemistry

Upon completion of the 28-day bioaccumulation tests, *N. caecoides* and *M. nasuta* tissues were submitted for chemical analyses. Results of the tissue chemistry analyses are summarized below and presented in Table 42 and for *N. caecoides* and *M. nasuta*, respectively. Dioxin and furan results are presented separately in Table 44. All values reported in the summary tables are on a wet weight basis and all statistical calculations were performed based on lipid normalized wet tissue weights. Appendix F contains the complete laboratory analytical results for tissue chemistry.

As discussed with Mr. Brian Ross and Mr. Allan Ota of the USEPA Region IX, replicate tissue samples and sediment samples were tested for the same analytes. Sediment chemistry results indicated several groups of analytes (PAHs; chlorinated pesticides, including Aroclor PCBs as well as individual congeners; and organotins) were not detected, or were detected at estimated values below the MRL. This suggests these analytes would likely not be present in tissue samples. For dioxins/furans analyses, the five tissue replicates from each sample were composited and analyzed (Ross 2008).

4.3.3.1 Nephtys caecoides Tissue Chemistry

North Alternative Area

With the exception of antimony, beryllium and thallium, all *N. caecoides* tissue samples exposed to North Alternative project sediment (composite sample ID GO 1-2-3) had detectable concentrations of target metals (Table 42). Average metals concentrations of tissue samples exposed to North Alternative study area project sediment were as follows: aluminum (8.46 µg/wet g); arsenic (3.11 µg/wet g); barium (0.103 µg/wet g); cadmium (0.197 µg/wet g); chromium (0.186 µg/wet g); cobalt (0.451 µg/wet g); copper (1.94 µg/wet g); iron (72.7 µg/wet g); lead (0.081 µg/wet g); manganese (1.23 µg/wet g); mercury (0.014 µg/wet g); molybdenum (0.377 µg/wet g); nickel (1.30 µg/wet g); selenium (0.885 µg/wet g); silver (0.147 µg/wet g); strontium (20.9 µg/wet g); tin (0.078 µg/wet g); titanium (0.318 µg/wet g); vanadium (2.52 µg/wet g); zinc (33.0 µg/wet g).

All PCBs (both individual congeners and Aroclors) were not detected at concentrations greater than the MDL. Only one chlorinated pesticide (4,4'-DDD) was detected in four of the five replicate samples ranging in concentration from 53.5 to 113.3 ng/wet g. Several PAHs, including 1-methylnaphthalene, 2,6-dimethylnaphthalene, 2-methylnaphthalene, benzo[k]fluoranthene, chrysene, fluorene, naphthalene, and phenanthrene, were detected in low concentrations in one or more replicates from tissue samples exposed to North Alternative area project sediment. Concentrations of 2,6-dimethylnaphthalene, fluorine, and naphthalene were measured in day zero tissue samples. Dioxins and furans were also detected in tissue samples exposed to North Alternative area project sediment (17.6 pg/g and 3.07 pg/g, respectively); however, these two groups were also detected in day zero tissue samples (Table 44).

With the exception of silver and several PAHs and total detectable dioxins, all chemical concentrations in *N. caecoides* tissue were similar (less than or within 1.5 times) to day zero concentrations. Concentrations of silver in tissue samples exposed to North Alternative area project sediment were greater than 2.5 times the concentration of silver in day zero tissue samples. Several PAHs, including 1-methylnaphthalene, 2-methylnaphthalene, benzo[k]fluoranthene, chrysene, and phenanthrene were not detected in day zero tissue samples. Total detectable dioxins were nearly 1.8 times the day zero concentration.

Table 42. *Nephthys caecoides* Tissue Chemistry Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	MDL	RL	Composite ID															Day 0
			GO 1-2-3					GO 6-7-8					GO 5					
			North Alternative Area					Northwest Alternative Area					Proposed Reference Site					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	
General Chemistry																		
Lipids (%)	0.01	0.05	1.33	1.29	1.27	1.36	0.92	1.3	1.26	1.34	1.2	1.32	1.3	1.32	1.24	1.08	1.28	1.22
Metals (µg/wet g)																		
Aluminum (Al)	1	5	4.1J	2.5J	2.4J	24.7	8.6	3.5J	5.8	2.5J	13.6	6.7	2.3J	3.9J	2J	2J	1.9J	31.9
Antimony (Sb)	0.025	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Arsenic (As)	0.025	0.05	3.156	3.205	3.373	3.311	2.496	3.09	3.356	3.224	3.111	3.101	3.655	3.459	3.437	3.234	3.35	3.715
Barium (Ba)	0.025	0.05	0.094	0.094	0.102	0.14	0.088	0.114	0.115	0.116	0.161	0.215	0.096	0.107	0.09	0.098	0.089	0.382
Beryllium (Be)	0.025	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Cadmium (Cd)	0.025	0.05	0.194	0.214	0.201	0.215	0.162	0.202	0.215	0.21	0.199	0.211	0.199	0.19	0.207	0.224	0.203	0.249
Chromium (Cr)	0.025	0.05	0.172	0.075	0.062	0.524	0.098	0.126	0.098	0.059	0.471	0.233	0.052	0.153	0.048J	0.049J	0.054	0.202
Cobalt (Co)	0.025	0.05	0.461	0.468	0.476	0.503	0.346	0.459	0.641	0.551	0.406	0.449	0.484	0.475	0.434	0.466	0.505	0.427
Copper (Cu)	0.025	0.05	1.777	2.094	2.025	2.386	1.409	1.95	2.071	2.459	2.006	1.909	1.991	2.033	1.826	2.024	1.666	1.98
Iron (Fe)	1	5	63.4	64.9	64.9	111.4	59.1	60.2	70.8	71.1	76.9	69.6	65.1	64.1	61.7	62.6	64.3	133.7
Lead (Pb)	0.025	0.05	0.08	0.082	0.083	0.097	0.061	0.079	0.088	0.086	0.075	0.089	0.078	0.096	0.073	0.074	0.079	0.136
Manganese (Mn)	0.025	0.05	1.008	0.962	1.021	2.086	1.075	1.319	2.784	1.338	1.834	1.39	2.185	1.02	1.028	1.089	0.951	1.297
Mercury (Hg)	0.01	0.02	0.01J	0.02	0.01J	0.02	0.01J	0.02	0.02	0.01J	0.02	0.01J	0.01J	0.01J	0.01J	0.02	0.02	0.01J
Molybdenum (Mo)	0.025	0.05	0.377	0.399	0.378	0.428	0.304	0.369	0.377	0.342	0.427	0.399	0.376	0.402	0.374	0.386	0.353	0.393
Nickel (Ni)	0.025	0.05	1.184	1.225	1.247	1.877	0.991	1.197	1.326	1.301	1.375	1.183	1.248	1.163	1.186	1.138	1.347	1.684
Selenium (Se)	0.025	0.05	0.952	0.932	0.941	0.863	0.735	0.915	0.948	0.974	0.949	0.909	0.828	0.921	0.923	0.959	0.958	1.053
Silver (Ag)	0.025	0.05	0.152	0.159	0.145	0.154	0.127	0.142	0.142	0.133	0.149	0.164	0.241	0.174	0.206	0.218	0.176	0.055
Strontium (Sr)	0.025	0.05	21.3	21.46	22.54	21.34	17.89	21.56	21.92	23.69	20.17	20.82	20.71	20.93	20.54	21	21.89	22.13
Thallium (Tl)	0.025	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Tin (Sn)	0.025	0.05	0.083	0.081	0.069	0.102	0.054	0.06	0.07	0.06	0.067	0.073	0.059	0.064	0.057	0.064	0.061	<0.025
Titanium (Ti)	0.025	0.05	0.282	0.302	0.281	0.45	0.275	0.272	0.395	0.3	0.407	0.354	0.282	0.295	0.25	0.28	0.292	0.999
Vanadium (V)	0.025	0.05	2.519	2.582	2.909	2.586	2.008	2.827	2.633	3.127	1.992	2.205	2.89	2.864	2.735	2.225	3.859	3.584
Zinc (Zn)	0.025	0.05	33.24	36.16	35.39	33.46	26.8	33.58	34.91	33.66	33.82	32.92	36.54	36.28	36.73	36.28	33.77	30.84
Aroclors (ng/wet g)																		
Aroclor 1016	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1221	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1232	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1242	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1248	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1254	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1260	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
PCB congeners (ng/wet g)																		
PCB003	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB008	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB018	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB028	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB031	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB033	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB037	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB044	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB049	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB052	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB056/060	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table 42. *Nephthys caecoides* Tissue Chemistry Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	MDL	RL	Composite ID															Day 0
			GO 1-2-3					GO 6-7-8					GO 5					
			North Alternative Area					Northwest Alternative Area					Proposed Reference Site					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	
PCB066	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB070	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB074	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB077	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB081	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB087	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB095	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB097	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB099	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB101	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB105	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB110	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB114	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB118	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB119	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB123	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB126	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB128	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB138	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB141	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB149	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB151	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB153	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB156	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB157	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB158	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB167	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB168+132	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB169	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB170	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB174	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB177	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB180	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB183	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB187	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB189	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB194	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB195	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB200	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB201	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB203	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB206	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB209	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlorinated Pesticides (ng/wet g)																		
2,4'-DDD	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,4'-DDE	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,4'-DDT	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
4,4'-DDD	1	5	<1	113.3	111	71.8	53.5	91.1	39	96.6	125.5	199.7	118.9	61.4	87.2	98.4	116.8	80.5

Table 42. *Nephthys caecoides* Tissue Chemistry Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	MDL	RL	Composite ID															Day 0
			GO 1-2-3					GO 6-7-8					GO 5					
			North Alternative Area					Northwest Alternative Area					Proposed Reference Site					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	
4,4'-DDE	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
4,4'-DDT	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	38.4	<1	<1	<1	<1	<1
Aldrin	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
BHC-alpha	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
BHC-beta	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
BHC-delta	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
BHC-gamma	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlordane-alpha	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlordane-gamma	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
DCPA (Dacthal)	5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dicofol	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dieldrin	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endosulfan Sulfate	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endosulfan-I	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endosulfan-II	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin Aldehyde	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin Ketone	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Heptachlor	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Heptachlor Epoxide	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Methoxychlor	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Mirex	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Oxychlordane	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Perthane	5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Toxaphene	10	50	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
cis-Nonachlor	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
trans-Nonachlor	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PAHs (ng/wet g)																		
1-Methylnaphthalene	1	5	4J	<1	3.8J	<1	1.9J	2.6J	4.1J	3.9J	2J	<1	1.4J	2.2J	2.6J	2.3J	2.5J	<1
1-Methylphenanthrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,3,5-Trimethylnaphthalene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,6-Dimethylnaphthalene	1	5	35.2	24.1	22.5	20.9	20.1	14.9	27.3	8.2	<1	12.9	17.8	21.1	21.1	<1	36.5	34
2-Methylnaphthalene	1	5	1.9J	4.8J	7.5	4.6J	5.1	2.8J	12.8	2.5J	8	6.4	2J	2.3J	5.9	10.6	5.4	<1
Acenaphthene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthylene	1	5	<1	<1	<1	<1	<1	<1	10.4	<1	<1	<1	<1	<1	<1	<1	<1	<1
Anthracene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	8.7	<1	<1	<1	<1	<1	<1	<1
Benz[a]anthracene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[a]pyrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[b]fluoranthene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[e]pyrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[g,h,i]perylene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[k]fluoranthene	1	5	10.9	12.6	<1	<1	15.7	17.6	18.7	24.4	<1	<1	<1	<1	<1	<1	<1	<1
Biphenyl	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chrysene	1	5	9	17.1	17	13.5	4.7J	15.5	8.5	24.5	14.5	35.9	28.4	21.5	17.3	32.2	26.3	<1
Dibenz[a,h]anthracene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzothiophene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluorene	1	5	11	9.4	9.3	6.6	14.1	5.6	19.6	15.5	16.7	10.5	6.2	<1	<1	10.4	9	8.1

Table 42. *Nephthys caecoides* Tissue Chemistry Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	MDL	RL	Composite ID															Day 0
			GO 1-2-3					GO 6-7-8					GO 5					
			North Alternative Area					Northwest Alternative Area					Proposed Reference Site					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	
Indeno[1,2,3-c,d]pyrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	1	5	3J	9	5.6	9	11.1	4J	6.5	7.2	11.8	5.5	4.2J	3.7J	7.1	4.6J	3.6J	11.9
Perylene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phenanthrene	1	5	<1	1.8J	<1	4.1J	6.2	1.5J	<1	1.2J	1.4J	<1	<1	<1	<1	4.8J	<1	<1
Pyrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table 43. *Macoma nasauta* Tissue Chemistry Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	MDL	RL	Composite ID															Day 0
			GO 1-2-3					GO 6-7-8					GO 5					
			North Alternative Area					Northwest Alternative Area					Proposed Reference Site					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	
General Chemistry																		
Lipids (%)	0.01	0.05	0.82	0.5	0.68	0.76	1.08	0.78	0.86	1.07	1.13	0.91	1.09	1.03	0.8	0.75	0.92	1.03
Metals (µg/wet g)																		
Aluminum (Al)	1	5	35.8	34.1	26.2	25.8	35.2	40.3	42.5	36	36.9	43.1	55.3	32.4	34.2	34.1	31.4	6.7
Antimony (Sb)	0.025	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Arsenic (As)	0.025	0.05	1.773	2.032	1.675	1.555	1.944	1.748	1.865	1.625	1.243	1.607	1.537	1.645	1.579	1.416	1.702	2.034
Barium (Ba)	0.025	0.05	2.561	1.793	1.288	1.36	1.893	4.479	5.235	4.421	6.069	4.341	3.172	2.631	2.941	2.985	2.069	0.15
Beryllium (Be)	0.025	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Cadmium (Cd)	0.025	0.05	<0.025	0.028J	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.027J	<0.025	<0.025	<0.025
Chromium (Cr)	0.025	0.05	0.117	0.113	0.095	0.091	0.118	0.124	0.135	0.129	0.117	0.131	0.191	0.131	0.142	0.134	0.122	0.053
Cobalt (Co)	0.025	0.05	0.145	0.174	0.137	0.122	0.16	0.155	0.172	0.144	0.134	0.157	0.151	0.152	0.156	0.15	0.141	0.086
Copper (Cu)	0.025	0.05	2.551	2.441	2.441	2.077	2.679	2.396	2.914	2.342	2.576	2.47	2.328	2.509	2.15	2.425	2.029	2.28
Iron (Fe)	1	5	88.1	93.4	77.9	72.1	91	88	99.9	92.8	88.7	97.5	115.4	81.6	89.1	84.2	78.8	44.9
Lead (Pb)	0.025	0.05	0.125	0.148	0.124	0.111	0.144	0.103	0.139	0.128	0.12	0.127	0.125	0.12	0.111	0.127	0.104	0.188
Manganese (Mn)	0.025	0.05	4.224	4.426	3.385	3.288	4.184	5.2	6.29	4.691	4.691	5.213	3.624	3.421	3.139	3.702	2.979	0.836
Mercury (Hg)	0.01	0.02	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	0.01J	<0.01
Molybdenum (Mo)	0.025	0.05	0.466	0.496	0.449	0.403	0.505	0.441	0.485	0.439	0.429	0.43	0.442	0.452	0.449	0.415	0.431	0.537
Nickel (Ni)	0.025	0.05	0.346	0.465	0.354	0.316	0.365	0.35	0.395	0.379	0.347	0.384	0.383	0.34	0.379	0.334	0.323	0.231
Selenium (Se)	0.025	0.05	0.362	0.356	0.35	0.331	0.385	0.36	0.375	0.371	0.291	0.318	0.34	0.315	0.326	0.328	0.355	0.42
Silver (Ag)	0.025	0.05	0.086	0.086	0.071	0.073	0.088	0.056	0.08	0.07	0.09	0.066	0.089	0.088	0.078	0.089	0.07	0.065
Strontium (Sr)	0.025	0.05	11.46	10.4	8.977	8.93	10.25	12.28	11.19	10.78	14.38	10.9	13.24	11.47	12.51	11.38	10.23	6.364
Thallium (Tl)	0.025	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Tin (Sn)	0.025	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Titanium (Ti)	0.025	0.05	0.687	0.769	0.628	0.565	0.771	0.726	0.818	0.744	0.694	0.859	0.956	0.719	0.774	0.707	0.616	0.226
Vanadium (V)	0.025	0.05	0.234	0.234	0.19	0.187	0.237	0.243	0.262	0.236	0.245	0.258	0.29	0.224	0.249	0.233	0.224	0.108
Zinc (Zn)	0.025	0.05	11.2	10.25	11.03	9.944	12.05	11.28	11.91	11.13	9.685	10.21	10.93	11.51	11.61	11.8	10.88	11.74
Aroclors (ng/wet g)																		
Aroclor 1016	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1221	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1232	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1242	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1248	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1254	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Aroclor 1260	10	20	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
PCB congeners (ng/wet g)																		
PCB003	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB008	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB018	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB028	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB031	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB033	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB037	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB044	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB049	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB052	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB056/060	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table 43. *Macoma nasauta* Tissue Chemistry Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	MDL	RL	Composite ID															Day 0
			GO 1-2-3					GO 6-7-8					GO 5					
			North Alternative Area					Northwest Alternative Area					Proposed Reference Site					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	
PCB066	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB070	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB074	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB077	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB081	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB087	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB095	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB097	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB099	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB101	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB105	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB110	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB114	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB118	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB119	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB123	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB126	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB128	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB138	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB141	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB149	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB151	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB153	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB156	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB157	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB158	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB167	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB168+132	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB169	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB170	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB174	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB177	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB180	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB183	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB187	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB189	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB194	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB195	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB200	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB201	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB203	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB206	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PCB209	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlorinated Pesticides (ng/wet g)																		
2,4'-DDD	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,4'-DDE	1	5	11.7	15.1	<1	<1	10.8	29.4	46.3	30.8	22.6	<1	28.1	32.5	68.9	56.1	9.7	33.3
2,4'-DDT	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
4,4'-DDD	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
4,4'-DDE	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table 43. *Macoma nasauta* Tissue Chemistry Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	MDL	RL	Composite ID															Day 0
			GO 1-2-3					GO 6-7-8					GO 5					
			North Alternative Area					Northwest Alternative Area					Proposed Reference Site					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	
4,4'-DDT	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
BHC-alpha	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
BHC-beta	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
BHC-delta	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
BHC-gamma	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlordane-alpha	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlordane-gamma	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
DCPA (Dacthal)	5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dicofol	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dieldrin	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endosulfan Sulfate	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endosulfan-I	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endosulfan-II	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin Aldehyde	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin Ketone	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Heptachlor	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Heptachlor Epoxide	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Methoxychlor	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Mirex	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Oxychlordane	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Perthane	5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Toxaphene	10	50	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
cis-Nonachlor	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
trans-Nonachlor	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PAHs (ng/wet g)																		
1-Methylnaphthalene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
1-Methylphenanthrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,3,5-Trimethylnaphthalene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,6-Dimethylnaphthalene	1	5	<1	1.2J	4.3J	6.8	5.5	5.7	<1	3.2J	4.8J	<1	<1	<1	<1	5.2	<1	<1
2-Methylnaphthalene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthylene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Anthracene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benz[a]anthracene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[a]pyrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[b]fluoranthene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[e]pyrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[g,h,i]perylene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo[k]fluoranthene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Biphenyl	1	5	9.8	5.4	4.4J	4J	5.7	5.5	5.3	5.1	4.4J	10.2	<1	8.9	6.8	7.6	9.2	6.2
Chrysene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenz[a,h]anthracene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzothiophene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	1	5	10.1	<1	7	<1	7.1	12.7	7.5	7.1	5.8	<1	10.9	6.8	10	10	9.9	14.5
Fluorene	1	5	<1	<1	<1	<1	<1	<1	<1	2.4J	5.1	7.2	<1	<1	<1	<1	<1	<1
Indeno[1,2,3-c,d]pyrene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table 43. *Macoma nasauta* Tissue Chemistry Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	MDL	RL	Composite ID															Day 0
			GO 1-2-3					GO 6-7-8					GO 5					
			North Alternative Area					Northwest Alternative Area					Proposed Reference Site					
			Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	
Naphthalene	1	5	5.7	4.8J	4.4J	3.5J	6.5	12.8	6	14.5	6.4	12	<1	9.7	13.9	3.9J	8.4	<1
Perylene	1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phenanthrene	1	5	10.6	4.7J	7.7	13.7	5	8.3	15.2	6.3	4.1J	13.2	10.6	2J	9.1	<1	9.7	52.9
Pyrene	1	5	72.8	47.8	72.5	94.1	65.4	78.4	44.1	40.4	63	29.1	110.7	112	88	86.1	55.4	6.9

Table 44. Nephtys caecoides and Macoma nasuta Tissue Chemistry (Dioxins and Furans) Results for Bioaccumulation Potential Tests of North and Northwest Alternative Project Sediment and Proposed Reference Site Sediment.

Analyte	Units	*Nephtys caecoides*								*Macoma nasuta*							
		GO 1,2,3	EDL	GO 6,7,8	EDL	GO 5	EDL	DAY 0	EDL	GO 1,2,3	EDL	GO 6,7,8	EDL	GO 5	EDL	DAY 0	EDL
Dioxins																	
2,3,7,8-Tetra CDD *	pg/g	<0.190	0.190	<0.129	0.129	<0.153	0.153	<0.189	0.189	<0.168	0.168	<0.163	0.163	<0.196	0.196	<0.161	0.161
1,2,3,7,8-Penta CDD	pg/g	<0.163	0.163	<0.134	0.134	<0.171	0.171	<0.237	0.237	0.354	0.193	<0.139	0.139	<0.186	0.186	<0.197	0.197
1,2,3,4,7,8-Hexa CDD	pg/g	<0.198	0.198	<0.225	0.225	<0.187	0.187	<0.243	0.243	<0.326[1]	0.326	<0.186	0.186	<0.218	0.218	<0.212	0.212
1,2,3,6,7,8-Hexa CDD	pg/g	<0.213	0.213	<0.242	0.242	<0.202	0.202	<0.262	0.262	<0.240	0.240	<0.200	0.200	<0.235	0.235	<0.229	0.229
1,2,3,7,8,9-Hexa CDD	pg/g	<0.208	0.208	<0.237	0.237	0.245	0.197	<0.256	0.256	0.488	0.234	<0.195	0.195	0.340	0.229	<0.224	0.224
1,2,3,4,6,7,8-Hepta CDD	pg/g	1.95	0.162	1.41	0.171	<2.07[1]	2.07	1.13	0.221	1.01	0.169	0.924	0.177	0.744	0.148	0.878	0.234
Octa CDD	pg/g	13.6	0.321	9.92	0.282	17.5	0.288	6.03	0.389	5.35	0.332	5.57	0.358	4.16	0.341	3.19	0.348
Total Tetra CDD	pg/g	<0.263[1]	0.263	<0.129	0.129	<0.153	0.153	<0.485[1]	0.485	0.258	0.168	<0.266[1]	0.266	<0.196	0.196	0.191	0.161
Total Penta CDD	pg/g	<0.163	0.163	<0.134	0.134	<0.447[1]	0.447	<1.00[1]	1.00	0.354	0.193	<0.139	0.139	<0.186	0.186	<0.340[1]	0.340
Total Hexa CDD	pg/g	0.219	0.211	<0.240	0.240	0.755	0.200	<0.260	0.260	0.488	0.238	<0.198	0.198	0.340	0.232	<0.227	0.227
Total Hepta CDD	pg/g	3.38	0.162	2.61	0.171	1.61	0.128	2.11	0.221	1.56	0.169	0.924	0.177	1.41	0.148	0.878	0.234
ΣCDD		17.625		13.033		20.465		9.89		8.01		7.097		6.292		4.826	
Furans																	
2,3,7,8-Tetra CDF **	pg/g	<0.304[1]	0.304	0.184	0.128	0.199	0.144	0.263	0.206	0.223	0.202	<0.190	0.190	0.274	0.134	0.239	0.187
1,2,3,7,8-Penta CDF	pg/g	<0.218	0.218	<0.186	0.186	<0.165	0.165	<0.278	0.278	<0.232	0.232	<0.182	0.182	<0.243	0.243	<0.168	0.168
2,3,4,7,8-Penta CDF	pg/g	<0.205	0.205	<0.176	0.176	<0.156	0.156	<0.262	0.262	<0.377[1]	0.377	0.341	0.172	0.287	0.229	<0.158	0.158
1,2,3,4,7,8-Hexa CDF	pg/g	<0.137	0.137	<0.169	0.169	<0.177	0.177	<0.218	0.218	0.297	0.175	<0.136	0.136	<0.197	0.197	<0.147	0.147
1,2,3,6,7,8-Hexa CDF	pg/g	<0.151	0.151	<0.186	0.186	<0.195	0.195	<0.241	0.241	<0.209[1]	0.209	<0.150	0.150	<0.218	0.218	<0.163	0.163
2,3,4,6,7,8-Hexa CDF	pg/g	<0.143	0.143	<0.176	0.176	<0.184	0.184	<0.227	0.227	<0.182	0.182	0.217	0.142	<0.205	0.205	<0.153	0.153
1,2,3,7,8,9-Hexa CDF	pg/g	<0.144	0.144	<0.177	0.177	<0.186	0.186	<0.229	0.229	0.494	0.184	<0.143	0.143	<0.207	0.207	<0.155	0.155
1,2,3,4,6,7,8-Hepta CDF	pg/g	<0.651[1]	0.651	<0.538[1]	0.538	<0.951[1]	0.951	<0.449[1]	0.449	<0.405[1]	0.405	<0.404[1]	0.404	<0.326[1]	0.326	<0.289[1]	0.289
1,2,3,4,7,8,9-Hepta CDF	pg/g	<0.176	0.176	<0.141	0.141	<0.139	0.139	<0.197	0.197	<0.399[1]	0.399	<0.172	0.172	<0.197	0.197	<0.210	0.210
Octa CDF	pg/g	1.41	0.273	<1.11[1]	1.11	1.70	0.284	0.900	0.412	<0.885[1]	0.885	0.695	0.301	0.766	0.347	0.764	0.318
Total Tetra CDF	pg/g	0.374	0.180	0.463	0.128	0.199	0.144	0.731	0.206	0.223	0.202	0.345	0.191	0.274	0.134	0.546	0.187
Total Penta CDF	pg/g	<0.211	0.211	<0.181	0.181	<0.161	0.161	<0.270	0.270	<0.377[1]	0.377	0.341	0.177	0.287	0.236	<0.163	0.163
Total Hexa CDF	pg/g	0.218	0.144	<0.177	0.177	0.427	0.185	<0.228	0.228	0.790	0.183	0.217	0.143	<0.207	0.207	<0.154	0.154
Total Hepta CDF	pg/g	<0.861[1]	0.861	1.14	0.131	1.56	0.129	<0.449[1]	0.449	<0.423[1]	0.423	0.534	0.159	<0.357[1]	0.357	<0.289[1]	0.289
ΣCDF		3.074		3.071		4.05		2.578		2.698		2.132		1.891		1.916	

EDL = Estimated Detection Limit
CDD = Chloro Dibenzo-p-Dioxin
CDF = Chloro Dibenzo-p-Furan
[1] = EMPC / NDR - Peak detected does not meet ratio criteria and has resulted

Northwest Alternative Area

With the exception of antimony, beryllium, and thallium, all *N. caecoides* tissue samples exposed to Northwest Alternative project sediment (composite sample ID GO 6-7-8) had detectable concentrations of target metals (Table 42). Average metals concentrations of tissue samples exposed to North Alternative study area project sediment were as follows: aluminum (6.42 µg/wet g); arsenic (3.18 µg/wet g); barium (0.144 µg/wet g); cadmium (0.207 µg/wet g); chromium (0.197 µg/wet g); cobalt (0.501 µg/wet g); copper (2.08 µg/wet g); iron (69.7 µg/wet g); lead (0.083 µg/wet g); manganese (1.73 µg/wet g); mercury (0.016 µg/wet g); molybdenum (0.383 µg/wet g); nickel (1.28 µg/wet g); selenium (0.939 µg/wet g); silver (0.146 µg/wet g); strontium (21.6 µg/wet g); tin (0.066 µg/wet g); titanium (0.346 µg/wet g); vanadium (2.56 µg/wet g); zinc (33.8 µg/wet g).

All PCBs (both individual congeners and Aroclors) were not detected at concentrations greater than the MDL. Only one chlorinated pesticide (4,4'-DDD) was detected in each of the five replicate samples ranging in concentration from 39.0 to 199.7 ng/wet g. Several PAHs, including 1-methylnaphthalene, 2,6-dimethylnaphthalene, 2-methylnaphthalene, acenaphthylene, anthracene, benzo[k]fluoranthene, chrysene, fluorene, naphthalene, and phenanthrene, were detected in low concentrations in one or more replicates from tissue samples exposed to Northwest Alternative area project sediment. Of these PAHs, only 2,6-dimethylnaphthalene, fluorine, and naphthalene were measured in day zero tissue samples. Dioxins and furans were also detected in tissue samples exposed to North Alternative area project sediment (13.0 pg/g and 3.07 pg/g, respectively); however, these two groups were also detected in day zero tissue samples (Table 44).

With the exception of silver, several PAHs, and 4,4'-DDT, all chemical concentrations in *N. caecoides* tissue were similar (less than or within 1.5 times) to day zero concentrations. Concentrations of silver in tissue samples exposed to Northwest Alternative area project sediment were greater than 2.5 times the concentration of silver in day zero tissue samples. Several PAHs, including 1-methylnaphthalene, 2-methylnaphthalene, acenaphthylene, anthracene, benzo[k]fluoranthene, chrysene, and phenanthrene were not detected in day zero tissue samples. The concentration of 4,4'-DDT in two of the five replicate tissue samples exposed to Northwest Alternative area project sediment was 1.5 times to 2.5 times the concentration measured in day zero tissue samples.

Proposed Reference Area

With the exception of antimony, beryllium and thallium, all *N. caecoides* tissue samples exposed to the proposed reference site project sediment (composite sample ID GO 5) had detectable concentrations of target metals (Table 42). Average metals concentrations of tissue samples exposed to North Alternative study area project sediment were as follows: aluminum (2.42 µg/wet g); arsenic (3.43 µg/wet g); barium (0.096 µg/wet g); cadmium (0.205 µg/wet g); chromium (0.071 µg/wet g); cobalt (0.473 µg/wet g); copper (1.91 µg/wet g); iron (63.6 µg/wet g); lead (0.080 µg/wet g); manganese (1.25 µg/wet g); mercury (0.014 µg/wet g); molybdenum (0.378 µg/wet g); nickel (1.22 µg/wet g); selenium (0.918 µg/wet g); silver (0.203 µg/wet g); strontium (21.0 µg/wet g); tin (0.061 µg/wet g); titanium (0.280 µg/wet g); vanadium (2.91 µg/wet g); zinc (35.9 µg/wet g).

All PCBs (both individual congeners and Aroclors) were not detected at concentrations greater than the MDL. Only one chlorinated pesticide (4,4'-DDD) was detected in each of the five replicate samples ranging in concentration from 61.4 to 118.9 ng/wet g. Several PAHs, including 1-methylnaphthalene, 2,6-dimethylnaphthalene, 2-methylnaphthalene, chrysene, fluorene, naphthalene, and phenanthrene, were detected in low concentrations in one or more replicates from tissue samples exposed to the proposed reference site project sediment. Of these PAHs, only 2,6-dimethylnaphthalene, fluorine, and naphthalene were measured in day zero tissue samples. Dioxins and furans were also detected in tissue samples exposed to the proposed reference site project sediment (20.5 pg/g and 4.05 pg/g, respectively); however, these two groups were also detected in day zero tissue samples (Table 44).

With the exception of silver, several PAHs, dioxins and furans, all chemical concentrations in *N. caecoides* tissue were similar (less than or within 1.5 times) to day zero concentrations. Concentrations of silver in tissue samples exposed to Northwest Alternative area project sediment were greater than 3.5 times the concentration of silver in day zero tissue samples. Several PAHs, including 1-methylnaphthalene, 2-methylnaphthalene, chrysene, and phenanthrene were not detected in day zero tissue samples. Total detectable dioxins were measured in tissue samples exposed to the proposed reference site project sediment at concentrations greater than 2 times the day zero tissue samples and total detectable furans were measured in tissue samples exposed to the proposed reference site project sediment at concentrations greater than 1.5 times the day zero tissue samples.

4.3.3.2 Macoma nasuta Tissue Chemistry

North Alternative Area

With the exception of antimony, beryllium, thallium and tin, at least one of the five replicate *M. nasuta* tissue samples exposed to North Alternative project sediment (composite sample ID GO 1-2-3) had detectable concentrations of each of the target metals (Table 43). Average metals concentrations of tissue samples exposed to North Alternative study area project sediment were as follows: aluminum (31.4 µg/wet g); arsenic (1.80 µg/wet g); barium (1.78 µg/wet g); cadmium (0.026 µg/wet g); chromium (0.107 µg/wet g); cobalt (0.148 µg/wet g); copper (2.44 µg/wet g); iron (84.5 µg/wet g); lead (0.130 µg/wet g); manganese (3.90 µg/wet g); mercury (0.010 µg/wet g); molybdenum (0.464 µg/wet g); nickel (0.369 µg/wet g); selenium (0.357 µg/wet g); silver (0.081 µg/wet g); strontium (10.0 µg/wet g); titanium (0.684 µg/wet g); vanadium (0.216 µg/wet g); zinc (10.9 µg/wet g).

All PCBs (both individual congeners and Aroclors) were not detected at concentrations greater than the MDL. Only one chlorinated pesticide (2,4'-DDE) was detected in three of the five replicate samples ranging in concentration from 10.8 to 15.1 ng/wet g. Several PAHs, including 2,6-dimethylnaphthalene, biphenyl, fluoranthene, naphthalene, phenanthrene and pyrene were detected in low concentrations in one or more replicates from tissue samples exposed to North Alternative area project sediment. Concentrations of biphenyl, fluoranthene, phenanthrene, and pyrene were measured in day zero tissue samples. Dioxins and furans were also detected in tissue samples exposed to North Alternative area project sediment (8.01 pg/g and 2.70 pg/g, respectively); however, these two groups were also detected in day zero tissue samples (Table 44).

With the exception of several metals, PAHs and total detectable dioxins, all chemical concentrations in *M. nasuta* tissue were similar (less than or within 1.5 times) to day zero concentrations. Concentrations of aluminum, barium, chromium, cobalt, iron, manganese, nickel, titanium, and vanadium in tissue samples exposed to North Alternative area project sediment were greater than 1.5 times the concentration of these metals measured in day zero tissue samples. Two PAHs, 2,6-dimethylnaphthalene, and naphthalene were not detected in day zero tissue samples. Total detectable dioxins were 1.6 times the day zero concentration.

Northwest Alternative Area

With the exception of antimony, beryllium, cadmium, thallium, and tin, *M. nasuta* tissue samples exposed to Northwest Alternative project sediment (composite sample ID GO 6-7-8) had detectable concentrations of each of the target metals (Table 43). Average metals concentrations of tissue samples exposed to Northwest Alternative study area project sediment were as follows: aluminum (39.8 µg/wet g); arsenic (1.62 µg/wet g); barium (4.91 µg/wet g); chromium (0.127 µg/wet g); cobalt (0.152 µg/wet g); copper (2.54 µg/wet g); iron (93.4 µg/wet g); lead (0.123 µg/wet g); manganese (5.22 µg/wet g); mercury (0.010 µg/wet g); molybdenum (0.445 µg/wet g); nickel (0.371 µg/wet g); selenium (0.343 µg/wet g); silver (0.072 µg/wet g); strontium (11.9 µg/wet g); titanium (0.768 µg/wet g); vanadium (0.249 µg/wet g); zinc (10.8 µg/wet g).

All PCBs (both individual congeners and Aroclors) were not detected at concentrations greater than the MDL. Only one chlorinated pesticide (2,4'-DDE) was detected in each of the five replicate samples ranging in concentration from 9.7 to 68.9 ng/wet g. Several PAHs, including 2,6-dimethylnaphthalene, biphenyl, fluoranthene, naphthalene, phenanthrene, and pyrene were detected in low concentrations in one or more replicates from tissue samples exposed to Northwest Alternative area project sediment. Concentrations of biphenyl, fluoranthene, phenanthrene, and pyrene were measured in day zero tissue samples. Dioxins and furans were also detected in tissue samples exposed to Northwest Alternative area project sediment (7.10 pg/g and 2.13 pg/g, respectively); however, these two groups were also detected in day zero tissue samples (Table 44).

With the exception of several metals and PAHs, all chemical concentrations in *M. nasuta* tissue were similar (less than or within 1.5 times) to day zero concentrations. Concentrations of aluminum, barium, chromium, cobalt, iron, manganese, nickel, titanium, and vanadium in tissue samples exposed to Northwest Alternative area project sediment were greater than 1.5 times the concentration of these metals measured in day zero tissue samples. Two PAHs, 2,6-dimethylnaphthalene, and naphthalene were not detected in day zero tissue samples.

Proposed Reference Area

With the exception of antimony, beryllium, thallium and tin, *M. nasuta* tissue samples exposed to the proposed reference site project sediment (composite sample ID GO 5) had detectable concentrations of each of the target metals (Table 43). Average metals concentrations of tissue samples exposed to the proposed reference site project sediment were as follows: aluminum (37.5 µg/wet g); arsenic (1.58 µg/wet g); barium (2.76 µg/wet g); cadmium (0.254 µg/wet g); chromium (0.144 µg/wet g); cobalt (0.150 µg/wet g); copper (2.29 µg/wet g); iron (89.8 µg/wet g); lead (0.117 µg/wet g); manganese (3.37 µg/wet g); mercury (0.010 µg/wet g); molybdenum (0.438 µg/wet g); nickel (0.352 µg/wet g); selenium (0.334 µg/wet g); silver (0.083 µg/wet g); strontium (11.8 µg/wet g); titanium (0.754 µg/wet g); vanadium (0.244 µg/wet g); zinc (11.3 µg/wet g).

All PCBs (both individual congeners and Aroclors) were not detected at concentrations greater than the MDL. Only one chlorinated pesticide (2,4'-DDE) was detected in each of the five replicate samples ranging in concentration from 22.6 to 46.3 ng/wet g. Several PAHs, including 2,6-dimethylnaphthalene, biphenyl, fluoranthene, naphthalene, phenanthrene, and pyrene were detected in low concentrations in one or more replicates from tissue samples exposed to the proposed reference site project sediment. Concentrations of biphenyl, fluoranthene, phenanthrene, and pyrene were measured in day zero tissue samples. Dioxins and furans were also detected in tissue samples exposed to the proposed reference site project sediment (6.29 pg/g and 1.89 pg/g, respectively); however, these two groups were also detected in day zero tissue samples (Table 44).

With the exception of several metals, PAHs and 2,4'-DDE, all chemical concentrations in *M. nasuta* tissue were similar (less than or within 1.5 times) to day zero concentrations. Concentrations of aluminum, barium, chromium, cobalt, iron, manganese, nickel, titanium, and vanadium in tissue samples exposed to the proposed reference site project sediment were greater than 1.5 times the concentration of these metals measured in day zero tissue samples. Two PAHs, 2,6-dimethylnaphthalene and naphthalene were not detected in day zero tissue samples. In two replicates, 2,4'-DDE in tissue samples exposed to the proposed reference site project sediment was greater than 1.5 times the concentrations found in day zero samples.

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