APPENDIX L

Sediment Dynamics Study Report

APPENDIX L

DRAFT

HUNTERS POINT SHIPYARD PARCEL F

SEDIMENT DYNAMICS STUDY REPORT

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EXECUTIVE SUMMARY

This report presents the results of a sediment dynamics study of the offshore area (Parcel F) at the Hunters Point Shipyard (HPS) in San Francisco, CA. The primary objectives of the sediment dynamics study were to 1) characterize sediment flux at selected locations around HPS under typical summer and winter conditions; 2) predict regional sediment transport patterns around HPS through modeling; and 3) predict sediment resuspension and transport under extreme weather conditions. The results of this study will be used to support the evaluation of sediment management options for Parcel F.

Time-series measurements of currents, waves, suspended sediment concentrations, temperature, and salinity were collected at three stations at HPS in winter and summer 2001 using Sediment Transport Measurement Systems (STMS). The principal objective of the deployments was to collect site-specific hydrodynamic data during winter and summer. During winter in San Francisco Bay, frequent storms typically cause strong southerly winds and local flooding. During summer, persistent northerly to northwesterly winds usually occur, with little to no rainfall. This study addressed the significant contrasts in sediment transport in the region that might be caused by seasonal differences in physical forcing.

The STMS data were used to estimate the magnitude and direction of suspended sediment flux over each deployment period at the three stations. The STMS data also were used in a one-dimensional (1D) bottom boundary layer and sediment transport model to predict hydrodynamic bottom stresses at each site. The model provides predictions of bottom stresses due to the combined influences of waves and currents. These results were used to estimate the frequency of sediment resuspension at the three stations during winter and summer. Regional hydrodynamic and sediment transport patterns were characterized using a regional hydrodynamic and sediment transport model.

Near-bottom tidal and residual currents were most energetic at Station North 1 on the north side of HPS near Point Avisadero. Analysis of the STMS measurements and the 1D modeling indicated that surficial bottom sediment was resuspended by flood and ebb currents during spring tides at Station North 1, and significant flux of the resuspended materials occurred. The cumulative flux over the deployment period estimated from the measurements was about 1.66×10^8 g/m toward the SE. No resuspension by wave-induced bottom stresses at this site was predicted. Small near-bottom wave velocities were caused by the relatively small amplitude waves. Regional modeling results showed that bottom sediments in the vicinity of Station North 1 are potentially subject to weak to moderate erosion by tidal currents, and are potentially subject to waves during extreme events.

Currents and waves at the two shallow stations in South Basin on the south side of HPS were typically small except during winter storms. Wave-induced bottom stresses during infrequent storms of 1-3 days duration exceeded estimated critical stresses that were required to resuspend the surficial and cohesive bottom sediment. During one storm event in late January 2001, calculated bottom stresses were quite large, and likely eroded into the sediment bed in South Basin. Otherwise, during both seasons, wave energy and residual currents were quite low, and circulation in South Basin was sluggish. Suspended sediment that entered this region likely accumulated except during the infrequent, brief but energetic winter storm events. Regional modeling of tidal circulation and sediment resuspension indicated that South Basin is generally a region of sediment accumulation, largely because it is sheltered by the surrounding land area. The results from this study suggest that, although bottom sediment in South Basin was infrequently mobilized by increased wave and current stresses during storms, no appreciable transport occurred.

During extreme storm events when strong southerly winds generate waves that propagate into South Basin from the S-SE, erosion of bottom sediment likely would occur. However, subsequent transport throughout South Basin during extreme events cannot be quantified with existing field or model data.

Overall, this study provides site-specific information that can be used to predict the fate and transport of sediment-bound contaminants at HPS. This information will be used in the FS along with other lines of evidence (e.g. horizontal and vertical distribution of contamination, radioisotope profile data) to support the development of remedial alternatives for sediment.

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ACRONYMS AND ABBREVIATIONS

1D	one dimensional
2D	two dimensional
ADV	Acoustic Doppler Velocimeter
CDFG	(State of) California Department of Fish and Game
DF	Dispersive Flux
FS	Feasibility Study
HPS	Hunters Point Shipyard
LPF	low-pass filter
MLLW	mean lower low water
NA	not applicable
NOAA	National Oceanographic and Atmospheric Administration
OBS	optical backscattering sensor
psu	practical salinity units
RAF	Residual Advective Flux
SDF	Stokes Drift Flux
SSC	suspended sediment concentrations
STMS	Sediment Transport Measurement Systems
SWP	Southwest Piling
WHG	Woods Hole Group

1.0 INTRODUCTION

This appendix presents the results of a sediment dynamics study of the offshore area (Parcel F) at the Hunters Point Shipyard (HPS) in San Francisco, CA (Figure 1-1). The primary objectives of the sediment dynamics study were to 1) characterize sediment flux at selected locations around HPS under typical summer and winter conditions; 2) predict regional sediment transport patterns around HPS through modeling; and 3) predict sediment resuspension and transport under extreme weather conditions. The results of this study will be used to support the evaluation of sediment management options for Parcel F.

1.1 Background

Many contaminants associated with sediments at HPS and throughout San Francisco Bay are adsorbed onto fine-grained particles (clays and fine silts). The eventual fate of these contaminants is determined largely by processes that control resuspension and flux of sediments within the bay. Processes that may affect the mobilization and transport of sediments at HPS include tides, wind, waves, bottom currents, surface water runoff, and benthic biological activity. Other factors such as sediment characteristics, physical structures along the shoreline, the orientation of the embayment on the southern side of HPS (i.e., South Basin), and water and sediment discharged from Yosemite Creek could also influence sediment transport within local areas (Figure 1-1).

An initial evaluation of the potential for sediment resuspension at HPS based on available regional data indicated that average wave conditions in both the summer and winter were likely to cause periodic resuspension in shallow areas (Battelle and Woods Hole Group, 2000). Additionally, it was determined that tidal currents could remobilize unconsolidated surficial sediment at maximum ebb and flood flows during spring tides. However, the initial analysis lacked site-specific data on wave, current, and bottom sediment conditions around HPS, and therefore the results were only qualitative. Consequently, a site-specific sediment dynamics program was developed for the *Hunters Point Shipyard Parcel F Validation Study Work Plan* (Battelle et al., 2001). The program included collection and analysis of hydrodynamic data during winter and summer seasons of 2001, as described in the following subsection.

1.2 Technical Approach

The technical approach used for the sediment dynamics study included the following elements:

- Collection of field data from three stations at HPS over two one-month deployment periods;
- Direct calculation of sediment flux at the three stations using the field data;
- One dimensional (1D) modeling to determine bed shear stress at each of the stations; and
- Two dimensional (2D) regional sediment transport modeling to characterize sediment transport patterns and predict the potential effect of an extreme weather event.

Field measurements were collected at three offshore stations around HPS for approximately one month in January-February 2001 and July-August 2001 using Sediment Transport Measurement Systems (STMS). Parameters measured included currents, waves, suspended sediment concentrations, temperature, and salinity. Each STMS consisted of instrumentation mounted on a deployment platform as described in Section 2.1. These measurements provided time-series data on flows and suspended sediment concentrations representing two distinctly different seasons.

The STMS data were used to estimate the magnitude and direction of suspended sediment flux over the deployment period at each of the three stations. The STMS data also were used in conjunction with sediment grain-size data in a 1D bottom boundary layer model to predict hydrodynamic bottom stresses at

each station (Cacchione and Drake, 1990; Wiberg and Harris, 1994). The 1D model provided predictions of bottom stresses due to the combined influences of waves and currents, and was used to estimate the frequency of sediment resuspension at the study sites. The regional current and sediment transport patterns were characterized using hydrodynamic and sediment transport models (RMA-2; Roig et al., 1996). Study methods are described further in Sections 2.0 and 3.0.

1.3 Hydrodynamic Setting

HPS is located on the west side of South San Francisco Bay in the City of San Francisco (Figure 1-1). The shoreline at HPS trends generally N-S, but is highly irregular because of the piers and other man-made structures at the former shipyard. An E-W embayment (South Basin) is located to the south of HPS. Yosemite Creek discharges into the west end of South Basin. Yosemite Creek is shallow (i.e., less than 1 m deep at high tide) and is an outlet for a City of San Francisco combined sewer overflow. No flow data are available for Yosemite Creek. India Basin is a shallow embayment located to the north of HPS.

Water depths immediately adjacent to HPS in India Basin are approximately 7-8 m mean lower low water (MLLW), increasing to 13-22 m in the adjacent shipping channel to the east of HPS (Figure 1-2). Water depths in within South Basin range from approximately 2 m to less than 1 m. The tidal range is approximately 3 m. The sediments to the north of HPS near Point Avisadero are mixed fine silt, clay, and coarser material in varying amounts. Sediments in South Basin are predominantly fine silts and clays ("muds").

Water movement in South San Francisco Bay is driven by tides, winds, and freshwater flow from seasonal streams. Conomos and Peterson (1977) presented an early summary of the general water properties, circulation, and tidal flows in San Francisco Bay. More recent discussions about hydrodynamic conditions in South San Francisco Bay can be found in Cheng and Gartner (1985) and Walters et al. (1985).

Hydrodynamic conditions show strong seasonal differences in San Francisco Bay, which are expected to lead to significant seasonal differences in sediment transport. During the summer, persistent northerly to northwesterly winds usually occur, with little to no rainfall. During the winter, frequent storms (cyclonic low-pressure atmospheric systems) transit the region and cause strong, gusty S-SE winds over the South Bay. These storms often bring substantial rainfall to local land areas with subsequent runoff into the bay (Cheng and Gartner, 1985). Local streams and small creeks that enter South San Francisco Bay discharge varying amounts of sediment and freshwater during and after flooding. Winter runoff into North San Francisco Bay and Delta from the Sacramento and San Joaquin River systems influences water levels and flows in South San Francisco Bay; however, the exchange of water between North and South San Francisco Bays, and the effects of this exchange on circulation and sediment transport are not well understood (Walters et al., 1985).

1.4 Report Organization

This Sediment Dynamics Study Report is organized as follows:

Section 1.0: **Introduction**.
Section 2.0: **Data Collection Program**. Details regarding the collection of hydrodynamic data at HPS are described in this section.
Section 3.0: **Data Analysis Methods**. Methods used to analyze and interpret the field-collected data are described in this section.

Section 4.0: **Hydrodynamic Data**. The results of the field data collection program are presented in this section.

Section 5.0: **Determination of Sediment Flux and Resuspension.** This section presents an evaluation of suspended sediment flux at three HPS stations and determination of bottom stresses using a 1D sediment transport model.

Section 6.0: **Regional Sediment Transport Patterns**. This section presents the results of the regional hydrodynamic and sediment transport modeling.

Section 7.0: **Summary and Conclusions**.

Section 8.0: **References**.

Supporting information is provided in Attachments L-1 through L-6.

2.0 FIELD PROGRAM

The STMS were deployed at three stations at HPS from January 15 through February 15, 2001 and from July 17 through August 14, 2001. Station locations and deployment periods are summarized in Tables 2-1 and 2-2 for the winter and summer deployments, respectively. One system was deployed northwest of Point Avisadero in India Basin (Station North 1) and two were deployed in South Basin (Stations South 1 and South 2) (Figure 2-1). Two of the three STMS stations (North 1 and South 1) were located in Parcel F areas that were determined to be the most likely to require sediment management (i.e., in Areas III and X, respectively, as described in the *HPS Parcel F Validation Study Work Plan* [Battelle et al., 2001]). The third station (South 2) was positioned in the center of a channel in South Basin to provide the best data for modeling hydrodynamics and sediment transport in South Basin.

Stations South 1 and South 2 were located in extremely shallow water. Prior to deployment, a bathymetric survey was conducted in South Basin to identify suitable deployment locations. The minimum feasible STMS deployment depth was approximately 1.7 m MLLW to avoid exposing the instruments to air during the extreme low spring tide, leading to gaps in data. The bathymetric data also were used to augment the sediment transport modeling for South Basin (see Section 6.0). The instrumentation used to collect the hydrodynamic data at HPS and the field collection programs conducted in the winter and summer of 2001 are described in following subsections.

2.1 Sediment Transport Measurement Systems

The Woods Hole Group (WHG) of Redwood City, CA designed and constructed three shallow water STMS platforms for the HPS sediment dynamics study. Each STMS included one wave-current meter; one optical backscattering sensor (OBS) which measured turbidity; temperature, and conductivity (salinity) sensors; a sonic altimeter to measure bed elevation; and a solid-state sampling, control, and recording data logger. Each system was designed to collect time-series measurements of each parameter near the seafloor for a one-month period. The STMS deployment platform was a freestanding tripod approximately 2 m in height with a triangular base approximately 2.5 m in diameter (Figure 2-2). The upper section of the tripod contained the electronics bay, which holds the current meter electronics, batteries, sonic altimeter, and self-contained conductivity/temperature recorder. An Acoustic Doppler Velocimeter (ADV) and OBS were suspended in the lower portion of the structure in an open area to minimize flow obstruction. An acoustic transponder was attached to one leg of the tripod to assist in tripod relocation and recovery, if necessary. The STMS instruments and their elevations above the bottom are listed in Tables 2-1 and 2-2. Instrument specification sheets are provided in Attachment L-1. The instruments that were used to measure waves, currents, tides, and suspended sediment concentrations are described in more detail below.

2.1.1 Wind Measurements

Wind and other atmospheric parameters (air temperature, relative humidity and barometric pressure) were measured at an HPS weather station that had been established for other studies. This meteorological station was situated on the northern side of HPS at a site that was partially shielded from the southern and western directions by local topography and buildings (Figure 2-1). This shielding may have reduced the measured wind speeds from those directions. Additional meteorological data were obtained from offshore buoys operated by the National Data Buoy Center to compare the local wind measurements to the regional winds and to compare winds during the two one-month deployment periods to multi-year statistics. Results of this comparison are discussed in Section 4.1.

2.1.2 Wave, Current and Tidal Measurements

Wave, current, and tidal measurements were obtained with a Sontek Hydra/ADV Ocean Wave Meter (i.e., Sontek ADV). This current meter measures flow along three principal orthogonal axes: x, y, and z. It has internal tilt and compass sensors that are used to transform x, y, and z velocities into east, north, and up velocities, respectively. The current meter sample cell was positioned approximately 90 cm above the seafloor. During the summer deployment a SEAPAC 2100 wave-current sensor was substituted ay Station North 1. Tide and wave measurements were collected with an internal strain gauge pressure sensor. The Sontek ADV and SEAPAC 2100 sampling schemes are described in Tables 2-3 and 2-4.

2.1.3 Suspended Sediment Measurements

Suspended sediment concentrations were measured using a D&A Instruments Optical Backscatter Sensor (OBS) Model 3 instrument. Each OBS was mounted about 90 cm above the tripod footpads. Each OBS recorded measurements using the same protocol as the Sontek ADV (Tables 2-3 and 2-4). Measurements were collected at 2 Hz during a 10-minute interval every hour over the one-month period of deployment. Each hourly set of measurements is referred to as a burst.

The use of an OBS for estimating suspended particulate concentrations is common in estuarine and marine environments, and they have been utilized in numerous studies of sediment transport (e.g., Schoellhamer, 1996; Sherwood et al., 1994; Cacchione and Drake, 1990). The OBS exhibits excellent linearity in response to suspended particulate concentrations in turbid water, making them a reasonable choice for these types of studies (Downing et al., 1981). However, OBS measurements are sensitive to sizes of the suspended particles in the sensing volume. Although the sensors were calibrated using local bottom sediment samples from HPS, the effects on the OBS data from suspended particulate matter that might have advected into the tripod site from upstream sources (e.g., algae, fish, and other organic matter) are uncertain. These types of effects have been discussed in previous studies, and add an undetermined uncertainty to the quantitative estimates of suspended sediment concentrations (Green and Boon, 1993; Bunt et al., 1999).

2.2 Field Operations Programs

The winter and summer 2001 field programs are described below. Meteorological data (wind speed and direction, air temperature, relative humidity and barometric pressure) for each deployment period were obtained from a weather station at HPS and from offshore buoys.

2.2.1 Winter Field Operations Program

Three STMS tripods were deployed on January 15, 2001, using an R/V Winner owned and operated by Brezina and Associates of Dillon Beach, CA. Upon arrival at each station, the tripods were lifted over the side with the small ship-mounted davit. The legs were extended and manually locked into position. After the final visual check of the sensors and instruments, each STMS was lowered to the bottom using a slip line. Two tide gauges also were deployed at Channel Markers 2 and 8 (Figure 2-1). Specific information regarding deployment dates and times, locations, and instrument positions are provided in Table 2-1.

Three surveys were conducted after the initial deployment. On January 19 surface buoys were deployed to protect the STMS tripods from potential damage due to commercial fishing operations. This action was in response to information provided by the California Department of Fish and Game (CDFG) regarding an unexpected increase in fishing activities associated with herring spawning in San Francisco Bay. During this survey, it was noted that the tide gauge deployed at Channel Marker 8 was missing. Also, the STMS tripod at Station North 1 was repositioned because of concerns about a possible

obstruction of the flow near the tripod. During the second post-deployment survey on January 29, 2001, STMS tripods were recovered and data were downloaded. The retrieved data were immediately reviewed to assess data quality. Data appeared acceptable, and the tripods were redeployed after the optical sensors were cleaned. A replacement tide gauge was installed on a piling on the southwest corner of HPS (designated as the Southwest Piling [SWP]) and additional warning buoys were installed near the deployment sites. The tide gauge was surveyed to a nearby established benchmark. The tide data were used to correct the hydrographic measurements to MLLW elevations.

The three STMS tripods were recovered successfully and without incident on February 15, 2001. At Stations South 1 and South 2, the tops of the STMS tripods were exposed above the water surface and a line was attached directly to the tripod for recovery. At Station North 1, a surface float attached to the tripod lifting bridle was recovered, and the tripod was lifted aboard the vessel. All surface markers were recovered prior to leaving the study area. Surface sediment samples were collected at each of the three sites during recovery operations using a grab sampler; grain-size data for these samples were used to calibrate the OBS (see Section 4.1.5 of this appendix).

2.2.2 Summer Field Operations Program

Three STMS tripods were redeployed at Stations North 1, South 1 and South 2 on July 17, 2001, using the R/V Winner (Figure 2-3). Two warning buoys were deployed at each tripod location. Two tide gauges were deployed on July 18, 2001; one approximately 3 mi north of HPS at South Beach Harbor and one approximately 4 miles south of HPS at Oyster Point Marina (Figure 2-3). The tide gauges were attached to triangular bottom mounts with a large load bearing base and a small (<1.0 psi) surface load to minimize any structural subsidence during deployment. Sampling protocols for each instrument are provided in Table 2-4.

Two surveys were conducted after the initial deployment. On August 2, 2001 the tripods were recovered and inspected, and the optical sensors were cleaned. The systems then were redeployed for an additional two weeks. The tripods, warning buoys, and tide gauges were successfully recovered on August 14, 2001. Upon recovery, condition of the optical windows and surrounding areas were noted. The OBS were immersed in seawater for transport and storage until optical characterization and calibration could be performed in the laboratory.

Bottom sediment samples for OBS calibration were collected from each station during the recovery cruise, and water column samples for OBS verification were collected from each station during the deployment, mid-deployment, and recovery cruises. OBS calibration and verification are discussed in Section 4.1.5 of this appendix.

3.0 DATA ANALYSIS METHODS

This section describes the methods used to 1) calculate sediment flux using the STMS data; 2) determine the bed shear stress using a 1D numerical model; 3) determine regional sediment transport patterns using a 2D numerical model; and 4) evaluate the potential effect of an extreme event.

3.1 Determination of Sediment Flux

The primary objective of the sediment flux calculations was to characterize sediment transport based on the STMS measurements at the three HPS stations during winter and summer conditions. The physical and geological parameters that are critical to understanding suspended sediment transport processes above the seabed include currents, waves, sediment sizes and concentrations, and water depth. These factors and their relevance to sediment transport have been discussed in numerous publications (e.g., Cacchione and Drake, 1990). Sediment flux at HPS was estimated directly from the site-specific measurements of velocity, suspended sediment concentration, and depth. Depth-integrated calculations of flux were made directly from the measurements. An important assumption in this technique is that the suspended sediment is well-mixed vertically (i.e., no appreciable stratification occurs due to suspended sediment). This assumption is generally acceptable for fine-grained shallow sedimentary environments, and has been used in other studies to estimate flux in San Francisco Bay (e.g., Lacy et al., 1996). Some of the limitations to this method are discussed more fully in Section 5.0 of this appendix.

STMS data collected in winter and summer 2001 were used to determine sediment flux at the three HPS stations. Unfortunately, failure of the OBS sensor at Station North 1 during the summer deployment precluded calculations of sediment flux for that site. In addition, biofouling and interference by in-water organisms degraded the suspended sediment concentration (SSC) data during summer at Station South 2 (see Section 4.2.5 of this appendix); consequently, sediment flux was not calculated for this station either.

Sediment flux was treated as a combination of modes that result from separation of current, SSC, and depth into fluctuating (tidal) and residual parts. The formulation of this technique and definition of the different modes are presented in Attachment L-2. The three most important modes at HPS are similar to those found by Lacy et al. (1996), and include flux induced by 1) residual currents, 2) time-correlated fluctuations of horizontal velocity and depth (a type of Stokes drift), and 3) products of velocity and suspended sediment concentrations over the water depth (dispersive flux). The results for the sediment flux calculations are presented in Section 5.1 of this appendix.

3.2 One-Dimensional Sediment Resuspension Modeling

A state-of-the-art, 1D bottom boundary layer and sediment transport model was used to calculate bed shear stress (τ_b) at the three STMS locations (Cacchione and Drake, 1990; Wiberg et al., 1994). The 1D model is based on the governing hydrodynamic equations for a stratified, fully turbulent bottom boundary layer in combined wave and current flows over a moveable sediment bed. The model was developed originally by Smith (1977) and Grant and Madsen (1979), but subsequently has been modified and improved by a number of other investigators (e.g., Glenn and Grant, 1987). The model was developed to predict the vertical profiles of wave and current velocities, bottom stresses, suspended sediment concentrations, and suspended sediment transport rates from inputs of wave, current, and bottom sediment parameters. The 1D bottom boundary layer and sediment transport model is described in more detail in Attachment L-3.

Estimating erosion of cohesive sediment beds remains a difficult task. Many studies of mobilization of cohesive bottom sediments have shown that erosion is a rate process that depends on many parameters including geotechnical properties of the bed, organic content, bioturbation, mineralogy, consolidation, and

history of sedimentation (Mehta et al., 1988). However, the key parameter influencing sediment mobility is critical bed stress (τ_c), the bottom stress required to resuspend the bed sediment. Estimates of τ_c were determined based primarily on sediment grain size analysis of surface and shallow subsurface sediment samples that were collected during the field program.

The loosely consolidated sediments that cover the bed surface (usually from several mm's to about 1 cm thick) are easily disturbed and entrained by fluid stresses. Typical values of τ_c are 0.08 to 0.1 Pa for surficial sediments (Whitehouse et al., 1999). Below the surficial layer, τ_c increases due to consolidation, dewatering, and other factors (Whitehouse et al., 1999). For bottom sediment below the surficial layer around HPS τ_c was assumed to be 0.3 Pa, a value that was used previously for San Francisco Bay sediments (McDonald and Cheng, 1997) and that falls in the range of typical τ_c values of 0.1 to 0.5 Pa that was reported for erosion of cohesive sediments in other studies (Roberts et al., 1998). The various input values that were chosen for the 1D modeling are discussed further in Attachment L-3.

3.3 Determination of Regional Sediment Transport Patterns

The STMS measured the near-bottom currents and sediment suspended above the bed in the water column at three HPS stations. To characterize the regional sediment transport patterns, these data were used to calibrate a 2D numerical sediment transport model. This section presents the formulation of the regional 2D model.

The RMA-2 model was used to estimate the regional flow patterns for this study (Roig et al., 1996). The grid for this model was developed to conform with the complex shoreline and bathymetry around HPS. The model theory and setup are discussed in detail in Attachment L-4.

3.3.1 Comparison of Modeled and Observed Currents

The National Oceanographic and Atmospheric Administration (NOAA) tidal current predictions for Station Number 349, located 0.3 mile east of HPS, were used to demonstrate the accuracy of the RMA-2 model in predicting depth-averaged tidal flow near HPS. The maximum tidal currents occurring during the winter deployment from February 5-9, 2001 were chosen for calibration of the model boundary conditions. The model predictions fit the NOAA data well, matching the observed flood and ebb velocities within 15% (Figure 3-1). The model overpredicted the current velocities only during maximum diurnal flood and ebb.

3.3.2 Two-Dimensional Regional Sediment Transport Modeling

The sediment transport modeling was developed to indicate regional areas of erosion potential and flux during tidal conditions present during the winter and summer deployment and an extreme tidal and wave event. Although the model was primarily applied to investigate regional sediment movement, specific areas of interest to the north and south of HPS also are examined.

Sediment transport is possible only after sediments are resuspended. Resuspension of bottom sediments is driven by bottom shear stress, which in turn is a function of the near bottom currents, as well as other factors. The near-bottom currents can be generated by ambient currents (tidal, wind driven) and/or waves. To estimate sediment transport, therefore, the influence of both waves and ambient currents needs to be considered. On a regional scale, the currents are dominated by tidal forcing because the relatively small (< 1 m) waves in the bay have no effect on bottom currents or bottom shear stress. However, wave-induced sediment resuspension is included in the extreme event analysis described in Section 3.4 so that the additional effect of waves on sediment resuspension in shallow waters can be calculated.

Greater shear stresses increase the ability to initiate sediment motion from the bed. Also, both the bathymetric conditions and the flow interaction with the geometry of the domain impact the sediment transport potential. The headlands, deep channels, and shallow basins present in the domain produce significant variation in transport potential. For example, areas which experience higher flow are subject to erosion, whereas others are more sheltered and are subject to deposition during the same time period.

A general erosion flux formulation that has been successfully used in the past for South San Francisco Bay was applied to the HPS model to determine erosion fluxes during various tidal extremes (McDonald and Cheng, 1997; Cheng et al., 1999; and Inagaki, 2000). The formulation is based on a simple approach where the estimated bottom shear stress is compared to the critical shear stress:

$$E = P\left(\frac{\tau_b}{\tau_c} - 1\right)$$

where E is the erosion flux in $g/m^2/s$, P is the erosion rate constant in $g/m^{2/}$-/s, τ_b is the bottom shear stress in Pascals, and τ_b is the critical shear stress for erosion for the sediment bed in Pascals. Critical shear stress is the critical value above which bed erosion will begin and is calculated here from grain size. The calculation of critical shear stress does not include the effects of cohesive sediments, bioturbation, and bed forms, but previous studies have shown these estimates to be reasonable. The total bottom shear stress is calculated from the combined effect of the wave-induced and current-induced shear stress:

$$\tau_b = \tau_{cur} + \tau_w$$

where τ_{cur} is the shear stress due to currents in Pascals and τ_w is the shear stress due to waves. More detail on the computation of the stresses and erosion parameters is included in Attachment L-4. If the bottom shear stress was greater than the critical shear stress for erosion, the area was assumed to be erosional (i.e., the sediment particle has the capability to be transported); otherwise, the area is classified as depositional (i.e., modeled shear stress is lower than the critical value). Depositional fluxes were not calculated as a part of this study due to the insufficient data available on SSC boundary conditions.

3.4 Evaluation of Extreme Events

By its nature, sediment transport in coastal regions tends to be episodic, occurring at times of peak tidal currents, storm-generated waves, or other extreme events and absent during quiescent periods. To quantify sediment transport in the study area, the implications of higher than normal tidal flow and wind-driven wave conditions must be considered. Extreme event analysis gives insight into the potential impacts on sediment resuspension at HPS due to these infrequent but significant events. During the El Nino event of 1997-98, higher than normal tides and storms created conditions that approximated a 100-year event. In the past one hundred years of sea-level records in the San Francisco Bay, no single event has exceeded the sea-level rise of storms during the 1997-98 El Nino.

In particular, on February 6, 1998, the largest storm of the winter struck the San Francisco Bay area. Tides were increased by an average of 0.6 m and peak winds of 17.9 m/s (35 knots) blew from the southeast. This event was simulated using the 2D hydrodynamic and sediment transport model based upon current data measured by the USGS during the 1998 storms and maximum wave height and period data from a similar southeast storm during the winter 2001 deployment. The results from this simulation are presented in Section 6.2.

4.0 HYDRODYNAMIC DATA

Hydrodynamic data collected at HPS in winter and summer 2001 are presented in this section. Additionally, sediment grab samples were collected from each station during the winter deployment and analyzed for grain size distribution. Sample results are provided in Attachment L-5. At Station North 1, bottom sediment sizes were mixed with about 33% sand, 30% coarse to medium silt, and about 37% fine silt and clay. In contrast, both South Basin sites were very fine-grained and cohesive. Sediments at Station South 1 were comprised of 73% clay, 20% fine silt, and about 7% medium silt. Station South 2 sediments were slightly coarser with 64% clay, 23% fine silt, and 13% medium silt. The coarser sediments at Station North 1 reflect a stronger energy regime due to the exposure to higher tidal flows in the nearby channel. The sediments at Station South 2 are slightly coarser then those at South 1 because of their closer proximity to channel tidal currents and greater exposure to N-NW winter storm waves.

4.1 Winter 2001

Measurements of currents, waves, suspended sediment concentrations, water level, bed elevation, temperature, and conductivity (salinity) were collected for the entire winter 2001 deployment period from the three STMS stations. In addition, hourly wind and other atmospheric data were obtained from the weather station located at HPS. A nearly complete data return was achieved for all parameters at all stations except as noted below. For Station North 1, only the data collected after January 19, 2001 when the tripod was relocated are included in the study.

4.1.1 Wind Data

Wind data collected from a weather station at HPS were provided to WHG by IT Corporation for this study. Wind speed and direction for the winter deployment periods are presented in Figures 4-1 and 4-2. A statistical summary of the measured wind data is provided in Table 4-1. Wind speeds and directions from January 15 through February 15 were variable. The diurnal sea breeze that often occurs in this region of San Francisco Bay was not well-developed during this winter period. Relatively strong sustained winds (~3-5 m/s) associated with winter storms were measured during four periods: January 15-16, January 22-25, February 5-9, and February 12-13. Peak sustained wind speeds exceeded 5.0 m/s during the storm of February 5-6. Mean wind over the entire measurement period was relatively light at 1.4 m/s (Table 4-1).

The potential inaccuracies of the wind speeds and directions associated with the placement of the meteorological station at HPS were discussed in Section 2.1.1 of this appendix. Wind data were obtained from offshore buoys maintained by the National Data Buoys Center for Station 46012, Half Moon Bay, (37.45N 122.70W) and Station 46026, San Francisco, (37.75 N 122.82 W) to evaluate the potential influence of sheltering on HPS wind data. Wind tends to be synoptic over large spatial scales of tens to several hundred kilometers, although the local influences of coastal mountains and the effect of locally generated sea breezes cannot be discounted. Figure 4-3 shows the wind speed and direction during the winter deployment period from offshore buoy 46012. Comparison with the HPS wind data presented in Figures 4-1 and 4-2 shows that the winds measured at the offshore buoy correlate well with the winds measured at the HPS for both speed and direction. However, the magnitude of the wind speed at the HPS meteorological station is three to four times lower than that measured at the offshore buoy. This is consistent with observations made in the field about sheltering of the wind sensor at the HPS meteorological station. However, the HPS wind data were not corrected for this study because they were not used in the sediment flux calculations or model calculations.

Figure 4-4 presents joint probability density functions of wind speed and direction during the winter deployment period (January 15th through February 15th) from the two offshore buoys. Figure 4-5

presents joint probability density functions of wind speed and direction for the winter season (October through March) for 2001, 2000, and 1997. By comparing the joint wind speed and direction density for the deployment period with the seasonal statistics for the year it is clear that wind conditions during the winter deployment period were generally typical for the season in magnitude although there were slightly greater occurrences of wind from the south and southeast. The seasonal mean wind speed was approximately 6 m/s and the maximum wind speeds for the season were measured at approximately 21 m/s, whereas the mean wind speed for the deployment period was about 6.5 m/s and the maximum about 18 m/s. By comparing the seasonal wind speed and direction distribution for the three-year period with the one-month deployment period it can be seen that the same pattern holds. Generally there were more occurrences of wind from the south and southeast during the one month deployment period than were observed in the seasonal statistics for the three-year period, but the magnitudes of the wind were about the same.

Hourly wind vectors throughout the winter experimental period are shown in polar plot format in Figure 4-2. The points in this plot represent the tips of hourly wind vectors (indicating speed and direction). The points are scattered over all of the quadrants, indicating variable wind directions throughout the period. However, highest wind speeds are generally situated in the NW and SE quadrants, and were typically associated with moderate to weak storms that transited the region. During the storm passages winds are dominantly from the south to southeast. As the storms pass winds typically shift to the northwest.

Atmospheric pressure was relatively high throughout the experimental period (mean ~ 1,025 mbars), and had significant low frequency cycles of about 2 weeks (Figure 4-1). The range of pressure levels over these low frequency cycles was about 20 mbars. Air temperature and relative humidity fluctuated daily but had no apparent trend. Mean air temperature was about 12°C.

4.1.2 Water Level Data

Water depths measured at each of the three deployment sites are shown in Figures 4-6, 4-7, and 4-8 (lower panels). The depth records clearly demonstrate the mixed nature of the local tidal fluctuations, with a maximum range of about 3.0 m on February 9 and 10 at Stations North 1 and South 2. The spring-neap tidal cycle is apparent in the depth records at all stations. The maximum difference in tidal range between spring and neap was about 1.5 m at Station North 1. As previously noted, the tripod at Station North 1 was relocated into slightly deeper water on January 19, and only the data collected after that time were used in this study to represent conditions at that station. Mean water depth during the period after relocation at Station North 1 was about 7.8 m (Table 4-2).

At Station South 1, the water level dropped below the pressure sensor over a portion of many tidal cycles causing “clipping” of the signal during low water (note the flat signal at low tide in Figure 4-7). The mean water depth was 1.9 m at this site (Table 4-2). The spring-neap cycles and mixed tidal character are obvious in the water level data at Station South 2 (Figure 4-8). Mean water depth at this station was 2.5 m (Table 4-2).

4.1.3 Current Data

N-S and E-W components of currents at about 90 cm above the bottom were measured at all three deployment sites (Table 4-2). Each measurement of current included contributions from all of the hydrodynamic processes that were active at the sites, including surface waves, tides, and low frequency (or residual) flows. Residual flows in San Francisco Bay have been described in previous studies, and are an important process for transporting suspended materials within the bay (Walters et al., 1985).

In the analysis of the current measurements, the N-S (v) and E-W (u) velocity components were represented as follows:

$$u = u_{sw} + u_{tide} + u_{res}$$
$$v = v_{sw} + v_{tide} + v_{res}$$

where the surface wave, tidal, and residual components of the velocity field are denoted with subscripts "sw," "tide," and "res," respectively. Flows to the N and E are positive and flows to the S and W are negative. Averages of the velocity component measurements (u.v) in each hourly burst were calculated to remove the contributions from surface waves. These hourly averages are referred to as "burst averages" and denoted u_{bavg} and v_{bavg}. Burst-averaged hourly speed U_c also was computed as follows:

$$U_c = \left(u_{bavg}^2 + v_{bavg}^2\right)^{1/2}$$

The hourly burst averages were passed through a low-pass filter (LPF) with a 33-hour cutoff to remove tidal fluctuations and generate an hourly series of residual velocities (u_{res}, v_{res}). Wave velocity components (u_{sw}, v_{sw}) were obtained by subtracting the appropriate hourly burst averages from each data point.

Values collected for u_{bavg} and v_{bavg} at the three deployment sites are shown in Figures 4-6, 4-7, and 4-8. The dominance of the eastward speed components $+u_{bavg}$ at Station North 1 can clearly be seen. Currents speeds U_c are plotted in Figures 4-9, 4-10, and 4-11. U_c reached 50 cm/s during spring tides on February 10, and daily peak speeds exceeded 20 cm/sec during neap tides from January 29 through February 6. The current speeds were considerably lower at Stations South 1 and South 2.

A statistical summary of the current data for all three deployment stations is provided in Table 4-2. Mean hourly current speeds at Stations North 1, South 1, and South 2 were 18 cm/s, 2.7cm/s, and 4.4 cm/s, respectively. At Station North 1, the mean hourly current was strongest in the eastward and southward quadrants (12.0 cm/s and -4.7 cm/s, respectively). Residual (LPF) currents were eastward and southward throughout the entire deployment period at Station North 1 (Figure 4-12) and were more variable at Stations South 1 and South 2 (Figures 4-13 and 4-14). The means of the current components at Stations South 1 and South 2 are quite low (<5 cm/s; Table 4-2). Because the ADV current meters have accuracies of ±1 cm/s and the record lengths were relatively short (~one month), the statistical confidence in the currents at South 1 and South 2 is reduced. Current speeds of less than about 2 cm/s have low statistical confidence. This factor does not render the results unusable, but values with low speeds (< ~2 cm/s) and directions for these low-speed currents have significant error bands.

The hourly burst-averaged current speeds and directions for each location are illustrated in polar plots (Figures 4-15, 4-16, and 4-17). Each point on the plot essentially represents the tip of the hourly burst-averaged current vector. Because the hourly burst averaged currents are dominated by tidal forcing, these vectors largely represent tidal flows. The dominant southeast current direction at Station North 1 is clearly shown in this type of display. The relatively tight cluster of current vectors along 330°-150° at Station South 1 essentially mimics the orientation of the embayment (Figure 1-1). The current vectors at Station South 2 are more dispersed (Figure 4-15), reflecting more variable flow conditions along the entrance to the embayment. However, there is a general ESE-WNW trend to the hourly current vectors at Station South 2.

As can be clearly observed in plots of u_{bavg} and v_{bavg} (Figures 4-6, 4-7, and 4-8), a progressive decrease in E-W current velocities can be observed from Station North 1 (highest) to Station South 1 (lowest). This decrease is explained by the positions of the sites: Station South 1 is situated well into the cove at South Basin, and is sheltered by surrounding land area, whereas Station North 1 is along the open waterfront and near the main channel in South San Francisco Bay (Figure 1-1). The differences in N-S current speeds at South 1 and 2 are not as dramatic. In fact, the N-S component speeds are slightly greater at Station South 1 during a few time periods, particularly around February 5-8.

Residual current speeds are relatively strong at Station North 1 compared to the other sites (Figures 4-12, 4-13, and 4-14). At Station North 1 the residual currents are persistently toward the southeast, suggesting that net movement of water and suspended materials will be in that direction. Walters et al. (1985) found similar easterly to southeasterly residual flows along the shallow margins of South San Francisco Bay based on analysis of earlier data. The weak residual flows at Stations South 1 and 2 have low confidence, but they indicate sluggish circulation within the embayment.

4.1.4 Wave Data

Measurements of surface waves were obtained at all three sites using pressure and velocity sensors. The results for significant wave height, spectral peak wave period, and near-bottom significant wave currents are shown in Figures 4-9, 4-10, and 4-11. A statistical summary of the wave data is provided in Table 4-2. Near-bottom wave currents were weak to moderate at Station North 1. Wave current velocities exceeded 6 cm/s during two periods (January 24-25 and February 5-12). These higher wave speeds were correlated with the periods of highest wind speeds at Station North 1 (Figure 4-1). Significant wave height at Station North 1 during these highest wave-speed events were rather small and barely exceeded 0.25 m. Peak spectral wave periods were less than 6 s throughout the record at Station North 1.

High bottom wave velocities at Stations South 1 and South 2 were observed during January 23-25 and February 9-12 (Figures 4-10 and 4-11). Winds that blew persistently and at moderate to high speeds from the S-SE, as is common during storms in this area, generated waves that propagated directly into the embayment at South Basin across the relatively long NW-SE fetch. For example, during February 9-12, increased wave heights and current speeds were measured at both South Stations during a period when winds were generally southerly. These high velocities also were caused by the shallow water depths at these stations. Near-bottom wave velocities exceeded 15 cm/s during these storm events, and reached 35 cm/s at Station South 2 on January 25. These high wave currents caused enhanced bottom stresses and sediment resuspension within the embayment. South Basin stations are essentially sheltered from N-NW winds, and waves that were generated by winds from these more northerly directions had little effect within the embayment.

4.1.5 Suspended Sediment Concentration Data

SSC values at one level above the bottom were calculated from the OBS data at each station. Each OBS sensor was calibrated using a surface sediment sample from the deployment site. Grain-size data for the sediment samples are provided in Attachment L-5, and OBS calibration procedures are described in Attachment L-6. As with the current data, hourly burst averages were calculated, plotted, and inspected for outliers. SSC data are presented in Figures 4-6, 4-7, and 4-8, along with water depth and hourly current velocity data. A statistical summary of SSC data is provided in Table 4-2. SSC values are considered to be reliable to about $\pm$10 mg/L.

SSC values at Station North 1 averaged about 63 mg/L (Table 4-2), with major peaks from about 150 to 265 mg/L (Figure 4-6). In general, the range of SSC due to tidal fluctuations averaged between 30 to 50 mg/L. SSC during neap tides from January 29 to February 4 were 27 to 56 mg/L, slightly less than

values measured during spring tides from January 20 to January 25. Significant increases in SSC occurred during a period of relatively strong southerly winds on January 23 to 25, and during the period of higher wind speeds on February 5-12. The highest SSC values of 265 mg/L were measured during the latter period of higher wind speeds, which also corresponded with spring tides from February 5 to February 12. Near-bottom wave velocities at Station North 1 also were elevated during this energetic period in early February (Figure 4-9).

SSC values at Station South 1 generally were < 100 mg/L (Figure 4-7). The mean SSC was 62 mg/L (Table 4-2). Southerly winds during January 23-25 generated higher wave speeds that were correlated with high SSC values in excess of 300 mg/L, with a maximum of over 700 mg/L. Similar to Station North 1, SSC again increased noticeably during spring tides and elevated wave speeds during February 9-12. SSC at Station South 2 had the same general patterns as those at South Station 1, with relatively high SSC values and high bottom wave velocities observed during January 23-25 (Figure 4-8). Mean SSC at Station South 2 was 56 mg/L (Table 4-2). As noted above, SSC data collected at Station South 2 after February 6 are unreliable because of apparent interference from herring spawn.

4.1.6 Temperature and Salinity Data

Temperature and salinity data from the three deployment stations are presented in Figures 4-18, 4-19, and 4-20. Statistical summaries are provided in Table 4-2. Mean water temperatures at all three stations over the deployment period were between 10°-10.5° C. Mean salinities were 28.6, 27.2, and 28.3 psu at Stations North 1, South 1, and South 2, respectively. Both temperatures and salinities at Station North 1 showed tidal fluctuations that are typical for San Francisco Bay.

The lower salinity at Station South 1 may be due to its proximity to the entrance of Yosemite Creek, and the tidally-induced lowering of the water surface to near the position of the conductivity sensor. The pulses of lower salinity water at Station South 1 (Figure 4-19) are correlated with the times of exposure of the STMS at this site. This result suggests that a lens of lower salinity water was present at the surface in the embayment during the measurement period. As the water level dropped during each tidal cycle, the lower-salinity surface layer was detected by the sensor. Although the source of this fresher water is uncertain, one possibility is that it was discharged from Yosemite Creek.

Both temperature and salinity were relatively stable at Station South 2, except for a few anomalous readings during early February that were likely caused by sporadic fouling of the sensors by organic matter (Figure 4-20). Diurnal pulses of warmer water reached highs of 12° C during February 3-6. Salinities did not clearly show these diurnal variations.

4.2 Summer 2001

After recovery of the STMS tripods on August 14, 2001, hydrodynamic data were downloaded at WHG facilities in Redwood City, CA, and reviewed to assess data quality. During these QA data checks it was discovered that the OBS data for Station North 1 were lost due to an instrument malfunction. The cause and nature of this malfunction is under investigation by the instrument manufacturer. Also, significant fouling of the OBS sensor at Station South 2 over an extended period rendered a large portion of SSC data unusable. STMS data are described further below.

4.2.1 Wind Data

Meteorological data from the weather station at HPS are presented in Table 4-1, and on Figures 4-21 and 4-22. All of the parameters indicate strong diurnal variations associated with day-night cooling. Wind speeds typically varied from about 4 m/s during the day to less than 1 m/s at night. The wind direction

generally remained constant from the west, except for brief and sporadic shifts to more northerly directions. Mean air temperature was about 18°C, which was considerably warmer than the mean winter temperature of about 12°C. Diurnal swings of about 7 °C were observed in the temperature data. Barometric pressure had diurnal and lower frequency fluctuations, with a slight trend toward higher pressure throughout the measurement period. The range of diurnal pressure changes was less than about 8 mbars, and the amplitude of the two-week oscillations was about 15 mbars. The diurnal pressure change of 8 mbars would induce a change in water level of about 8 cm.

Figure 4-23 presents joint probability density functions of wind speed and direction during the summer deployment period (July 15th through August 15th) from the two offshore buoys. Figure 4-24 presents joint probability density functions of wind speed and direction for the summer season (April through September) for 2001, 2000, and 1997. By comparing the joint wind speed and direction density for the deployment period with the seasonal statistics for the year, it is clear that wind conditions during the summer deployment period generally were typical for the season although slightly lower in magnitude. The seasonal mean wind speed was 5-6 m/s and the maximum wind speeds for the season were measured at 15 to 16 m/s, whereas the mean wind speed for the deployment period was about 5 m/s and the maximum about 12 m/s. The wind directional distribution during the deployment period, however, was completely consistent with the seasonal directional distribution. By comparing the seasonal wind speed and direction for the three-year period with the one month deployment period it is apparent that the same pattern holds. Wind direction during the deployment period is consistent with the three-year seasonal statistics, but the wind magnitude was slightly lower than a multiyear average.

4.2.2 Water Level Data

Water depths at each of the three deployment sites are shown in Figures 4-25, 4-26, and 4-27 (lower panels). Depth data are listed in Table 4-3. Water level data were similar in character to the winter period at the three stations, and again clearly showed mixed tides and spring-neap cyclicity that are typical of San Francisco Bay (Cheng and Gartner, 1985). The maximum difference in tidal ranges between springs and neaps was about 1.4 m at Station North 1.

STMS tripods were deployed during a period of increasing spring tides in mid-July, and recovered near the commencement of spring tides in mid-August. The tripod at Station North 1 was relocated August 2. Mean water depth at North 1 was about 6.5 m until August 2, when the STMS was recovered for maintenance and cleaning, and then relocated approximately 35 m west of the original site in shallower water (Figure 4-25). Mean depth after relocation was about 4.5 m.

Mean water depth was 2.2 m at South 1; maximum water level during this period was about 3.6 m (Table 4-3). At Station South 1, the water level dropped to below the pressure sensor during low tides over a small portion of each tidal cycle causing “clipping” of the signal (note the flat signal during spring tides; Figure 4-26). Mean water depth at Station South 2 was about 2.8 m. Maximum water level during spring tides in mid-July was about 4.3 m (Table 4-3).

4.2.3 Current Data

Current speed components for the hourly burst averages (u_{bavg} and v_{bavg}) at the three deployment sites are shown Figures 4-25, 4-26, and 4-27. At Station North 1, the highest speed components were about 30 cm/s toward the east, similar to the strong eastward flows during winter. Northward and southward speed components were nearly equal at this station. Maximum hourly burst-averaged speeds reached 36.6 cm/s during spring tides in mid-July, and daily peak speeds exceeded 20 cm/sec during neap tides (Figure 4-28). Hourly current speeds were considerably lower at Stations South 1 and South 2 (Figures 4-29 and 4-30).

A statistical summary of the current data for all three stations is provided in Table 4-3. Mean hourly current speeds at Stations North 1, South 2, and South 1 were 14.3 cm/s, 3.1 cm/s, and 3.9 cm/s, respectively. At Station North 1, means of hourly current components were eastward and southward (9.0 cm/s and -2.8 cm/s, respectively). No storms occurred during summer, and current speeds were largely tidal.

Residual (LPF) currents at Station North 1 were considerably weaker than during the winter experiment (Figure 4-31). They were in the same direction toward the SE throughout the entire deployment period. This difference in magnitudes of residual flows during winter and summer is significant for net movement of water and suspended materials. It is probably related to influences of lateral water density variations due to fresh water inputs during winter, and to differences in seasonal wind speeds and directions. Similar to the results for winter, residual currents at Stations South 1 and 2 are weak (< 3 cm/s) and not statistically significant (Figures 4-32 and 4-33) (as discussed in Section 4.1.3, current speeds of less than about 2 cm/s have low statistical confidence.)

4.2.4 Wave Data

Similar to the winter experiment, measurements of surface waves were obtained at all three sites using pressure and velocity sensors. The results for significant wave height, spectral peak wave period, and near-bottom significant wave currents are shown in Figures 4-28, 4-29, and 4-30. A statistical summary of the wave data is provided in Table 4-3. Near-bottom wave currents were generally smaller than the winter results at Station North 1. Mean and maximum wave current velocities at Station North 1 were 1.0 and 5.4 cm/s during summer, respectively. During winter they were 3.3 and 6.0 cm/s. Significant wave heights and wave periods were small and similar to winter values.

Unlike the significant increases in wave parameters during winter storms, waves were small throughout the summer at both South Stations 1 and 2 (Figures 4-29 and 4-30). Maximum near-bottom wave velocities were < 3 cm/s at each station (Table 4-3). Maximum significant wave heights at Stations South 1 and South 2 were only 11.9 and 15.7 cm, respectively. At Station South 1 peak spectral wave periods were between 1 - 2 s. The cutoff period for waves at this depth is 1 s; all wave peak periods below 1 s were removed. These small short period waves had little effect on the bottom sediment within South Basin during summer.

4.2.5 Suspended Sediment Concentration Data

No data were available at Station North 1 during the summer sampling event due to instrument failure. Time-series of SSC at Station South 1 is shown in Figure 4-29. The SSC signal had daily tidal peaks that were generally correlated with highest daily tidal currents. This correlation likely represented tidal advection of the suspended matter past the sensor, and not resuspension of the local bottom sediment. Mean SSC over the entire record at South 1 was about 55 mg/L. A gradual increase in SSC from about July 22 to August 3 was caused by biofouling of the sensor port (raw data are not shown). This trend was removed statistically. Biofouling produced a second upward trend in the SSC data starting on August 6. This trend also was removed statistically. SSC values after August 12 were erratic and unusable.

As previously discussed, biofouling of STMS instruments affected current and SSC data at Station South 2 (Figure 4-27). When the instruments were cleaned at the mid-deployment point on August 3, a large mass of organic material (algae and seaweed) was attached to one of the tripod legs. The organic mass was removed, and the optics were cleaned. However, it appears that sufficient organic material was present in the vicinity of the tripod to cause continued interference with the current meter sample cell,

OBS, and conductivity sensor. The statistical values for these parameters that are listed in Table 4-3 were calculated after de-trending and removal of the spurious measurements at Station South 2.

4.2.6 Temperature and Salinity Data

Summer temperature and salinity data are again typical for San Francisco Bay for this season. Time series data from the three stations are presented in Figures 4-34, 4-35, and 4-36). Statistical summaries are presented in Table 4-3. Both temperature and salinity for all three sites were again relatively stable over the length of the deployment, with the exception of salinity at Station South 2. The conductivity sensor at this station suffered from intense biological fouling and physical damage which degraded the conductivity measurement after about July 24. It remained relatively constant at around 26.1 psu until that time. Mean summer water temperatures at the three sites were 19°C at both south sites, and 17.6°C at Station North 1. Mean salinities were 24.5, 25.8, and 26.1 psu at Stations North 1, South 1, and South 2, respectively. Salinities at Station North 1 show very minor tidal variation, while those at the South Basin sites show almost none. The tidal variation is reflected in the temperature data for all three sites. The lower temperature at Station North 1 reflect the proximity at that site to colder water circulating in the nearby channel, while the southern sites reflect the warmer summer environment in the more restricted shallows of South Basin.

5.0 DETERMINATION OF SEDIMENT FLUX AND RESUSPENSION

The calculation of sediment flux at each of the three HPS stations in winter and summer 2001 is presented in Section 5.1, and the results of the 1D sediment resuspension modeling are presented in Section 5.2.

5.1 Sediment Flux Calculations

Sediment flux was calculated for each of the three HPS stations using the winter and summer 2001 STMS data following the methods presented in Section 3.1 of this appendix.

5.1.1 Winter 2001

The results of the winter 2001 sediment flux calculations for each station are presented below.

5.1.1.1 Station North 1

Results of the sediment flux analysis indicate that the largest contribution to the long-term transport of suspended sediment at HPS is from the Residual Advective Flux (RAF), followed by the Stokes Drift Flux (SDF) and Dispersive Flux (DF). RAF at Station North 1 is persistently to the SE with significant increases associated with the higher residual flows during spring tides around January 25 and February 9 (Figures 5-1 and 5-2). The cumulative total flux at this site was about 1.66×10^8 g/m toward the SE over the period from January 19 to February 15, 2001. Daily averaged flux was 6.1×10^6 g/m (Table 5-1).

The magnitude and direction of the flux are controlled largely by the residual (LPF) currents (Figure 4-13). The direction of sediment flux at this site also is influenced by the natural shoreline and local bathymetry, as well as the maritime shipyard structures along the coast. The northern section of the HPS shoreline is relatively open to flood currents that flow in general alignment with the nearby main navigation channel. The flood currents approaching Point Avisadero are deflected E-SE by the shoreline near this site.

DF had peaks that were related to storm events that caused higher wave currents. The peaks on January 25 and on several days in early February (Figure 5-2) were related to storms and wave effects. SDF had greater variability, and fluctuations appeared to be correlated with spring-neap cycles and storms. Both SDF and DF had hourly values comparable to RSF; however, the hourly values oscillated about zero and produced small net flux over the entire measurement period. Cumulative SDF and DF were 7.9 and 4.2 $\times 10^6$ g/m , respectively (Table 5-1).

5.1.1.2 Stations South 1 and South 2

Because current velocities were generally small at South Basin stations (i.e., near the limit of resolution of the current meter), the estimates of flux have a lower degree of statistical confidence than the flux estimates calculated for Station North 1. The flux results for these stations must be regarded with a moderate degree of uncertainty. Also, the calculated depth-integrated flux values were expected to be smaller at the South Basin stations because the depths are significantly shallower than at Station North 1.

The three major modes of flux at Stations South 1 and South 2 were rather small except during January 23-25 and February 9-12 (Figures 5-3 and 5-4). RAF at these stations were highly correlated with wind speeds and spring tides. Relatively higher RAF occurred on January 23-25 when winds were about 3-4 m/s from the SSE (Figure 4-1). Similar increases in residual flux occurred during a period of sustained southerly winds during February 9-12. Although the February winds were lower than those during January 23-25, they occurred during spring tides when water depths were rather low. Waves generated relatively large near-bottom velocities and stresses that were sufficient to resuspend sediment in

the shallow areas of South Basin. The South Basin embayment has greatest exposure to wind waves from the S-SE (Figure 1-1). Cumulative total flux at Station South 1 was about 2.4×10^6 g/m toward the SSW (Table 5-1). RAF contributed over 62% to the total flux.

Flux calculations at Station South 2 were limited to 21 days due to anomalous OBS data beginning about February 6 (see Section 4.1.5). As noted earlier, these anomalous data were likely due to biologic activity. The magnitudes and temporal pattern of the three modes at Station South 2 were similar to those at Station South 1 (Figures 5-3 through 5-6). Major variations in all three modes occurred during the storm events on January 23-25 and in early February. Total flux was about 3.4×10^6 g/m to the NE during the 21 days of useable data collected this site (Table 5-1). The magnitude and direction of total flux are mainly due to RAF (68%). DF and SDF were each a factor of about four to five times smaller.

In summary, the total flux at Station North 1 was roughly two orders of magnitude greater that at the southern sites. This result was expected primarily due to the deeper water and proximity to the navigation channel where tidal flows are large. The flux estimates at Station South 1 and 2 have low statistical confidence, and although they are non-zero, the magnitudes indicate that transport of suspended matter in South Basin was generally small.

5.1.2 Summer 2001

In general, weak residual currents during summer suggest that suspended sediment flux was negligible at all three stations. The combination of weak low frequency currents and small to no predicted resuspension (from the 1D modeling results presented in Section 5.2 below) likely caused small to no appreciable flux at these sites. Unfortunately, because of the lack of SSC data at Station North 1 and unusable data for most of the deployment period at Station South 2, calculations of sediment flux were obtained only at Station South 1.

Flux magnitudes for summer at Station South 1 were lower than for winter at this site (Figures 5-7 and 5-8). The residual currents at this site were rather small, and SSC values were low. Consequently, flux estimates have low statistical confidence (considering the accuracies of the sensors). Total flux was 2.9×10^6 g/m and directed mostly toward the NW (Table 5-1). The time-series of hourly RAF is quite variable and has no well-defined mean. SDF and DF had tidal oscillations about zero, and a weak spring-neap cyclicity. However, the values are so small that the results are statistically insignificant. These results indicate negligible suspended sediment transport occurred during summer inside South Basin at Station South 1. This finding suggests that during summer any sediment that enters South Basin will likely be sequestered and deposited there.

5.2 One-Dimensional Sediment Resuspension Modeling

A state-of-the-art, 1D bottom boundary layer and sediment transport model was used to calculate bed shear stress (τ_b) at the three STMS locations (Cacchione and Drake, 1990; Wiberg et al., 1994). In this section, calculations of τ_b for both winter and summer data are presented. The results are used to determine the frequency of resuspension and to identify resuspension events for the bottom sediment at each station.

Time-series hourly values of bottom currents (wave and tidal) and calculated bed stresses at each station are shown in Figures 5-9, 5-10, and 5-11 for winter and Figures 5-12, 5-13, and 5-14 for summer. These plots clearly show that generally tidal currents exceed bottom wave currents at all sites except during moderate winter storms at the two shallow sites. At Station North 1, although near-bottom tidal currents were quite high and exceeded 35 cm/s during spring tides in both winter and summer, with maxima of ~50 cm/s during winter (February 8-10), bottom stresses were rather small ($\tau_b < 0.3$ Pa). These small

stresses had distinct tidal fluctuations and spring-neap cyclicity. Wave speeds were small and contributed little to the bed stresses ($U_{1/3} < 8$ cm/s). At Station North 1 highest τ_b (~ 0.3 Pa) occurred during winter spring tides on February 9.

At the two stations in South Basin, bottom currents and stresses were small except during winter storms when surface waves were more energetic. Values of τ_b exceeded the critical values of τ_c during these winter storms. These relatively high τ_b values were caused mostly by wave stresses. At Station South 1 τ_b exceeded 0.1 Pa on January 23 and 25, and on several days during February 9-12. On three days τ_b exceeded 0.3 Pa, and erosion of the bed may have occurred. A similar pattern of bottom stress was found at Station South 2. τ_b was rather large during January 23 and 25, and exceeded 1.0 Pa on January 25 when $U_{1/3}$ reached 35 cm/s. Resuspension of surficial material occurred at both South Basin stations during the storms, and significant erosion was predicted at Station South 2 on January 25. No distinct tidal modulation was found in the time-series of τ_b at either station.

Table 5-2 summarizes the parameter values used to calculate τ_b at each station during winter and summer. Mean τ_b values during summer were considerably lower than winter values at each station because of lower wave energy. Mean u_{*b} was about 50% lower in the summer period. Highest means were at Station North 1, but maximum τ_b were at the southern sites during winter storms.

Predicted resuspension of surficial and subsurface sediment for winter and summer at each station is presented in terms of "frequency of resuspension" in Table 5-3. Frequency of resuspension is defined as the ratio of number of hourly estimates when $\tau_b > \tau_c$ to the total number of estimates, expressed as a percentage. The columns are separated into two levels of τ_c that represent critical values for the surficial sediment (0.1 Pa) and the subsurface sediment (0.3 Pa).

At Station North 1, sediment in the surficial layer was resuspended 16% of the time during winter, and 4% during summer based on this analysis. This resuspension was largely because of strong maximum tidal currents. During the last week in summer bottom stresses were relatively low and consistently less than 0.1 Pa (Figure 5-12). No resuspension and erosion of subbottom sediment was predicted at Station North 1.

At Stations South 1 and South 2, summer wave and current conditions were extremely quiescent, and no resuspension was predicted during that period. During winter storm events produced $\tau_b > 0.1$ Pa, and during two storms (January 25 and February 9) $\tau_b > 0.3$ Pa. At Station South 2, the seasonal contrasts in predicted frequency of resuspension were dramatic. No resuspension was predicted during summer (Table 5-2). However, during winter, the highest bottom stresses calculated for either deployment period were achieved. Surficial sediment was resuspended 9% of the time, and subbottom sediment was eroded about 3% of the winter period. These results suggest that sediment accumulates during summer and part of winter periods in South Basin. However, surficial and sub-bottom sediment is resuspended infrequently in South Basin during winter storms.

6.0 REGIONAL SEDIMENT TRANSPORT PATTERNS

This section presents the results of regional two-dimensional (2D) modeling undertaken to characterize hydrodynamics and sediment transport patterns around HPS. The following section includes the results from the highest flow periods during the winter and summer deployments in order to quantify maximum sediment resuspension fluxes during these periods.

6.1 General Circulation

Figures 6-1 and 6-2 display the predicted circulation patterns during maximum flood and ebb tides on February 7, 2001. The black vectors represent the current magnitude and direction at each location as calculated from the hydrodynamic simulations and the colored contours represent velocity magnitude in m/s. The tidal currents during this time period represent a maximum tide that occurs on average four times per year. The tidal currents are generally bidirectional within the model, flowing SSE for flood tide and NNW for ebb tide. Tidal velocities within the model are highest within the vicinity of HPS where flows are funneled around the peninsula. Peak tidal velocities within the vicinity of HPS were predicted to range from 1.5 m/s during flood tide to 2.5 m/s during ebb tide during the maximum diurnal tide of the winter deployment. The predicted peak ebb velocities near HPS are typically higher than peak flood velocities, which is consistent with NOAA data (Figure 3-1). The slight ebb dominance in flow around HPS is due to the peninsula being angled slightly to the southeast and shallow waters in the southwest quadrant, which results in a flow constriction on the south side of HPS and forces the flow into the deeper channel offshore from the peninsula.

The fluid exerts a shearing force on the bottom sediments as it moves. The resulting shear stress is the driving force on sediment resuspension in the HPS region. Figures 6-3 and 6-4 show the bottom shear stress in Pascals (Pa) resulting from the currents around HPS. For the surficial sediments, 0.1 Pa is considered to be the critical shear stress for erosion. For the deeper, more consolidated sediments of interest in this study, 0.3 Pa is the critical shear stress for erosion. A more detailed explanation of the bottom shear stress and sediment transport parameters is included in Attachment L-4. The shear stress plots can be examined directly for areas of sediment motion according to these criteria. At this scale, minimal changes cannot be visualized in the two basins to the north and south of HPS. Because these regions are of primary interest, a more detailed look at these basins is presented.

6.1.1 Circulation within India Basin

Predictions for tidal velocities just north of HPS, within India Basin, were weak (< 0.25 m/s) due to the basin's sheltered location. The hydrodynamic model predicts the formation of an eddy within the basin during high flows, rotating in the clockwise direction during flood tide (Figure 6-5) and counterclockwise during ebb tide (Figure 6-6). This eddy is more pronounced within the basin during ebb tide, when flow separation around HPS results in flows reversing from west to east along the entire northern shoreline of the peninsula. This flow reversal is consistent with current observations collected from Station North 1 during the winter and summer deployments, where velocities also were observed to shift from west to east during the later part of ebb tide. The ebb tide produces generally higher bottom shear stresses throughout the basin. The shear stresses, although higher, are still only just enough to suspend low-density surficial sediments ($\tau_c = 0.1$ Pa).

It is important to note that waves can have a significant effect on the shear stresses within shallow areas of San Francisco Bay, such as India Basin. The weak circulation patterns and shear stresses predicted by the model within Indian Basin are subtle features, which could be altered by local waves. For regional simulations, wave effects were not included because the tidal currents are the dominant process and give

more insight into typical diurnal sediment transport patterns. However, the effect of waves is more closely examined in the extreme event analysis in Section 6.2 below.

6.1.2 Circulation within South Basin

Similarly to India Basin, predicted flows within South Basin (located on the south side of HPS) were weak. During flood tide (Figure 6-7), water remained fairly stagnant within the interior of South Basin, with the winter peak flow predicted to just exceed 0.05 m/s. During ebb tide (Figure 6-8), the water again remains fairly stagnant within the basin. In comparison to velocities during flood, flows propagate further into the basin, increasing to 0.1 m/s during peak winter ebb tide. The shear stresses remain below the critical shear stress for suspension of the surficial sediments (τ_c = 0.1 Pa) throughout most of the South Basin but does not exceed the value for deeper sediments (τ_c = 0.3 Pa).

As with India Basin, waves will have an influence on the shear stress within South Basin, specifically within the basin's interior where tidal influences are small. These wave effects are further investigated in the extreme event analysis in Section 6.2 below.

6.1.3 Regional Sediment Transport Patterns

In general, erosion flux (mass of sediment eroded per unit bed area per unit time, $g/m^2/s$) is higher within the deep channel than in the bays and basins to the north and south where shear stresses are high. Figures 6-9 and 6-10 show an overview of the erosion flux patterns during the maximum winter tidal ebb and flood (February 7, 2001). Figure 6-9 shows the maximum winter ebb tide around HPS creating a relatively high erosion flux (0.05 $g/m^2/s$) in the deep channel. As the water flows from south to north along the coastline, the flow is accelerated along the point, creating a higher zone of bed shear stress. The majority of the domain shows an erosion flux only in the deeper portions of the domain. Because these areas are generally coarser sediment sizes, these eroding sediments do not remain suspended as long as finer sediments, and therefore result in a minimal net transport over a tidal cycle. Figure 6-10 shows similar results for a typical flood tide around HPS. The areas of erosion are reduced significantly due to the smaller currents and a majority of the domain indicates a relatively small flux of sediments from the bed. India Basin and South Basin show no sediment erosion due to the tidal currents during this winter period. Slack tides (times between flood and ebb) are not shown, because the water velocity is minimal, the bed shear stress is reduced, and the entire domain is below the critical shear stress for erosion (τ_c = 0.3 Pa). This is typical for most tidally-influenced estuaries, where sediment is initiated and transported during flood and/or ebb flows, and settles out during slack tide conditions.

Figures 6-11 and 6-12 show the maximum ebb and flood erosion flux from the bed during the maximum tidal flow during the summer deployment (July 22, 2001). The ebb conditions again show the maximum erosion flux from the sediment bed (~ 0.05 $g/m^2/s$) located in the deep channel off of HPS. Both flood and ebb show an overall decrease in erosion due to the lower tidal currents during the summer period. Again, no erosion is predicted in India Basin or South Basin.

The sediment transport figures presented illustrate peak erosion flux during spring tides (times when the tidal range is largest due to gravitational interactions); during neap tides (times when the tidal range is smallest due to gravitational interactions), a majority of the region indicates lower erosion flux.

6.2 Potential Impact of Extreme Events

Results of regional sediment transport modeling illustrate typical conditions over the winter and summer deployment period. It is expected that significant changes to the circulation and transport patterns will

occur during extreme/storm conditions, specifically in the basins north and south of HPS. During storm events, wave forces become significant and combine with the tidal current to modify areas of erosion and deposition, as well as potential transport pathways.

The 1998 El Nino storm on February 6, 1998, was chosen for the extreme event analysis. The tidal currents were increased by 100% over NOAA predictions at the model boundaries. This increase is consistent with USGS current observations throughout the bay. Also, tidal water levels were increased by an average of 0.6 m during the storm period. Because the storm produced southeast winds similar in magnitude and direction to those experienced during the winter 2001 deployment, the wave height of 0.67 m and period of 3.8 s measured during the deployment was used to calculate the wave induced shear stresses in the model.

Figures 6-13 and 6-14 show the erosion flux calculated during maximum ebb and flood tides without waves included. The overall erosion flux in the deeper channel is about 4 times (0.2 $g/m^2/s$) the winter maximum (0.05 $g/m^2/s$). Both basins show only very small amounts of erosion (< 0.005 $g/m^2/s$) even with the dramatically increased flow. This illustrates the large extent to which these basins are sheltered from tidal currents. Figures 6-15 and 6-16 show erosion flux during the same maximum ebb and flood, but now the 0.67 m southeast wave shear stresses have been included. The erosion patterns and magnitudes show no significant change in the deeper waters (> 3 m), but the wave effects on the erosion flux are significant in the shallower basins. As the basins grow shallower, bottom velocities generated by the waves (orbital velocities) become larger. These larger orbital velocities generate erosion fluxes of up to 0.021 g/m^2-s in the shallow nearshore regions where tidal currents alone are incapable of initiating significant sediment motion. Therefore, significant sediment resuspension in both basins only occurs due to significant wave action. This result is consistent with the measurements and findings in the one-dimensional modeling. It also is generally observed that higher shear stress regimes have relatively coarse sediments. This agrees well with the coarse sediments found in the nearshore regions in the South Basin.

7.0 SUMMARY AND CONCLUSIONS

The results of the HPS sediment dynamics study are summarized below in Section 7.1. Uncertainties associated with the study and the use of the data are discussed in Section 7.2, and the primary conclusions are presented in Section 7.3.

7.1 Summary

Time-series measurements of waves, tides, currents, and suspended sediment concentrations that were made over one-month periods during winter and summer 2001 provide important insights into the relative importance of the different physical processes and seasonal contrasts that occur in the waters surrounding HPS. No previous data like these had been collected in this region. The increases in near-bottom currents and wave velocities due to winter storms are documented quantitatively, and temporal and spatial variations in residual flows lend a better understanding of transport processes in this region. Essentially, net movement of suspended sediment at and near HPS is closely linked to residual circulation in San Francisco Bay. Along the northern side of HPS residual currents were relatively strong (on the order of 10 cm/s) directed toward the SE during winter and summer, with lower speeds in summer. Within South Basin, residual currents were weak and variable. Water circulation in South Basin was sluggish, and little net transport of suspended matter occurred.

In shallow water coastal regions, sediment resuspension typically is controlled by wave-induced bottom stresses (Cacchione and Drake, 1990). At the measurement sites in this study, waves were generally small except during winter storms. Winds from S-SE associated with local storms generated surface waves in South San Francisco Bay that propagated into South Basin from a relatively long fetch. Relatively high near-bottom wave velocities and significant wave heights during these events were correlated with substantially increased SSC. Other than during these infrequent storm events, which had durations of about 1-3 days, near-bottom wave velocities and significant wave heights were rather small during winter and summer, and no appreciable resuspension by wave stresses occurred. At Station North 1, resuspension of surficial sediment occurred during spring tides. Maximum near-bottom flood and ebb currents during these periods were 25-50 cm/s, with highest flows occurring during winter.

Bottom stresses by waves and currents were calculated using the STMS data in a 1D bottom boundary layer model. The results show that highest τ_b occurred at Stations South 1 and 2 during the periods of largest waves in winter. During one storm on January 25, 2001, τ_b exceeded τ_c for the sub-bottom sediment (0.3 Pa), and probably caused erosion of the sediment bed. At Station South 2 during this storm, $U_{1/3}$ was measured at values greater than 35 cm/s, and τ_b was measured at values greater than 1.0 Pa; these types of stresses would produce substantial resuspension and erosion of the cohesive sediment bed. At Station South 1 during this same storm event, $U_{1/3} \sim 20$ cm/s and $\tau_b \sim 0.4$ Pa. At Station North 1, τ_b was controlled by tidal stresses, and maximum τ_b was about 0.3 Pa during spring tides (February 9). Frequencies of resuspension of the loosely consolidated surficial sediment during winter and summer (combined) at the Stations North 1, South 1, and South 2 were 20, 5, and 9%, respectively. Frequencies of resuspension of sub-bottom sediment during winter and summer (combined) at the three stations were 0, 1, 3%, respectively. Erosion of sub-bottom sediment only occurred in South Basin during infrequent high wave events (i.e., during winter storms).

The 2D regional hydrodynamic and sediment transport modeling offers a great deal of insight into the effects of currents and waves in a wide region surrounding HPS. The winter and summer calculations of tidal circulation completed for the spring tides during each deployment show a marked enhancement of currents around HPS during the ebb tide when compared with the flood tide. Sediment erosion occurs in the deeper waters where the currents are largest. In these deeper waters, the sediment particle sizes are equal to and larger than fine sand, so these sediments will settle out quickly during slack tides and result

in little or no net sediment transport out of these regions. During the largest tidal flow period, winter, neither India or South Basin show areas of shear stress high enough to suspend deeper consolidated sediments (τ_c = 0.3 Pa). These results generally agree with the computations made in the 1D modeling based on the hydrodynamic conditions measured during the deployments. The significant exception to this trend is when significant wave effects were measured and erosion was predicted in the 1D model. Because wave effects were considered only during the extreme event analysis, this erosion was not shown due to currents alone. The model supports the conclusion that little sediment erosion takes place due to tidal currents alone in India or South Basin during a non-storm spring/neap tidal cycle.

The 2D regional modeling also included the study of the 100-yr storm event. The tidal flow boundary conditions were based on currents measured in the bay during the February 6, 1998 El Nino storm. Erosion fluxes were shown for conditions with and without a 0.67 m southeast wave present. This wave direction favors maximum propagation into the basins. The calculation with no waves extends the earlier conclusion that no significant sediment erosion occurs due to a 100% increase in tidal currents. When the wave conditions were included, sediment erosion occurred in both India and South Basins. This result agrees well with the 1D modeling results of sediment erosion occurring only during higher wave conditions in the basins. Therefore, significant erosion of sediments in the areas of interest (India Basin and South Basin) should be expected in high wave conditions with a direction favoring propagation into the areas (the southeast).

The most significant limitation of the 2D regional sediment transport modeling is that only one type of sediment with constant characteristics (fine-grained silt and clay) was assumed throughout the region. This limitation does not alter the general patterns observed in the erosion flux calculations, because the flux calculations are based on an excess shear stress. This formulation still gives relative patterns of erosion correctly, although the erosion flux in areas with significantly different sediments (the deep channel) are probably less than predicted. The modeling can be improved through more detailed measurement of sediment properties (strength, density, and particle size with depth) throughout the region and recently available modeling techniques.

7.2 Uncertainty

Because of the complexity and variability associated with sediment transport processes in estuarine systems, it is not possible to directly measure all phenomena. The HPS Sediment Dynamics Study was designed to represent critical seasonal variations, tidal variations, and areas of greatest interest at HPS based on the potential need for sediment management (i.e., Point Avisadero and South Basin). Site-specific data for the most important forcing mechanisms were collected. For important parameters that were not directly measured (i.e., critical shear stress of the sediment bed), empirical values that best represented site conditions were used. Models were used to predict sediment transport phenomena that could not be directly observed. Specific sources of uncertainty and their potential effect on the reliability of the study results are discussed below.

7.2.1 Representativeness

Site-specific data were collected to represent a full tidal cycle in both winter and summer conditions in San Francisco Bay. Hydrodynamic conditions and water properties in San Francisco Bay have been reported by a number of researchers over the last 24 years (Cheng and Gartner, 1985; Walters et al., 1985; Conomos and Peterson, 1977). It is generally recognized that the region is dominated by two major meteorological periods: spring-summer upwelling and the winter storms. The one-month deployments were “snapshots” of the most energetic periods in the estuary, and represent the optimal periods for characterizing transport mechanics in the study area. Comparison of data for wind speed and direction at HPS during the deployment period to multi-year data from offshore buoys indicated that wind conditions

during the deployment periods were generally consistent with multi-year average conditions (see Sections 4.1.1 and 4.2.1 of this appendix). Therefore, the results of the study for the winter and summer 2001 deployment periods appear to adequately represent typical conditions at HPS.

7.2.2 Field Measurements and Sediment Flux Calculations

As with any field study of physical and geological processes, confidence in field measurements and results derived from measured data are primarily dependent on the proper calibration of sensors. The instruments employed in the study were manufactured by commercial firms with standard QA/QC procedures that ensured the functionality and accuracy of the individual instruments. The oceanographic instruments that were deployed were calibrated at the factory and routinely checked in the laboratory prior to deployment. Simple performance checks were included in the setup procedures provided in manufacturer control and acquisition software. The new generation of acoustic current and wave meters report a range of ancillary engineering data with basic hydrodynamic data, including backscatter intensities, beam correlation, percent good data, and range to boundary. The wave/current meter underwent a series of successful system self checks prior to deployment.

As with any measurement system, the uncertainty associated with the measurement is greatest near the limit of resolution of the sensor. The resolution of the ADV Ocean Current Meter is approximately 0.25 cm/s, resulting in a lower confidence at current speeds of <2 cm/s. The current data for Stations South 1 and South 2 were approaching the resolution of the ADV sensor; however, the lower confidence in the accuracy of the current data does not affect the study conclusions (i.e., sediment flux at Stations 1 and 2 was minor compared with flux at Station North 1 during the winter deployment period).

The primary uncertainty associated with the estimates of sediment flux were associated with the difficulties in OBS calibration. The OBS is widely used to make time-series measurements of suspended sediment concentrations because of its small size (low flow interference), low power requirements, and ease of integration into multi-sensing systems like STMS. However, it is difficult to calibrate accurately because of the inherent dependence of output on particle size and shape. OBS calibrations have been described by many other investigators, and the conversion of OBS detection outputs to SSC typically have large error intervals (the estimate of error for the HPS study is ~25% of the estimated SSC value).

The deployment of these instruments in the field is typically tailored to achieve specific study objectives, but the basic function of each instrument remains standardized. Because each deployment is tailored to the application, the scientific and commercial communities commonly accept experience as the best guide in the construction and deployment of these systems. The significant peer-reviewed field experience of the HPS project team reduces the uncertainty associated with instrument deployment and application.

7.2.3 Sediment Resuspension and Transport Models

As discussed in Section 3.2 of this appendix, modeling the erosion of a cohesive sediment bed is a complex task. Bed erosion is influenced by a number of parameters, many of which cannot be readily quantified. However, the most important parameters that influence sediment mobility are the critical shear stress and the erosion rate constant. In the absence of site-specific measurements of critical shear stress and erosion rate constant, empirical values determined from other studies of similar sediments in South San Francisco Bay were used (McDonald and Cheng, 1997; Cheng et al., 1999; and Inagaki, 2000). Although there is a variation in sediment type throughout the HPS region, these values are considered to be representative of the area as a whole. This is the dominant uncertainty in both the 1D and 2D sediment resuspension models.

The bottom boundary layer calculations in the 1D model are based on analytic solutions which have compared favorably to a large number of field measurements under a wide range of conditions (Cacchione and Drake, 1990; Wiberg et al., 1994). With accurate input conditions (wave and current parameters) the model is considered to be an excellent approximation of reality.

The 2D hydrodynamic model limitations have been well documented by the US Army Corps of Engineers Waterways Experiment Station. These limitations include:

- Hydrostatic assumption – vertical accelerations and stratification are neglected;
- Subcritical flow only – flows where small scale vertical variations are significant cannot be simulated.

Flows in the shallow regions of interest at HPS are primarily horizontal; therefore, a hydrostatic assumption is valid and adds little uncertainty to the model results. The flow around HPS was additionally verified to be subcritical throughout each calculation.

The primary uncertainty associated with the 2D hydrodynamic model is the flow rate specified at the northern and southern open boundaries. These flow rates were calculated from two NOAA buoys located along the northern boundary. Since only two points were used, a significant gradient between the two points may have been missed during the periods of study. This uncertainty was minimized by verifying that the calculated velocity off of HPS at NOAA Station Number 349 compared favorably (within 15%) with measured data. With the flow rates verified in this way, it is assumed that the hydrodynamics of RMA2 correctly calculated velocities throughout the domain.

7.3 Conclusions

The major conclusions of the HPS sediment dynamics study are as follows:

- Near-bottom tidal currents along the northern side of HPS are strong (maxima of ~ 50 cm/s). These currents keep the sediment surface swept by generating bed stresses high enough to resuspend loosely consolidated surficial materials. No appreciable erosion of the deeper sediment bed was predicted for Station North 1.

- Tidal currents are relatively small within South Basin (< 15 cm/s). Residual circulation is weak and highly variable. Suspended matter that enters this area has a high likelihood of accumulating there. Wave-induced resuspension during infrequent winter storms occurred because of the rather large bottom stresses. During one event, sediment in the bed below the "fluff" layer likely was eroded. However, during the measurement periods, sediment erosion was predicted only 3% of the time at Station South 2 and 1% of the time at Station South 1. No appreciable transport of resuspended sediment out of South Basin is likely because of the weak circulation.

- Suspended sediment flux was calculated directly from the STMS data. Highest fluxes were found at the northern site. Total flux was toward the SE during winter and summer, with highest total flux $= 1.66 \times 10^8$ g/m during winter. At the two southern stations, total fluxes were small and not statistically significant. In all cases, total flux was dominated by contributions from residual sediment flux (i.e., from transport associated with residual currents). Other modes of flux were minor.

- Coarser sediments eroded in the deeper channel offshore from HPS will quickly settle out during slack tides, resulting in little or no net sediment transport out of these regions.

- No significant sediment erosion takes place due to tidal currents alone in India or South Basin during an extreme tide event.

- Significant erosion of sediments in India Basin and South Basin should be expected in high wave conditions, with a direction favoring propagation into the basins (i.e., from the southeast). Subsequent transport throughout the South Basin during extreme events cannot be quantified with existing field or model data.

Overall, this study provides site-specific information that can be used to predict the fate and transport of sediment-bound contaminants at HPS. This information will be used in the FS along with other lines of evidence (e.g. horizontal and vertical distribution of contamination, radioisotope profile data) to support the development of remedial alternatives for sediment.

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Table 2-1. Summary of Winter Deployment Locations and Instruments

Station	Latitude	Longitude	Date and Time Deployed	Date and Time Recovered	Instrument	Height Above Bottom (cm)
North 1	37° 43.856′	122° 21.671′	01/15/01 2:00 PM	2/15/01 11:10 AM	Sontek ADV	39
					SeaBird CT	86
					Sonardyne Transponder	95
					D&A OBS	39
					TriTech Altimeter	86.5
South 1	37° 43.277′	122° 22.658′	1/15/01 4:00 PM	2/15/01 9:10 AM	Sontek ADV	19.89
					SeaBird CT	86.4
					Sonardyne Transponder	95
					D&A OBS	19.89
					TriTech Altimeter	86.4
South 2	37° 43.028′	122° 22.441′	1/15/01 3:00 PM	2/15/01 9:58 AM	Sontek ADV	43
					SeaBird CT	86.5
					Sonardyne Transponder	95
					D&A OBS	43
					TriTech Altimeter	86.5
Channel Marker 8	37° 42.7833′	122° 22.1167′	1/15/01 2:30 PM	NA	WHG SeaPac 2200	NA
Channel Marker 2	37° 43.1667′	122° 22.7667′	1/15/01 3:30 PM	2/15/01 10:10 AM	WHG SeaPac 2200	NA
Southwest Piling (SWP)	37° 42.8833′	122° 21.8833′	1/29/01 3:00 PM	2/15/01 10:25 AM	WHG SeaPac 2200	NA

Table 2-2. Summary of Summer Deployment Locations and Instruments

Station	Latitude	Longitude	Date and Time Deployed	Date and Time Recovered	Instrument	Serial Number	Distance From Bottom (cm)
S1	37° 43.229′	122° 22.659′	7/17/2001 10:35:AM	8/14/2001 9:00 AM	Sontek ADV/Hydra	G131/B176	20
					D&A OBS 3	651	20
					Tritech Altimeter	2125.54943	86.5
					YSI CTD	98G0754	86.5
					Sonardyne	ID 21	95
S2	37° 43.031′	122° 22.449′	7/17/2001 9:45 AM	8/14/2001 10:00 AM	Sontek ADV/Hydra	G125/B180	43
					D&A OBS 3	1544	43
					Tritech Altimeter	2125.54941	86.5
					YSI CTD	98D0209	86.5
					Sonardyne	ID 22	95
N1	37° 43.843′	122° 21.636′	7/17/2001 1:41 PM	8/14/2001 10:50 AM	SeaPac Sp2100	31007	39
					D&A OBS 3A	60	39
					YSI CTD	98K0682	86
					Sonardyne	20	95
Tide - South Beach Harbor	37° 46.749′	122° 23.104′	7/18/2001 5:15 PM	8/14/2001 12:35 PM	Coastal MacroTide	10335	18
Tide - Oyster Point Marina	37° 39.884′	122° 22.492′	7/18/2001 3:45 PM	8/14/2001 2:15 PM	Coastal MacroTide	10223	18

Table 2-3. Summary of Winter Sampling Parameters and Instruments

Parameter	Instrument	Sample Frequency	Number of Samples/Burst[(a)]	Burst Interval[(b)]
Wave height	Sontek ADV	2 Hz	1,024	1 Hour
Wave velocity	Sontek ADV	2 Hz	1,024	1 Hour
Wave period	Sontek ADV	2 Hz	1,024	1 Hour
Current velocity	Sontek ADV	2 Hz	1,024	1 Hour
Turbidity	D&A OBS	2 Hz	1,024	1 Hour
Temperature	SeaBird CT	4 second avg	1	1 Hour
Conductivity	SeaBird CT	4 second avg	1	1 Hour
Bottom elevation	TriTech Altimeter	2 Hz	1,024	NA
Tidal height	WHG SeaPac 2200	2 Hz	1,024	1 Hour
Relocation transponder	Sonardyne Transponder	Respond only	NA	NA

Table 2-4. Summary of Summer Sampling Parameters and Instruments

Parameter	Instrument(s)	Sample Frequency	Number of Samples/Burst[(a)]	Burst Interval[(b)]
Wave height	Sontek ADV/Hydra	2 Hz	1024	60 min
	SeaPac 2100	2 Hz	1024	60 min
Wave velocity	Sontek ADV/Hydra	2 Hz	1024	60 min
	SeaPac 2100	2 Hz	1024	60 min
Wave period	Sontek ADV/Hydra	2 Hz	1024	60 min
	SeaPac 2100	2 Hz	1024	60 min
Current Velocity	Sontek ADV/Hydra	2 Hz	1024	60 min
	SeaPac 2100	1 Hz	512	60 min
Turbidity	D&A OBS 3	2 Hz	1024	60 min
	D&A OBS 3A	1 Hz	512	60 min
Bottom Elevation	TriTech PA500/6-S Altimeter	2 Hz	1024	60 min
Temperature	YSI 600 XLM CTD	1 hr	1	60 min
Conductivity	YSI 600 XLM CTD	1 hr	1	60 min
Tidal height	Coastal MacroTide	6 Hz	300	6 min
Relocation transponder	Sonardyne Transponder	Respond only	NA	NA

(a) Burst is defined as the sequence of measurements that are made at the sample frequency
(b) Burst interval is defined as the time period between measurement sequences (i.e. bursts)
NA = not applicable

Table 4-1. Statistical Summary of HPS Wind Data

Statistical Parameter	Wind Speed (m/s)	Direction (deg from N)
January 15 – February 15, 2001		
Mean	1.43	210
Maximum	4.92	359
Minimum	0.22	001
Standard Deviation	0.89	102
July 16 – August 15, 2001		
Mean	2.08	258
Maximum	4.02	348
Minimum	0.45	8
Standard Deviation	0.79	38

Table 4-2. Statistical Summary of STMS Data from January 15 to February 15, 2001

	North 1 - Winter											
	Currents					Waves				SSC	CT	
	Hourly			LPF								
Statistical Parameter	Current Speed (cm/s)	Mean Velocity East	Mean Velocity North	Mean Velocity East	Mean Velocity North	Significant Wave Height Hsig (cm)	Peak Period Tp (s)	Wave Orbital Velocity U1/3 (cm/s)	Water Depth (m)	Sediment Concentration (mg/l)	Temperature (degrees Celsius)	Salinity (psu)
Mean	17.97	12.04	-4.66	12.02	-4.66	8.16	3.35	1.04	7.79	62.63	10.52	28.49
Max	48.76	44.36	13.71	15.82	-0.14	47.10	6.00	8.59	9.29	264.89	11.57	30.20
Min	0.64	-26.84	-24.17	3.47	-7.96	2.70	2.30	0.12	5.22	27.94	10.05	25.87
Standard Deviation	10.59	14.28	8.04	2.06	1.55	4.91	0.75	1.27	0.79	26.30	0.23	0.78

	South 1 - Winter											
	Currents					Waves				SSC	CT	
	Hourly			LPF								
Statistical Parameter	Current Speed (cm/s)	Mean Velocity East	Mean Velocity North	Mean Velocity East	Mean Velocity North	Significant Wave Height Hsig (cm)	Peak Period Tp (s)	Wave Orbital Velocity U1/3 (cm/s)	Water Depth (m)	Sediment Concentration (mg/l)	Temperature (degrees Celsius)	Salinity (psu)
Mean	2.68	-0.19	0.04	-0.19	0.04	4.55	1.52	1.56	1.93	61.79	10.13	27.17
Max	18.60	6.24	14.19	0.95	2.58	35.30	3.90	19.79	3.34	710.12	22.66	31.00
Min	0.05	-10.12	-15.61	-1.26	-3.31	0.00	1.00	0.02	0.94	3.75	5.76	0.44
Standard Deviation	1.84	1.62	2.82	0.46	1.02	4.54	0.64	3.66	0.65	59.72	1.50	3.65

	South 2 - Winter											
	Currents					Waves				SSC	CT	
	Hourly			LPF								
Statistical Parameter	Current Speed (cm/s)	Mean Velocity East	Mean Velocity North	Mean Velocity East	Mean Velocity North	Significant Wave Height Hsig (cm)	Peak Period Tp (s)	Wave Orbital Velocity U1/3 (cm/s)	Water Depth (m)	Sediment Concentration (mg/l)	Temperature (degrees Celsius)	Salinity (psu)
Mean	4.40	0.27	0.68	0.27	0.68	8.69	1.72	2.36	2.50	55.82	10.23	28.30
Max	16.79	15.53	8.84	3.04	3.67	67.00	4.00	38.57	3.98	331.23	13.27	29.60
Min	0.27	-11.17	-6.93	-1.94	-0.97	1.20	1.00	0.04	0.89	18.84	6.39	1.60
Standard Deviation	2.29	4.13	2.65	0.93	0.77	6.97	0.61	5.13	0.73	48.00	0.59	2.30

Table 4-3. Statistical Summary of Current Data from July 16 to August 15, 2001

	North 1 - Summer											
	Currents					Waves				SSC	CT	
	Hourly			LPF								
Statistical Parameter	Current Speed (cm/s)	Mean Velocity East	Mean Velocity North	Mean Velocity East	Mean Velocity North	Significant Wave Height Hsig (cm)	Peak Period Tp (s)	Wave Orbital Velocity U1/3 (cm/s)	Water Depth (m)	Sediment Concentration (mg/l)	Temperature (degrees Celsius)	Salinity (psu)
Mean	14.25	8.98	-2.77	8.98	-2.77	4.40	3.48	1.01	5.90	-	17.56	24.53
Max	36.59	32.18	15.01	12.87	-1.00	19.34	5.80	5.37	7.98	-	19.19	25.64
Min	0.43	-17.67	-19.91	6.27	-4.87	0.45	1.80	0.00	0.00	-	15.92	21.07
Standard Deviation	7.09	10.45	7.49	1.48	0.69	2.69	1.09	1.02	1.11	-	0.64	0.63

	South 1 - Summer											
	Currents					Waves				SSC	CT	
	Hourly			LPF								
Statistical Parameter	Current Speed (cm/s)	Mean Velocity East	Mean Velocity North	Mean Velocity East	Mean Velocity North	Significant Wave Height Hsig (cm)	Peak Period Tp (s)	Wave Orbital Velocity U1/3 (cm/s)	Water Depth (m)	Sediment Concentration (mg/l)	Temperature (degrees Celsius)	Salinity (psu)
Mean	3.08	-0.75	0.21	-0.75	0.21	4.58	1.34	0.20	2.15	54.85	19.38	25.84
Max	11.00	4.53	9.75	-0.01	1.35	11.90	1.90	2.24	3.59	344.60	21.69	26.31
Min	0.10	-5.37	-8.75	-1.81	-0.71	0.50	1.00	0.02	0.95	0.00	16.13	13.84
Standard Deviation	1.74	2.08	2.75	0.35	0.45	1.68	0.25	0.22	0.68	30.13	0.88	0.50

	South 2 - Summer											
	Currents					Waves				SSC	CT	
	Hourly			LPF								
Statistical Parameter	Current Speed (cm/s)	Mean Velocity East	Mean Velocity North	Mean Velocity East	Mean Velocity North	Significant Wave Height Hsig (cm)	Peak Period Tp (s)	Wave Orbital Velocity U1/3 (cm/s)	Water Depth (m)	Sediment Concentration (mg/l)	Temperature (degrees Celsius)	Salinity (psu)
Mean	3.90	-0.68	0.76	-0.59	0.66	6.36	1.49	0.20	2.79	53.92	19.11	26.06
Max	11.36	10.69	6.91	0.50	1.81	15.70	2.20	1.51	4.27	644.89	21.36	26.32
Min	0.02	-8.48	-5.22	-1.56	-0.82	1.30	1.00	0.02	1.15	0.00	17.11	25.87
Standard Deviation	2.24	3.65	2.44	0.48	0.52	1.99	0.28	0.16	0.72	73.46	0.75	0.09

Table 5-1. Summary of Cumulative Sediment Flux Calculations

Station	Total Flux		Average Daily Flux	Residual Advective Flux		Dispersive Flux		Stokes Drift Flux	
	Magnitude	Direction	Magnitude	Magnitude	Direction	Magnitude	Direction	Magnitude	Direction
Winter									
North 1	165.6	SE	6.1	153.4	SE	4.2	SE	7.9	NW
South 1	2.4	SW	0.1	1.5	SW	0.5	NW	0.4	NW
South 2	3.4	NE	0.1	2.3	NE	0.4	NE	0.7	NW
Summer									
North 1	-	-	-	-	-	-	-	-	-
South 1	2.9	NW	0.1	2.2	NW	0.3	NW	0.3	NW
South 2	-	-	-	-	-	-	-	-	-

Note: All magnitudes are in units $x10^{-6}$ g/m.
Note 2: The Average Daily Flux was determined by dividing the Total Flux by the number of days with useable data.

Table 5-2. Estimates of Critical Shear Velocities and Stresses

Size (cm)	% fraction	S*	Shields	u_{*cr} (cm/s)	t_{cr} (dy/cm^2)	W_s (cm/s)
Station North 1						
0.1061	4.9	23.16	0.034	2.42	5.95	15.8
0.033	14.6	4.02	0.046	1.57	2.5	4.25
0.0122	14.2	0.9	0.1	1.4	2.01	0.88
0.0034	21.1	0.13	0.38	1.45	2.13	0.08
0.0017	8.2	0.05		1.21	1.5	0.02
0.00037	37	0		0.99	1	0.00085
Station South 1						
0.005	0.3	0.24	0.38	1.75	3.13	0.108
0.0033	6.9	0.13	0.38	1.42	2.07	0.108
0.0016	20.1	0.04		1.21	1.5	0.018
0.00048	72.7	0.01		0.99	1	0.0016
Station South 2						
0.0075	0.3	0.44	0.38	2.15	4.7	0.108
0.0033	12.8	0.13	0.38	1.42	2.07	0.108
0.0016	22.9	0.04		1.21	1.5	0.018
0.00046	64	0.01		0.99	1	0.0014

S* is a dimensionless particle parameter defined by Madsen and Grant (1976).
S* is used to estimate the Shields parameter (see Shields in column above).

Table 5-3. Modeling Statistics and Frequency of Resuspension

	Uc	U1/3	U*b	τ_b
N1-w				
Mean	18.738	1.047	0.637	0.041
Std	10.789	1.280	0.340	0.051
S1-w				
Mean	2.601	1.567	0.265	0.007
Std	1.672	3.667	0.352	0.057
S2-w				
Mean	4.510	2.371	0.388	0.015
Std	2.321	5.141	0.471	0.108
N1-s				
Mean	14.387	1.014	0.545	0.030
Std	7.236	1.017	0.247	0.031
S1-s				
Mean	3.048	0.196	0.154	0.002
Std	1.669	0.218	0.069	0.003
S2-s				
Mean	3.816	0.131	0.153	0.002
Std	2.268	0.153	0.069	0.002

	0.1	0.3
N1-w	16	0
S1-w	5	1
S2-w	9.4	3
N1-s	4	0
S1-s	0	0
S2-s	0	0

***Values in percentage of time exceeding Tb limits**

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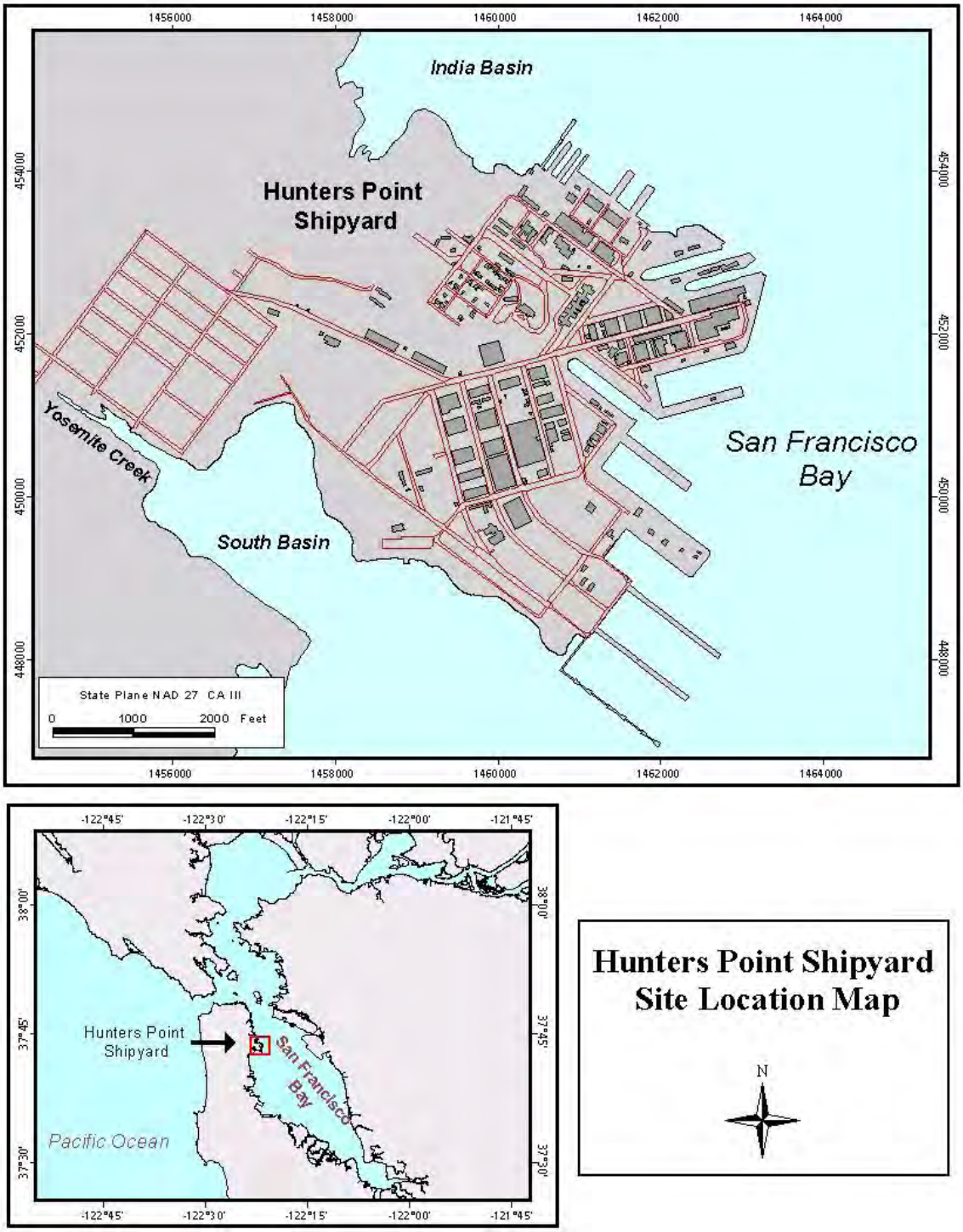


Figure 1-1. Hunters Point Shipyard Site Location Map

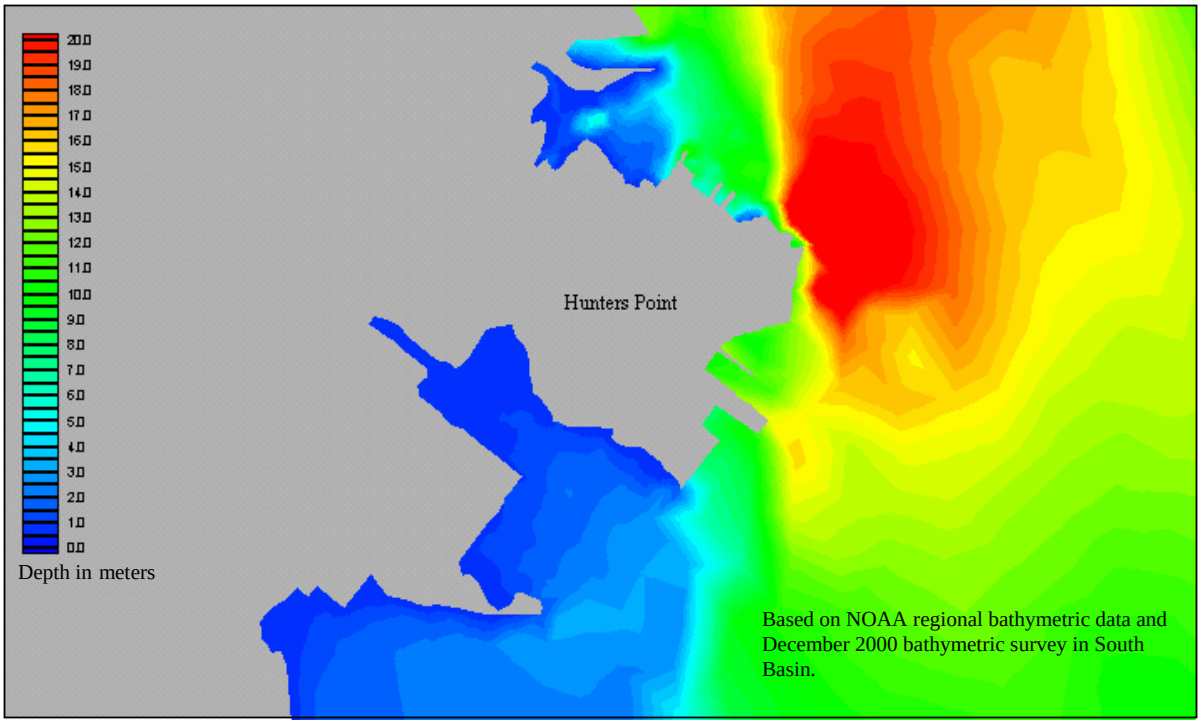


Figure 1-2. Bathymetry around Hunters Point Shipyard

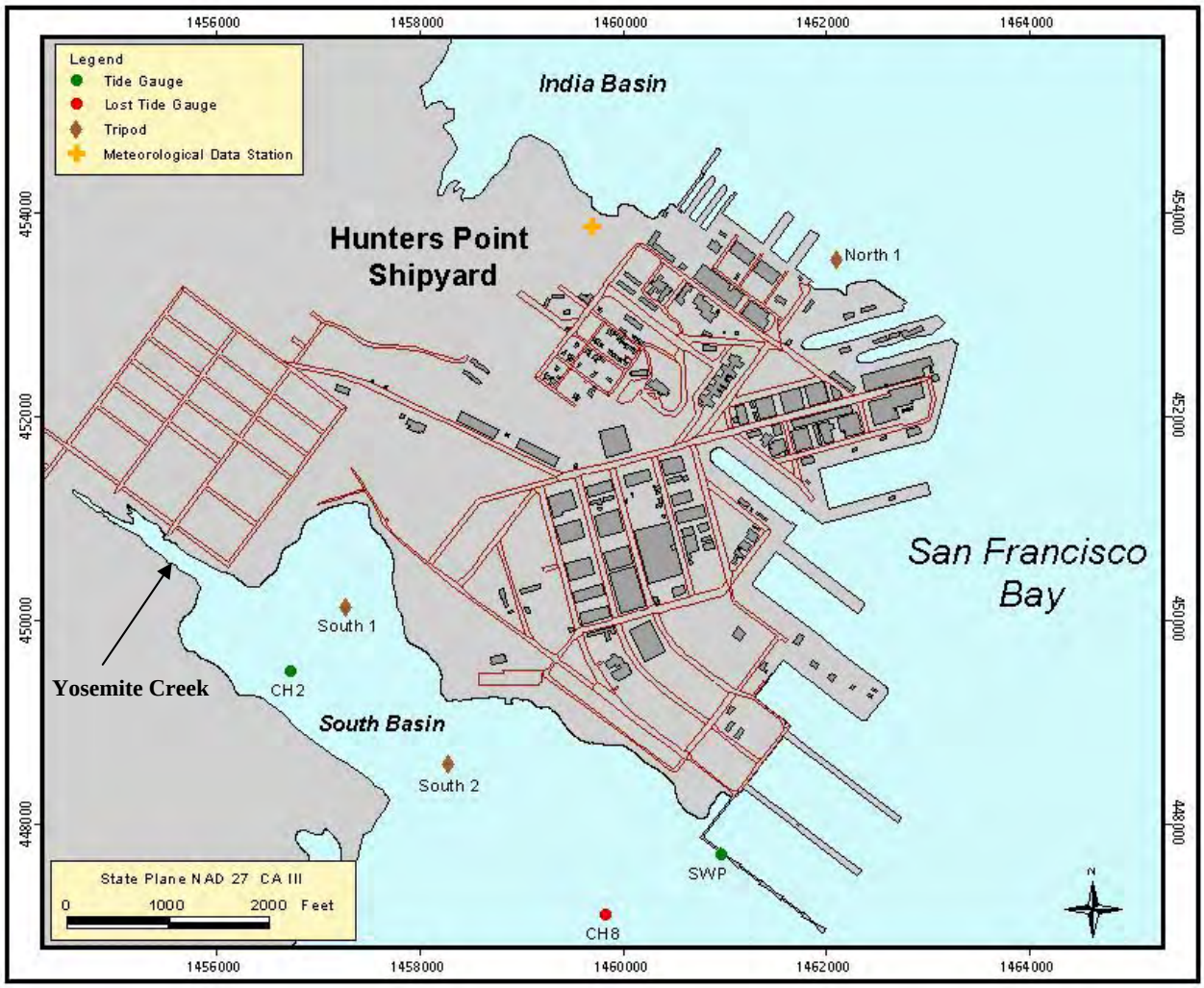


Figure 2-1. Winter STMS Station Locations

Figure 2-2. STMS Deployment Platform

Figure 2-3. Summer 2001 Instrument Deployment Locations

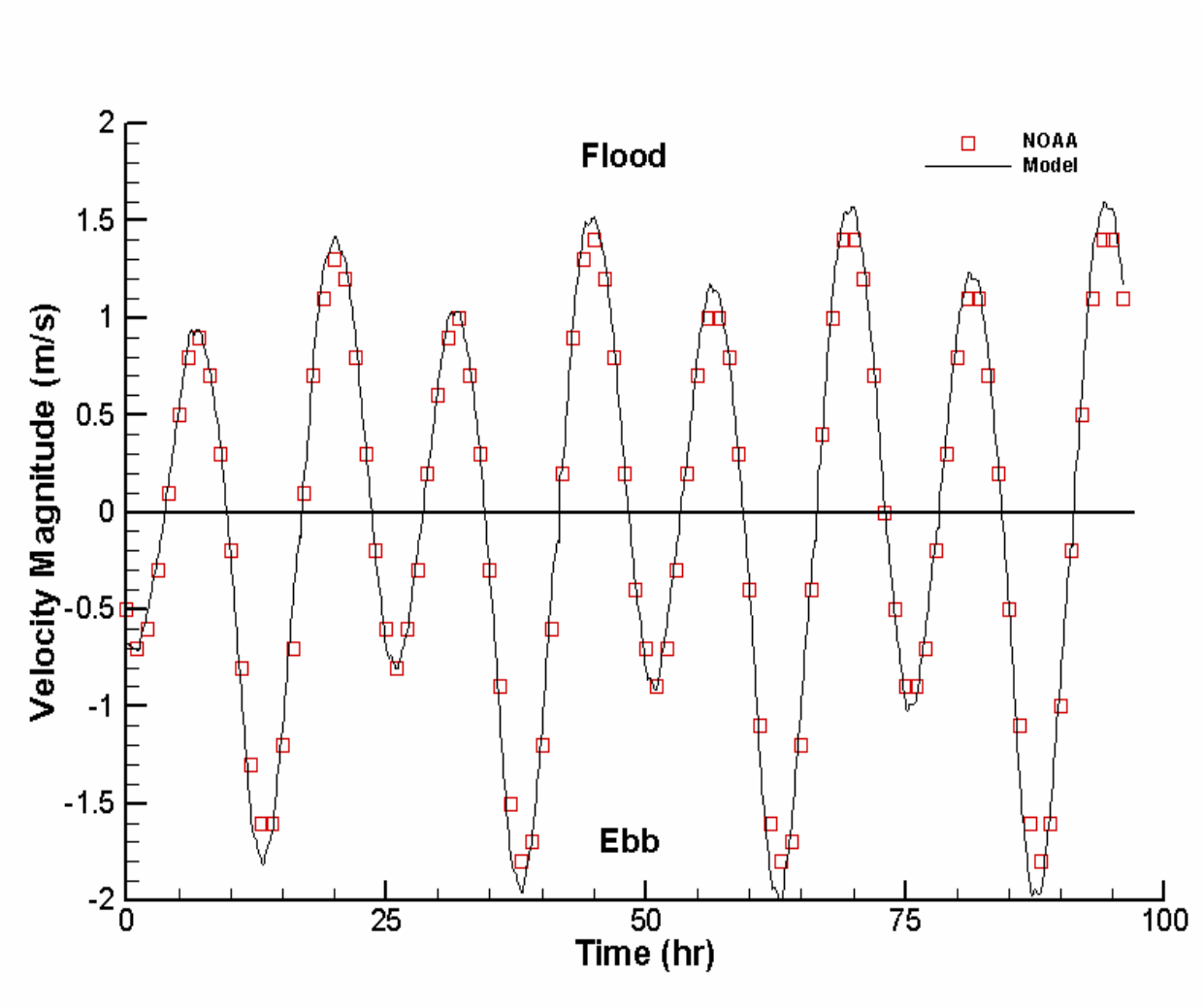


Figure 3-1. Comparison of NOAA current predictions and modeled currents for Station 349 (February 5th – 9th, 2001).

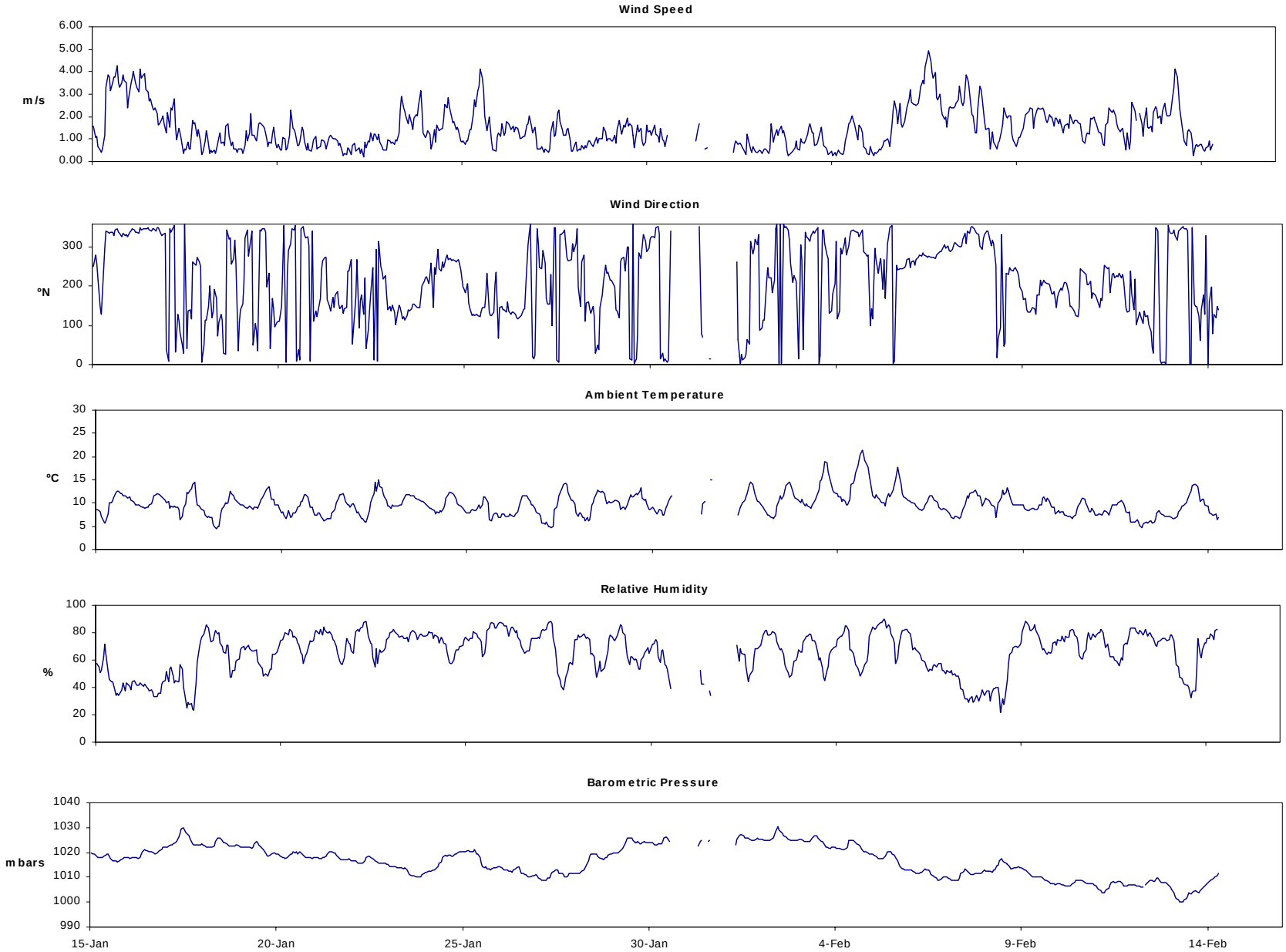


Figure 4-1. HPS Hourly Meteorological Data 1/15/2001-2/15/2001. Wind Vector is Direction from which Wind is Blowing.

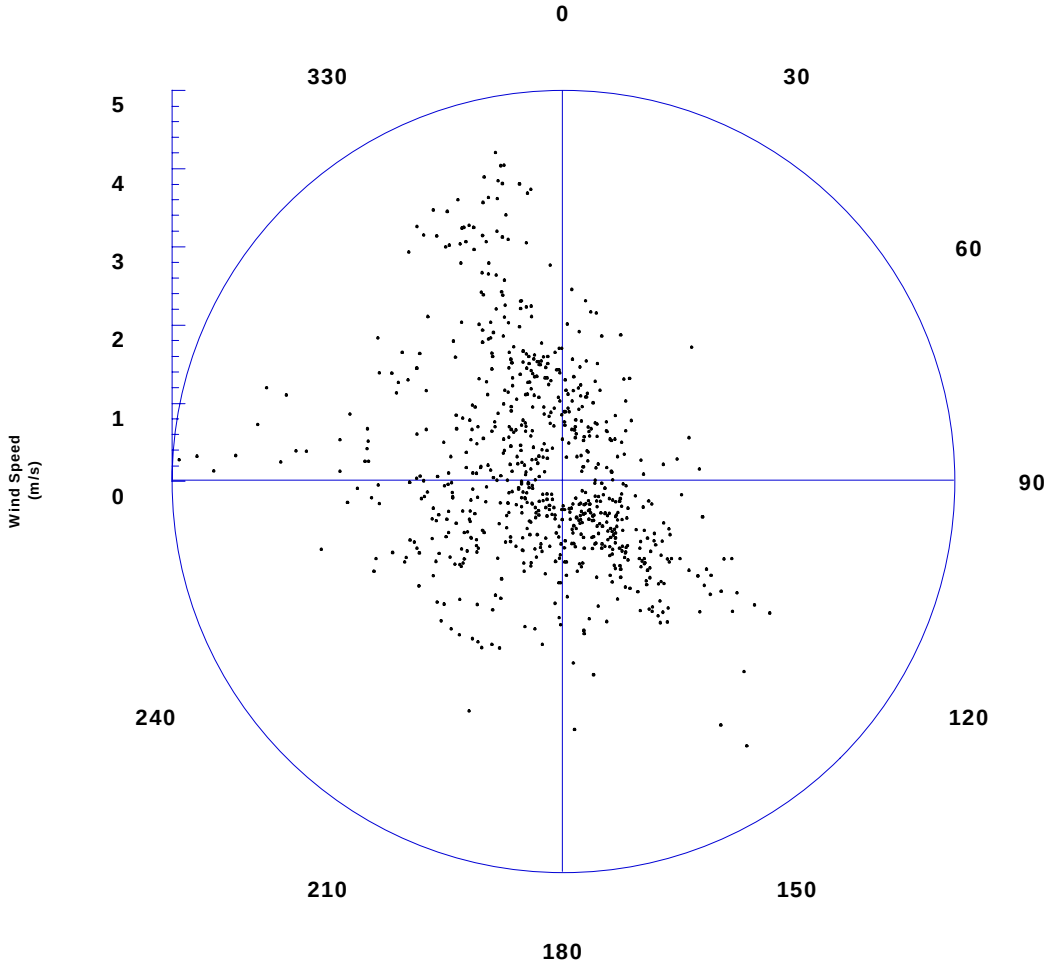


Figure 4-2. Winter Wind Speed Magnitude and Direction. Data Points Represent Tip of Wind Vector, with Tail at the Circle's Origin.

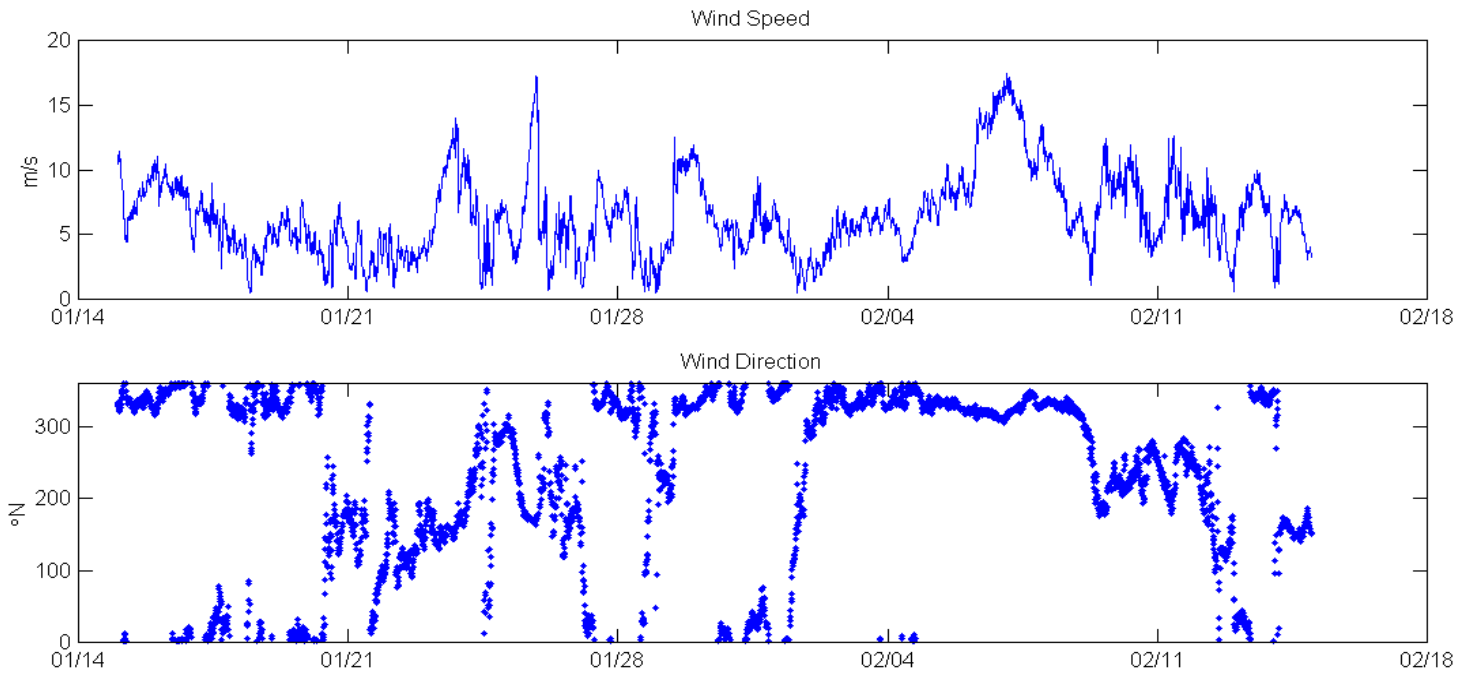


Figure 4-3. Wind Speed And Direction During Winter Deployment Period from Offshore Buoy 46012.

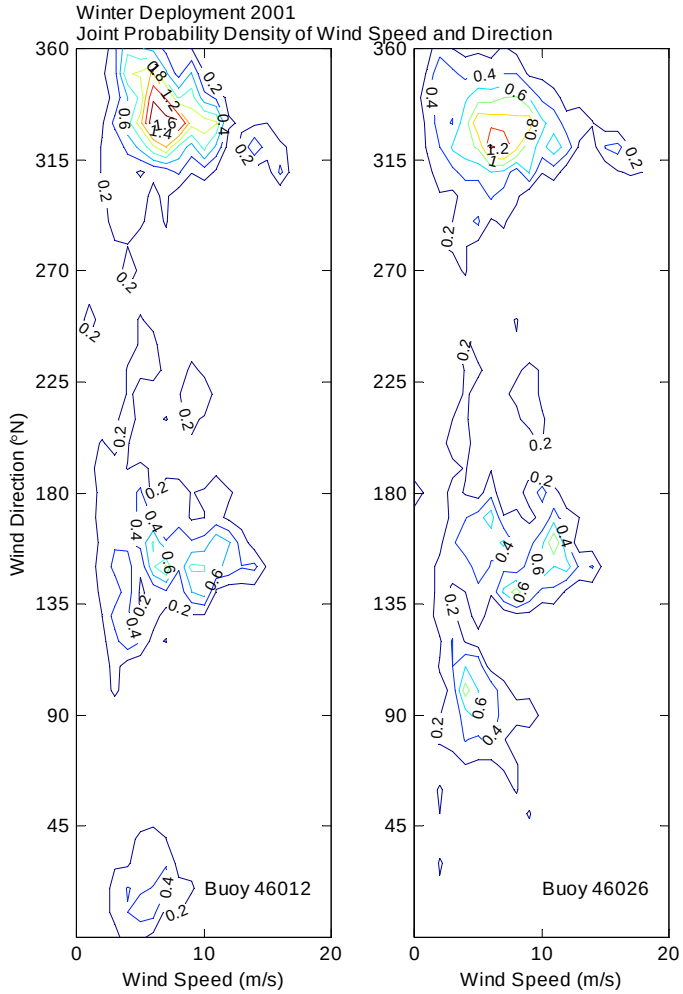


Figure 4-4. Joint Probability Density of Wind Speed and Direction During the Winter Deployment Period from Two Offshore Buoys.

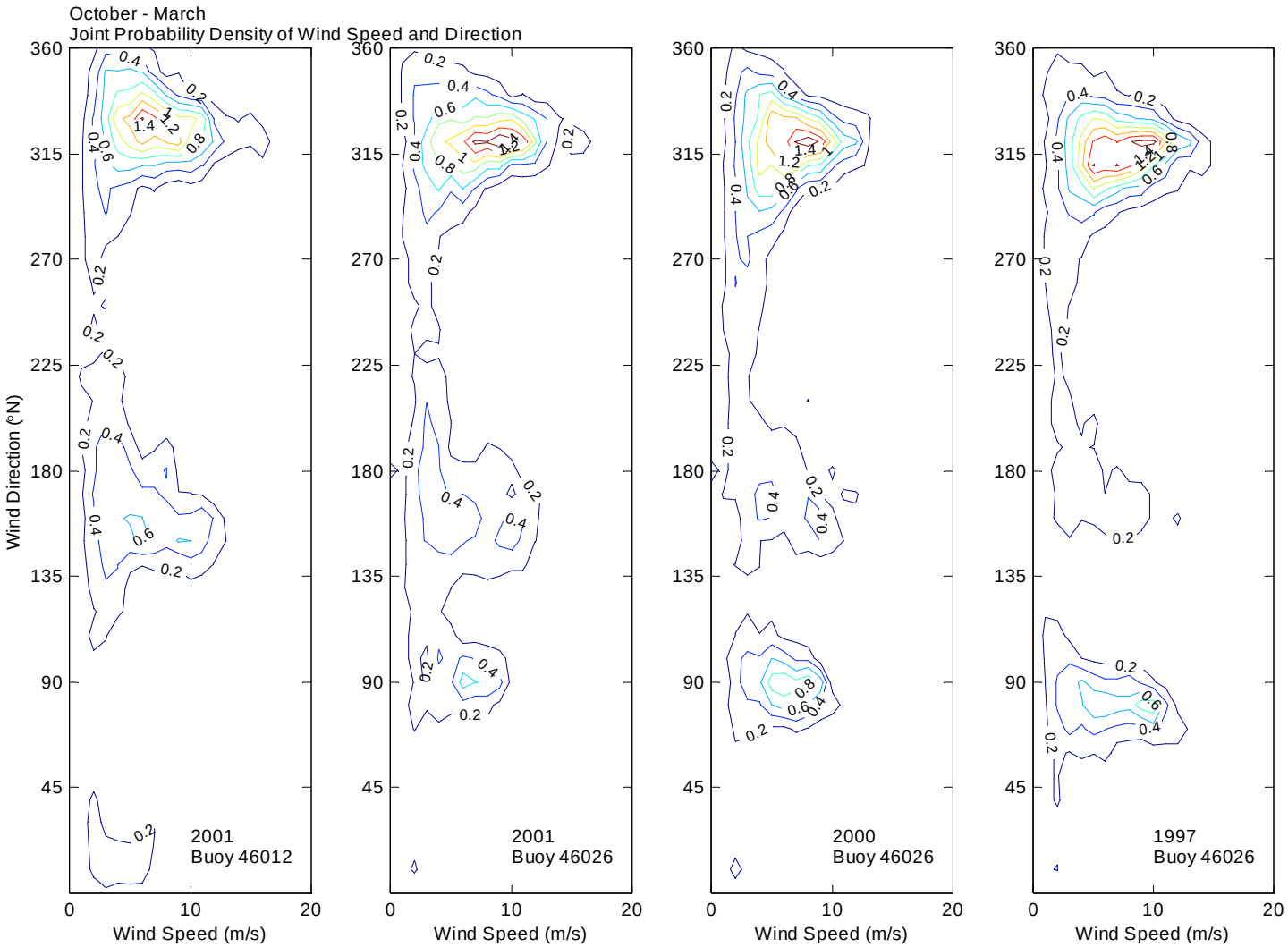


Figure 4-5. Joint Probability Density of Wind Speed and Direction During the Winter Season (October through March) for 2001, 2000, and 1997 from Two Offshore Buoys.

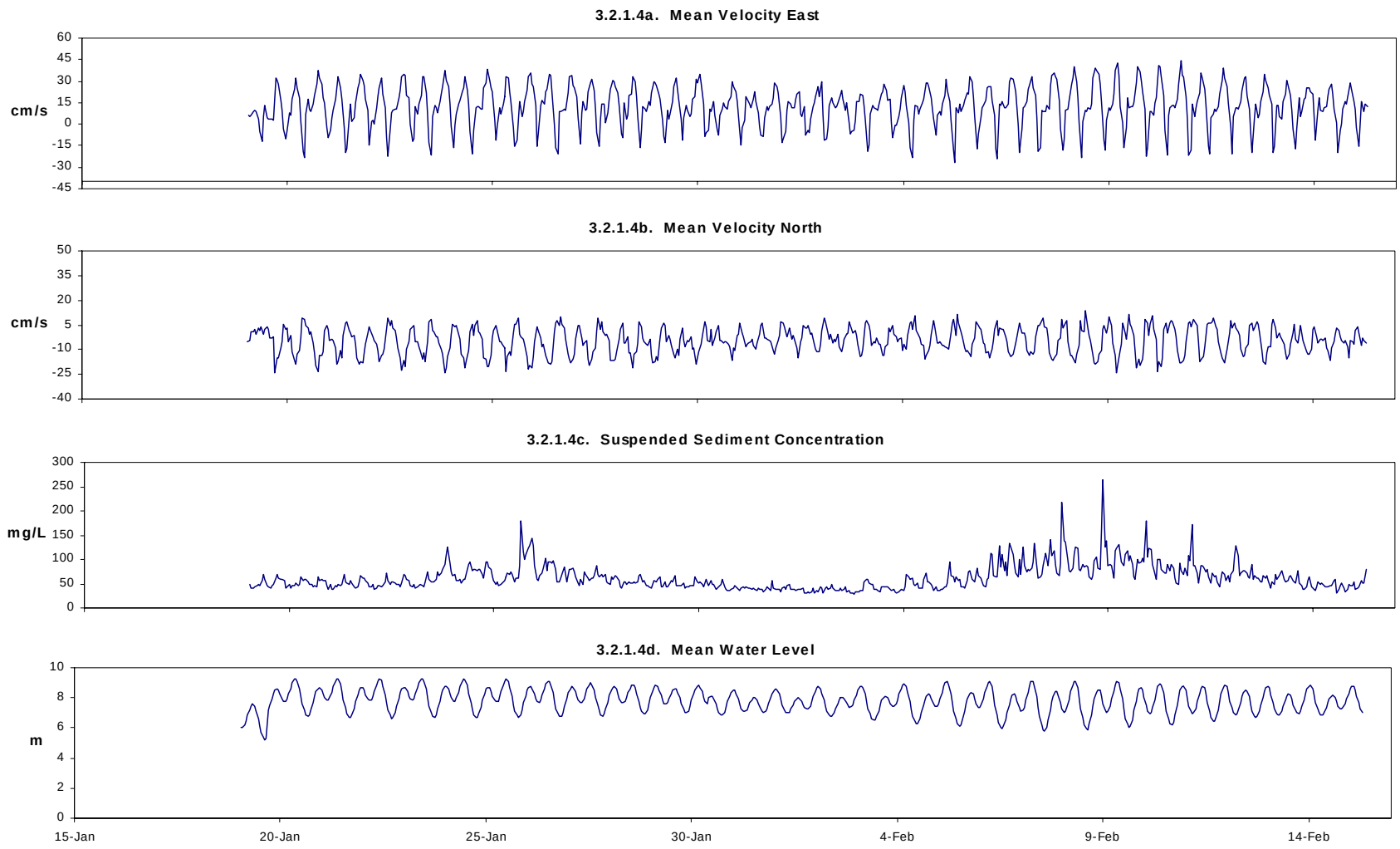


Figure 4-6. Station North 1 - Winter Current, SSC, and Depth Data

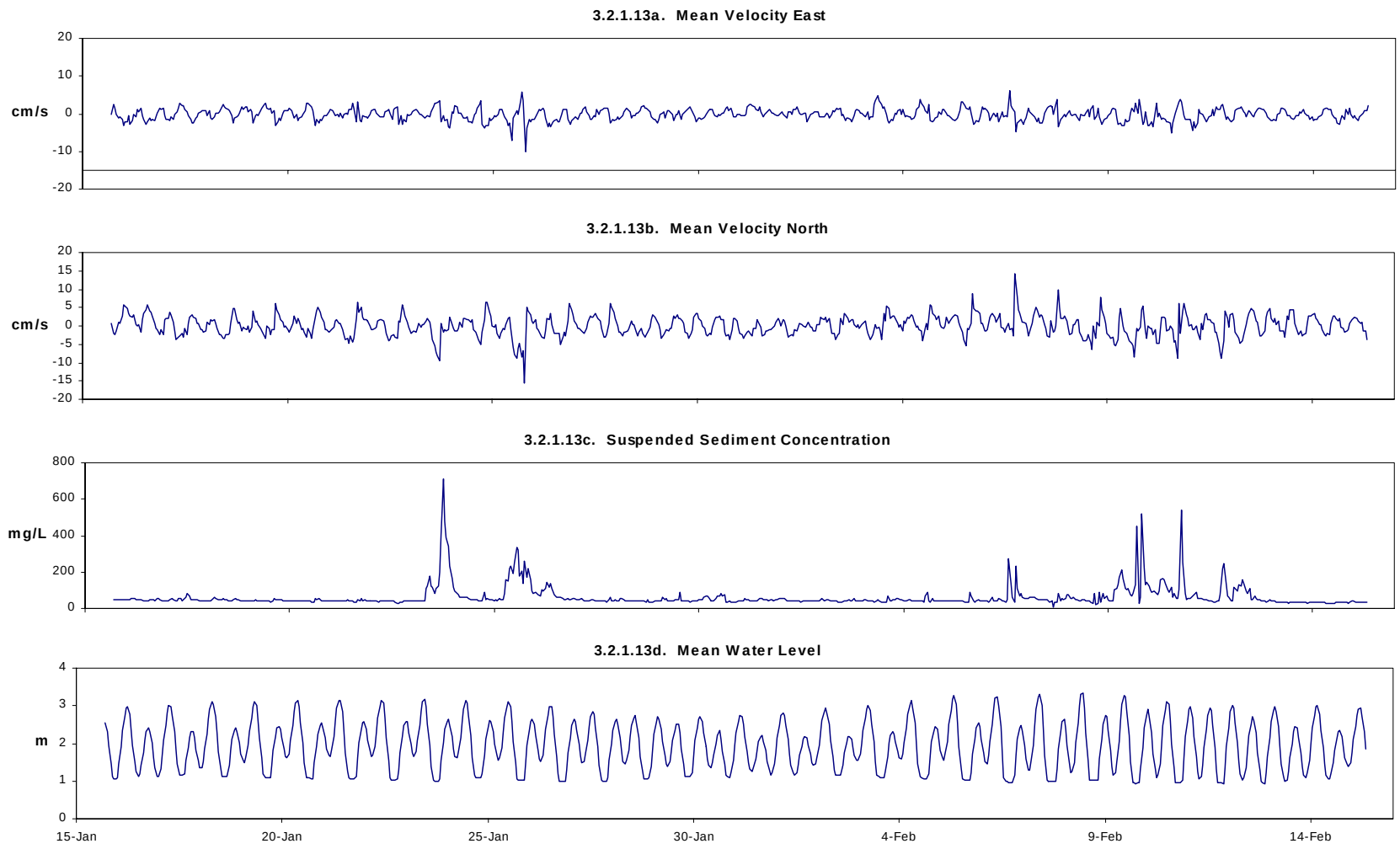


Figure 4-7. Station South 1 - Winter Current, SSC, and Depth Data

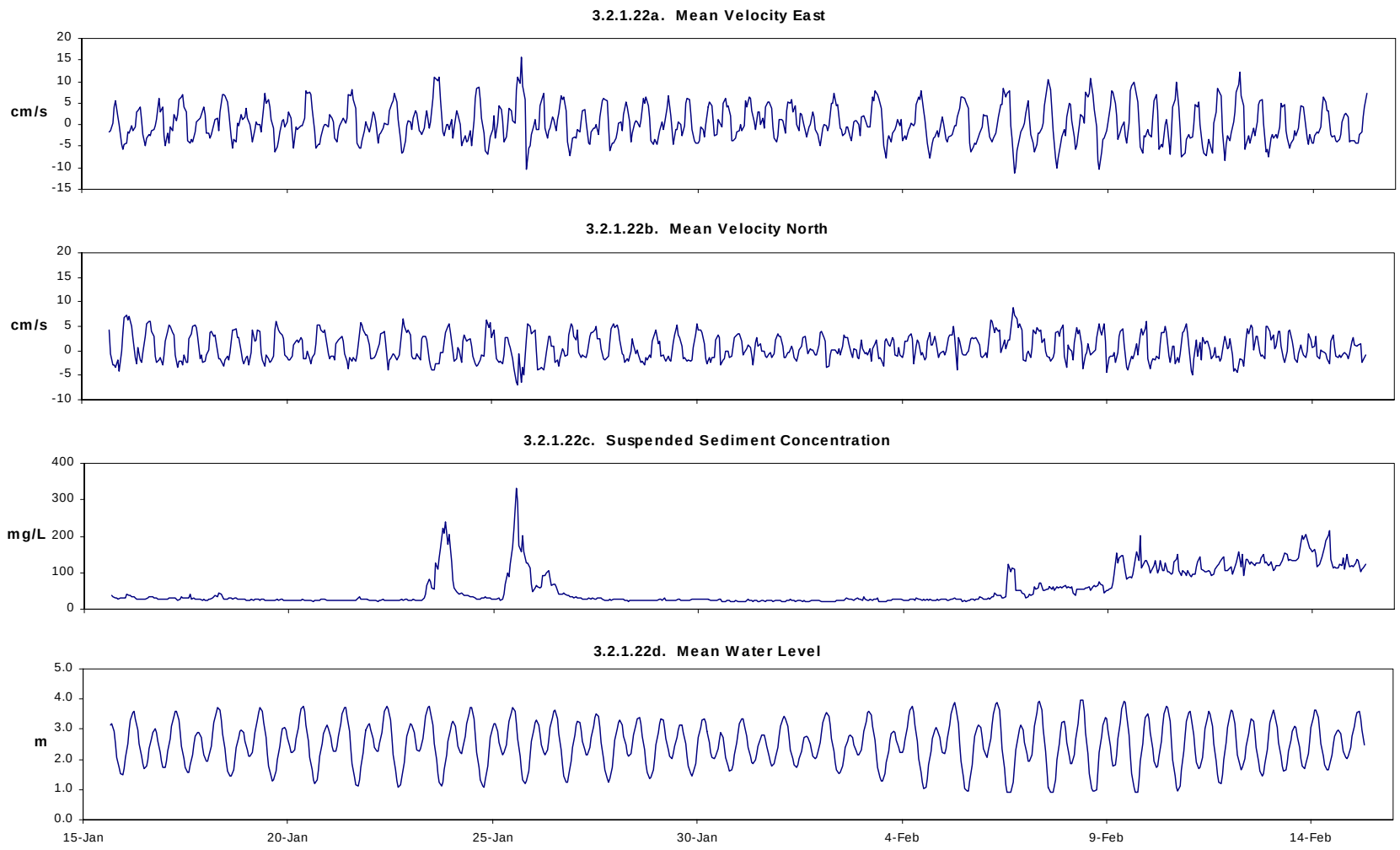


Figure 4-8. Station South 2 - Winter Current, SSC, and Depth Data.

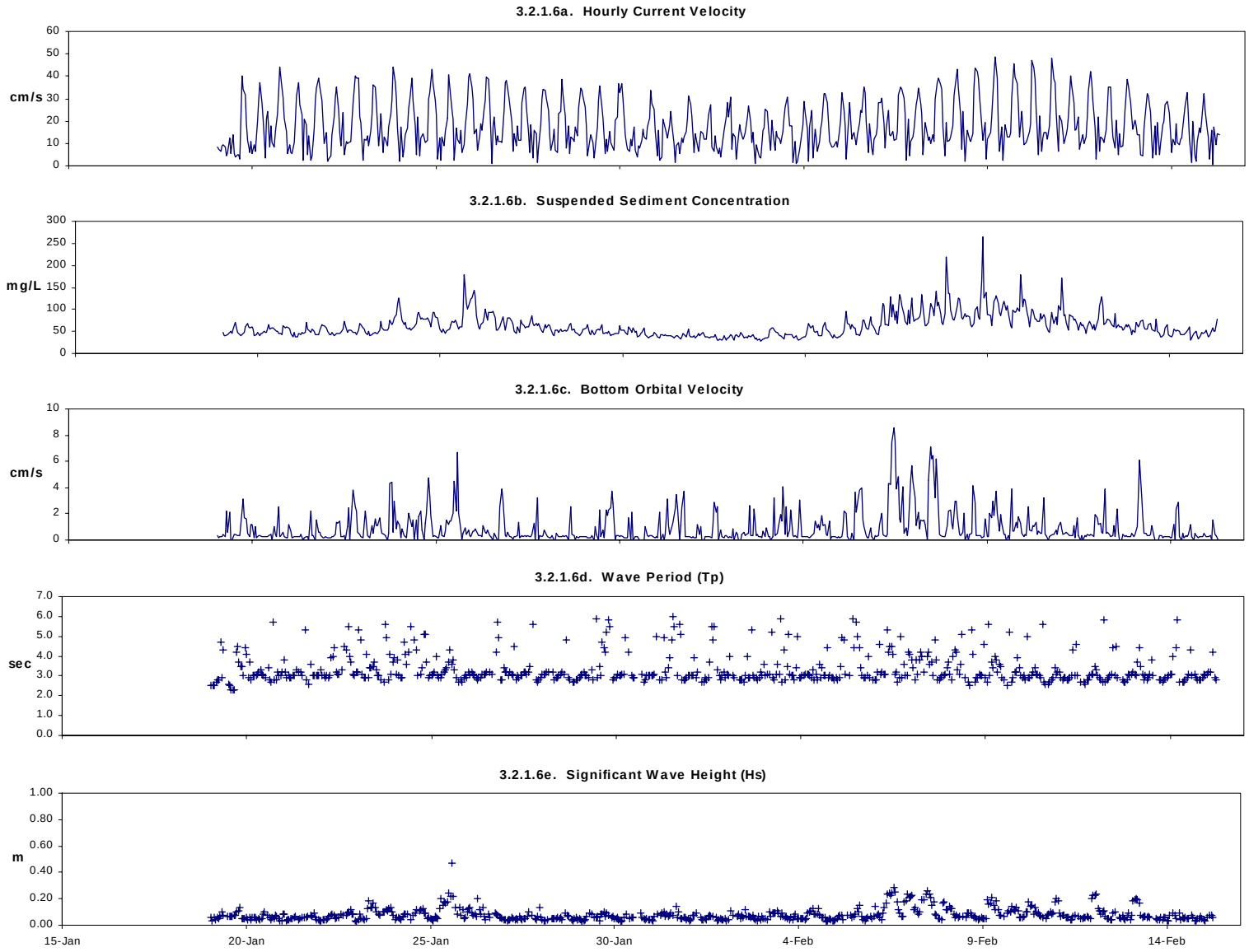


Figure 4-9. Station North 1 - Winter Current, SSC, and Wave Data

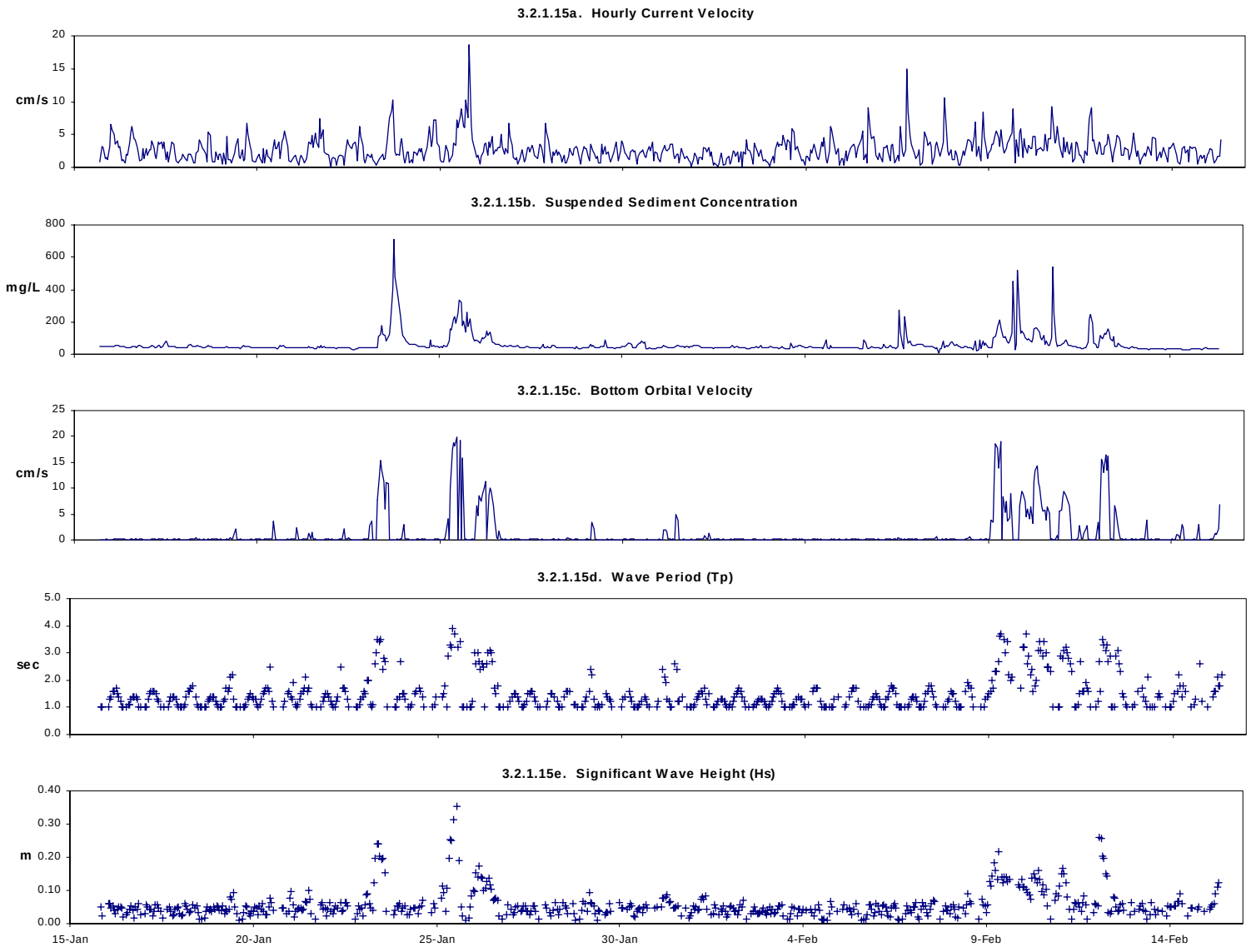


Figure 4-10. Station South 1 - Winter Current, SSC, and Wave Data

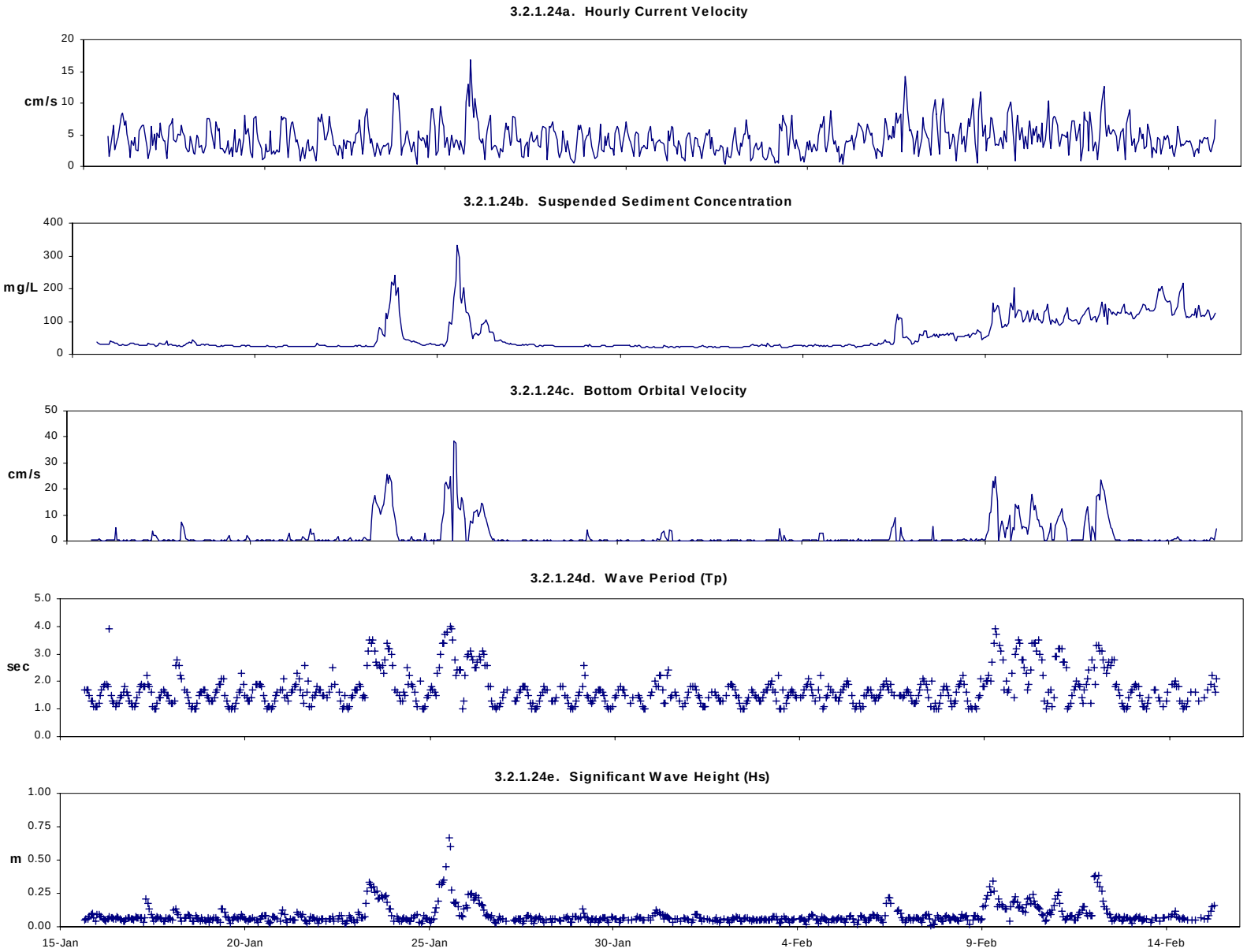


Figure 4-11. Station South 2 - Winter Current, SSC, and Wave Data

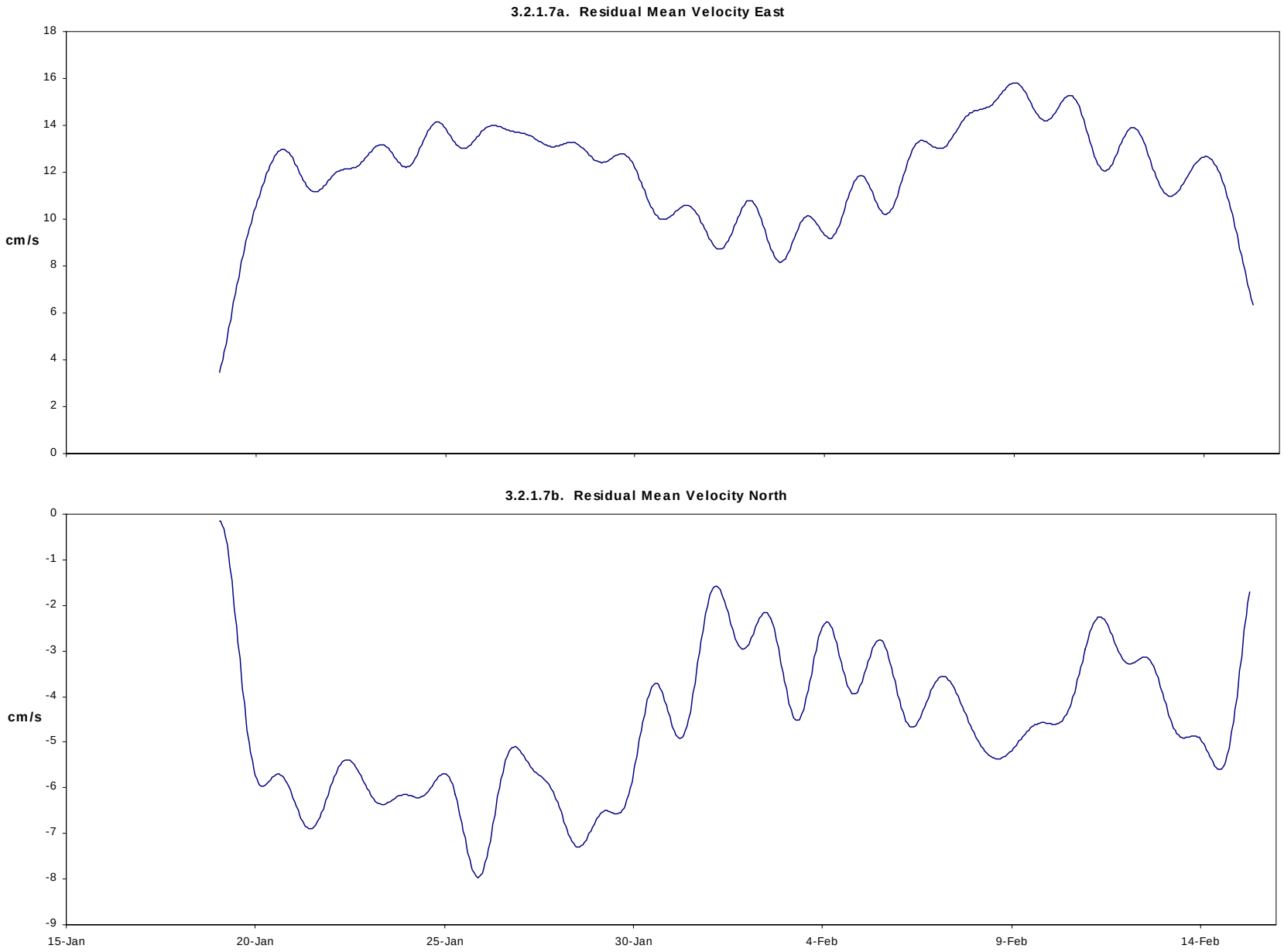


Figure 4-12. Station North 1 - Winter Residual Low Pass Frequency Current Velocities

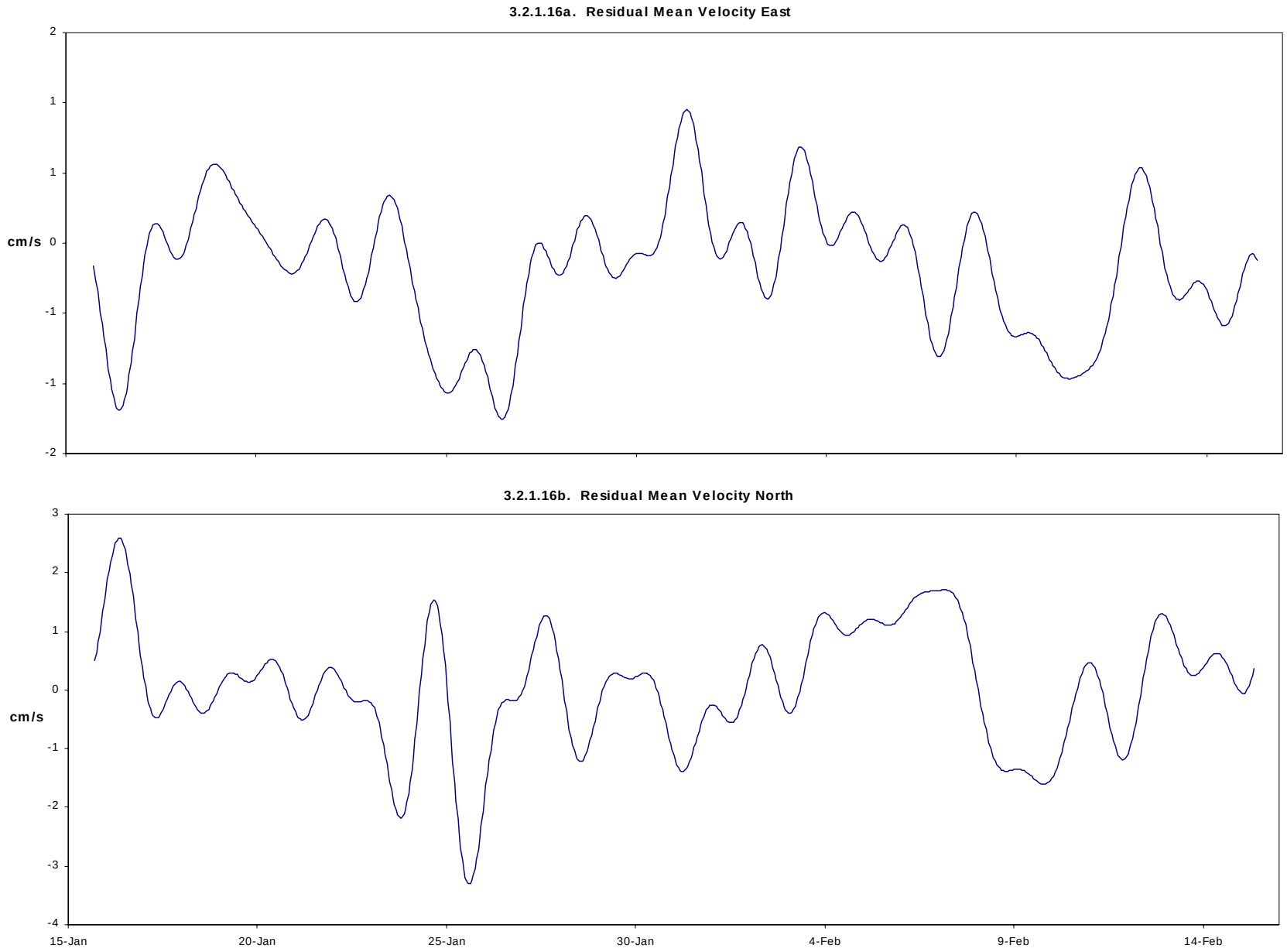


Figure 4-13. Station South 1 - Winter Residual Low Pass Frequency Current Velocities

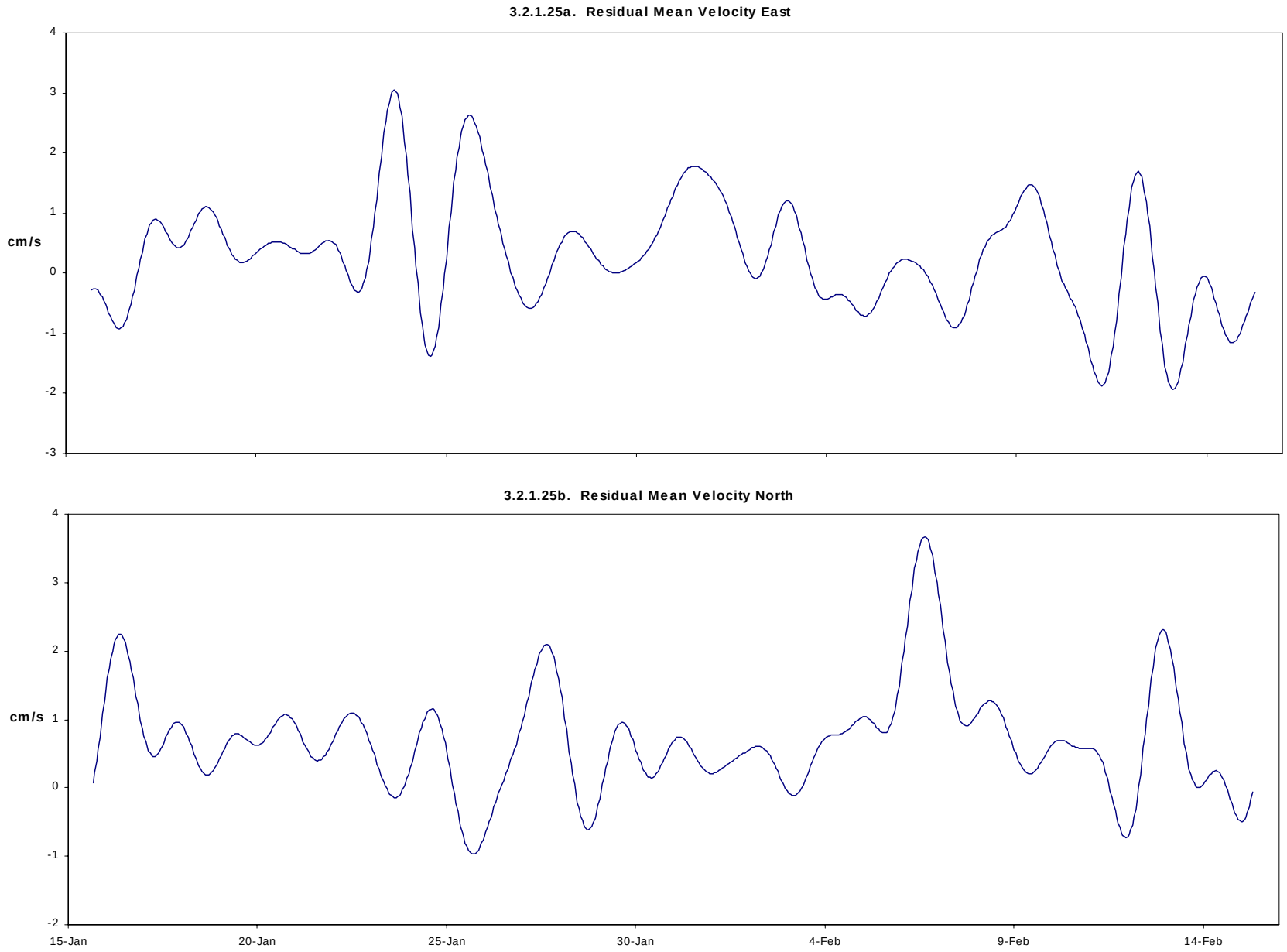


Figure 4-14. Station South 2 - Winter Residual Low Pass Frequency Current Velocities

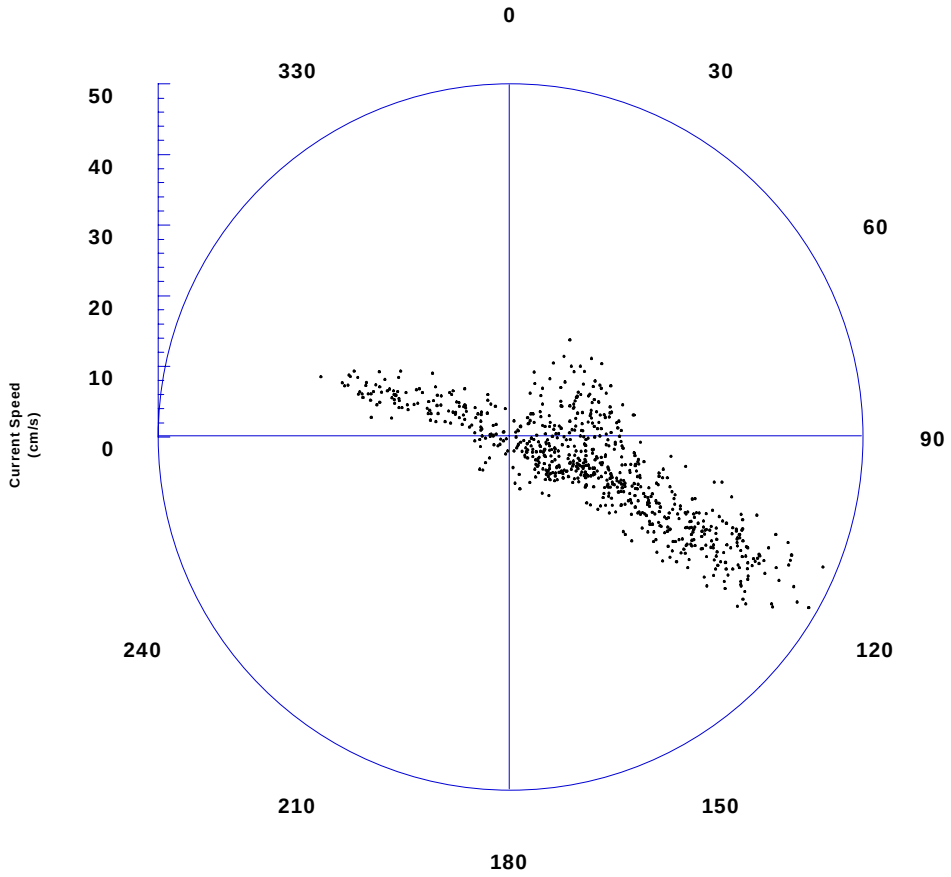


Figure 4-15. Winter Current Magnitude and Direction at Station North 1

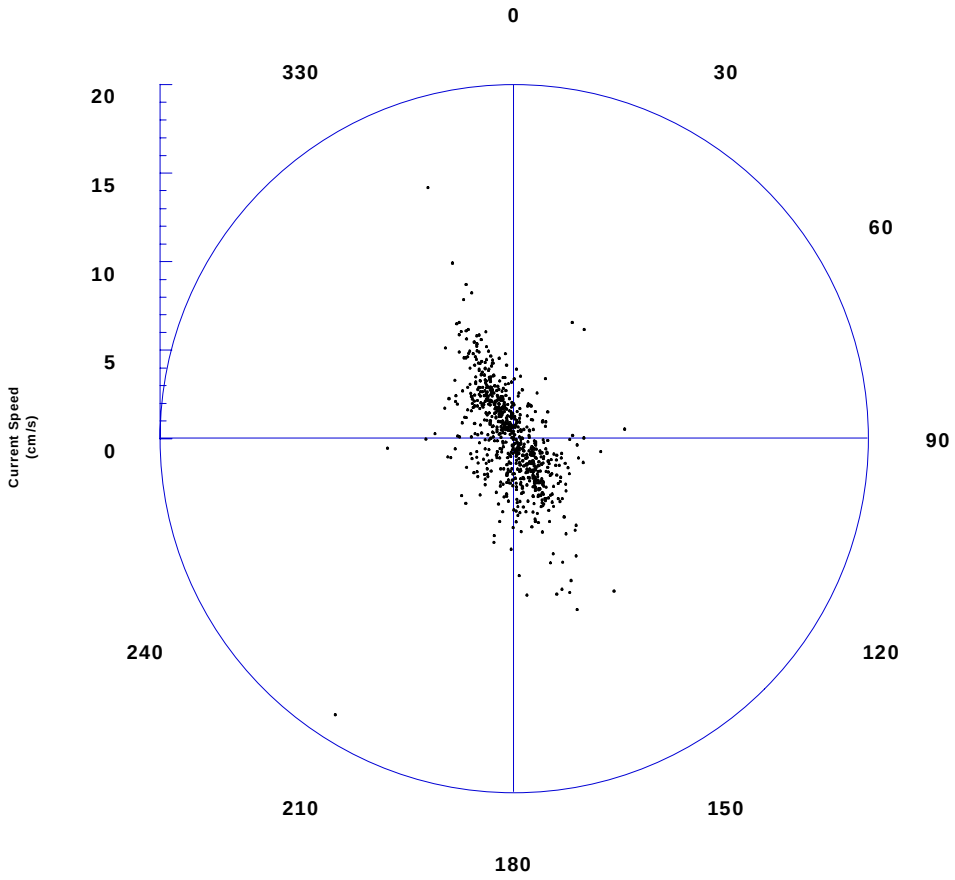


Figure 4-16. Winter Current Magnitude and Direction at Station South 1

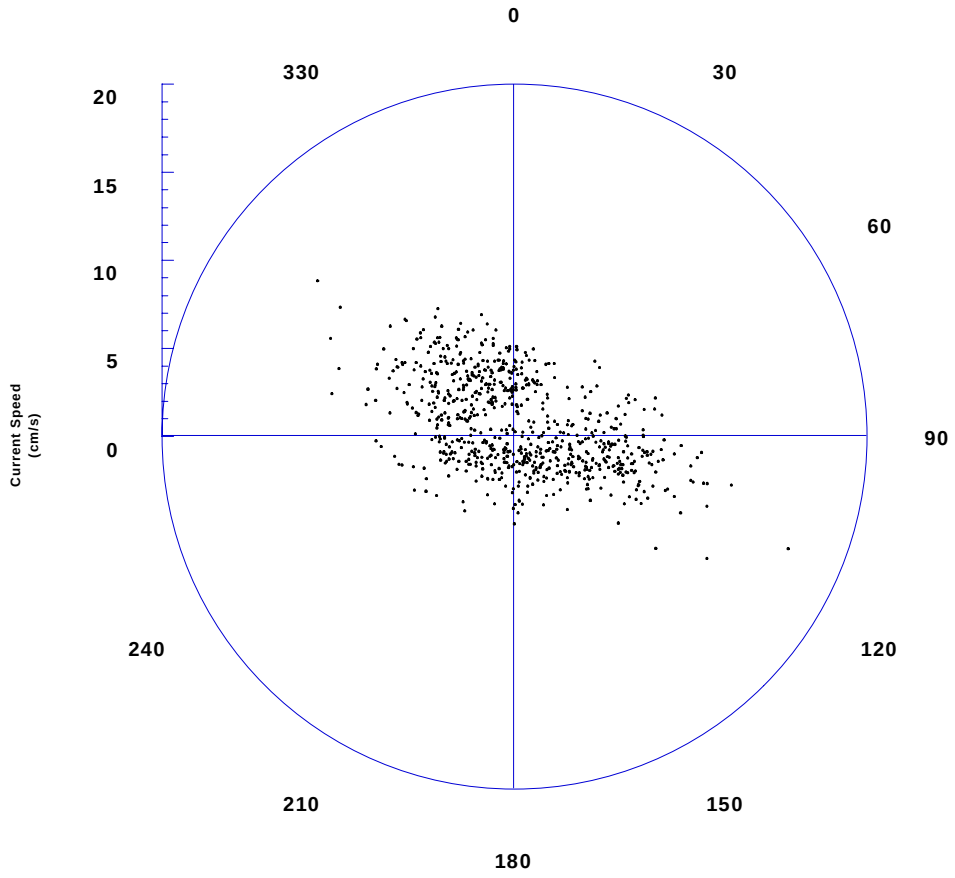


Figure 4-17. Winter Current Magnitude and Direction at Station South 2

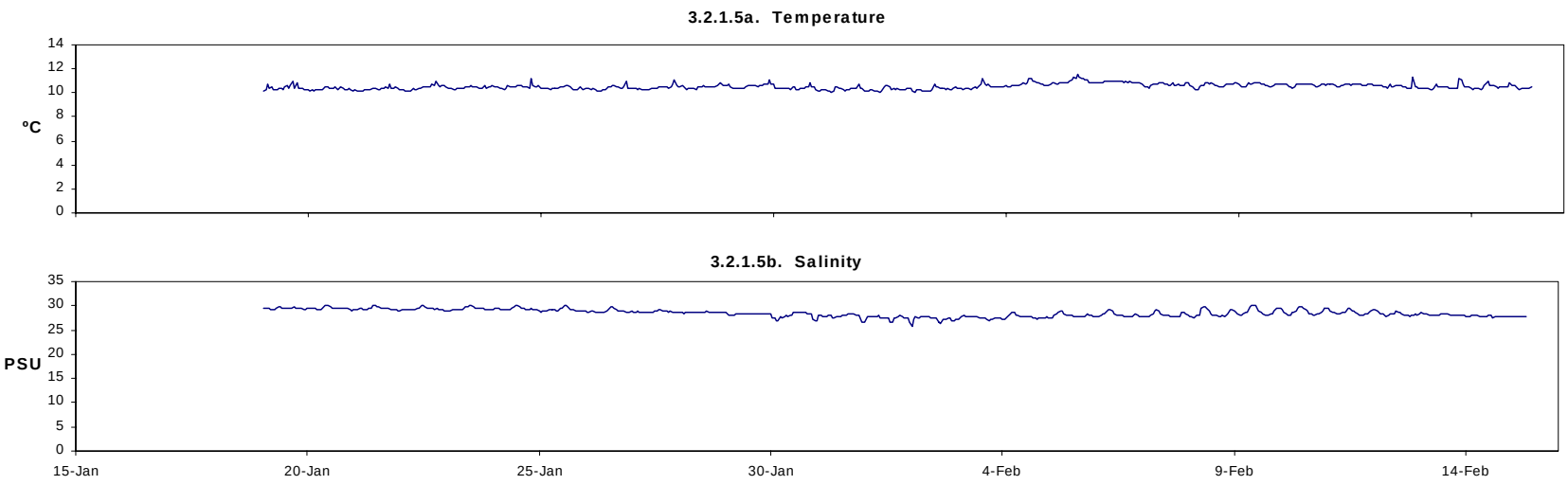


Figure 4-18. Station North 1 - Winter Temperature and Salinity

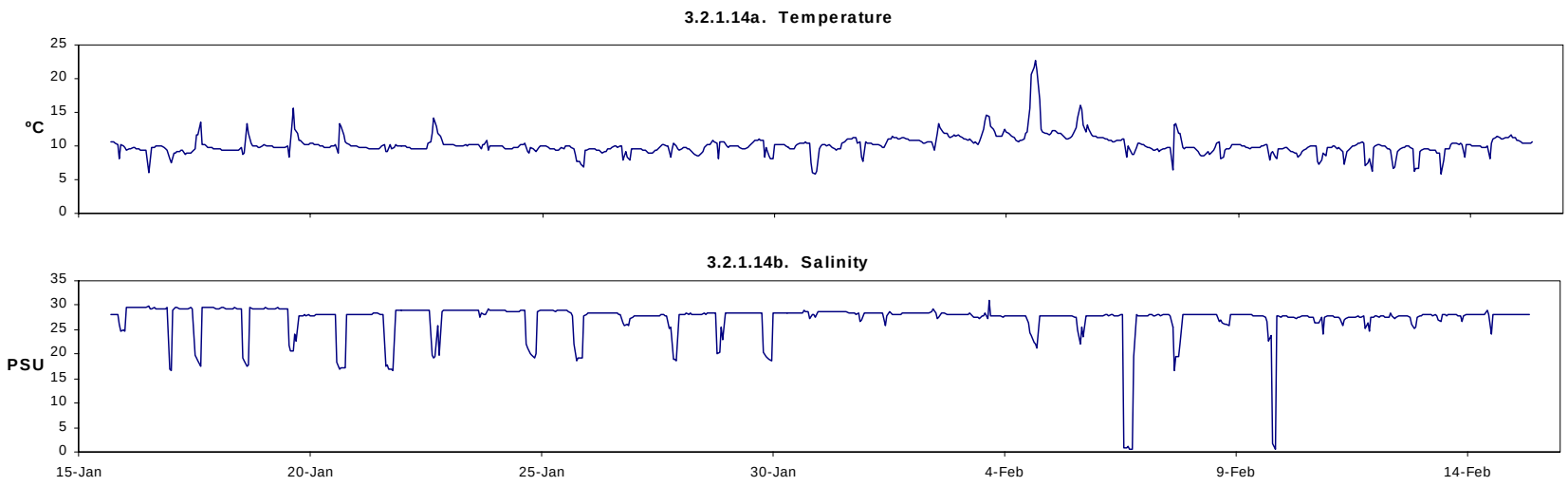


Figure 4-19. Station South 1 - Winter Temperature and Salinity

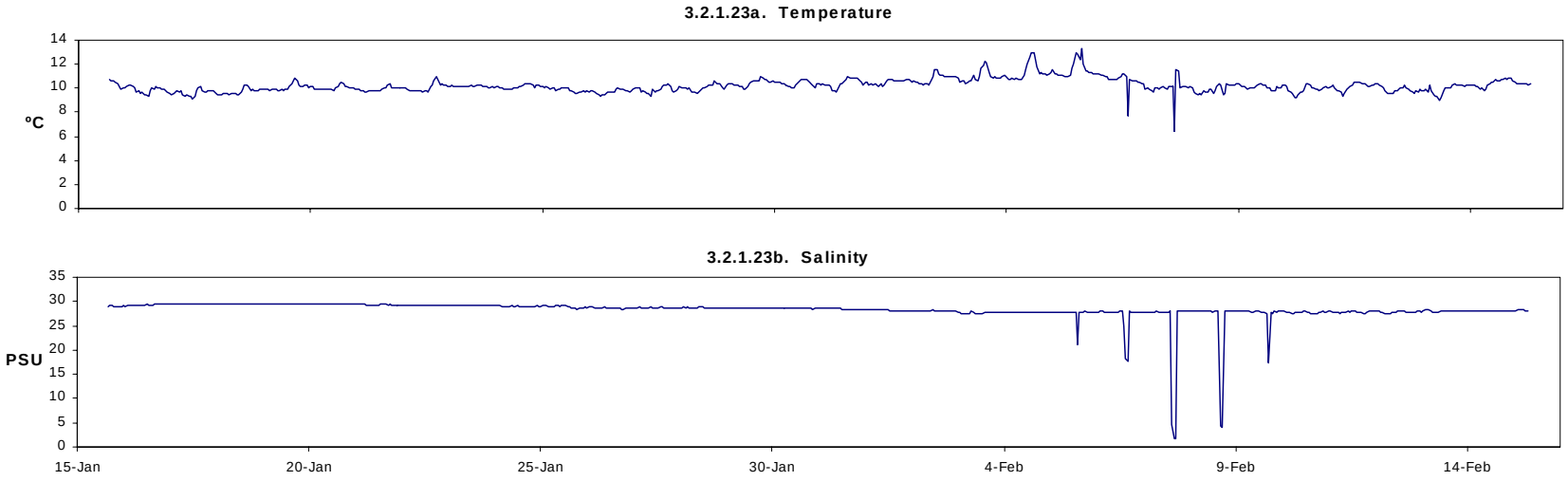


Figure 4-20. Station South 2 - Winter Temperature and Salinity

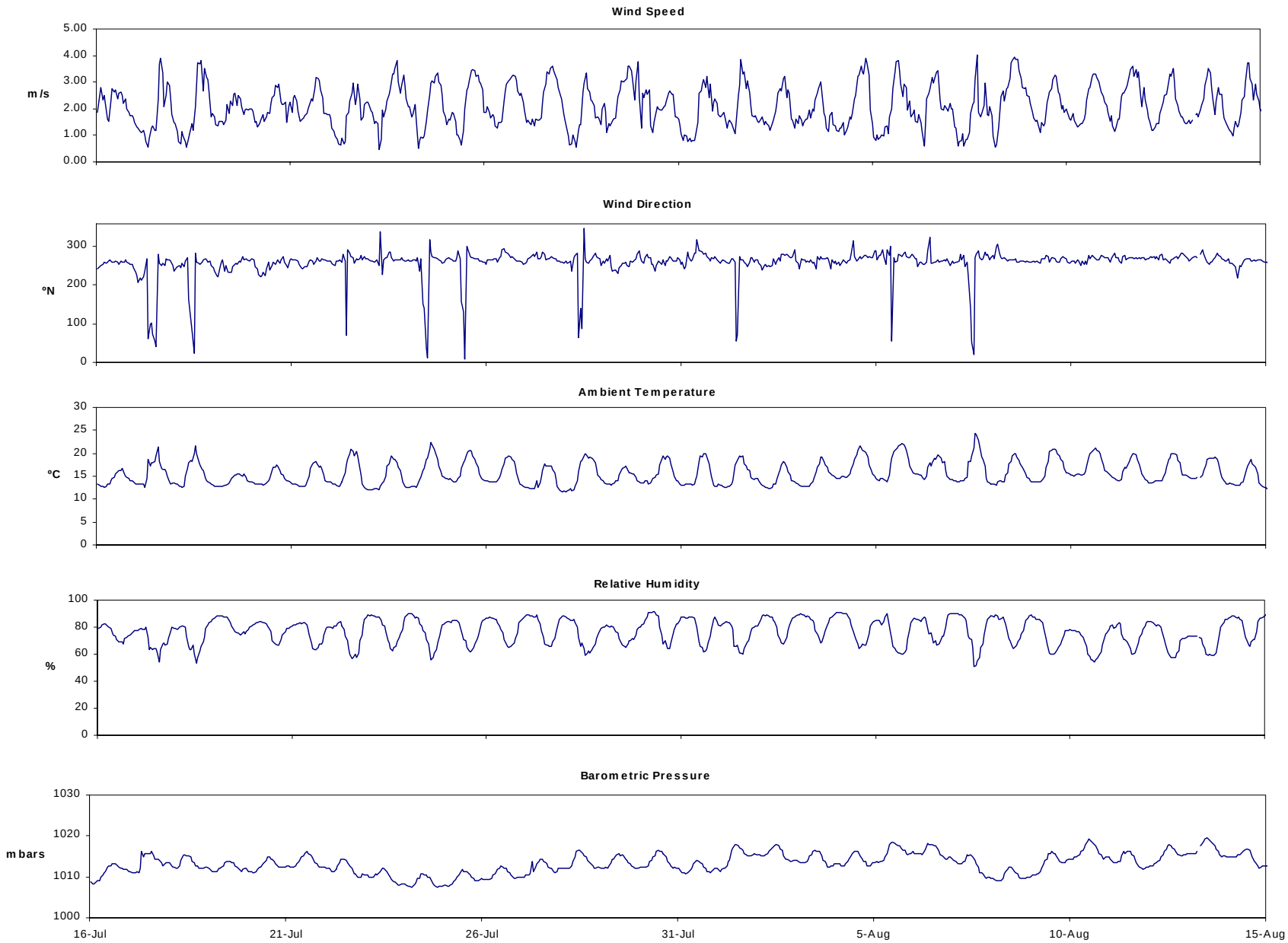


Figure 4-21. HPS Hourly Meteorological Data 7/16/2001-8/15/2001. Wind Vector is Direction from which Wind is Blowing.

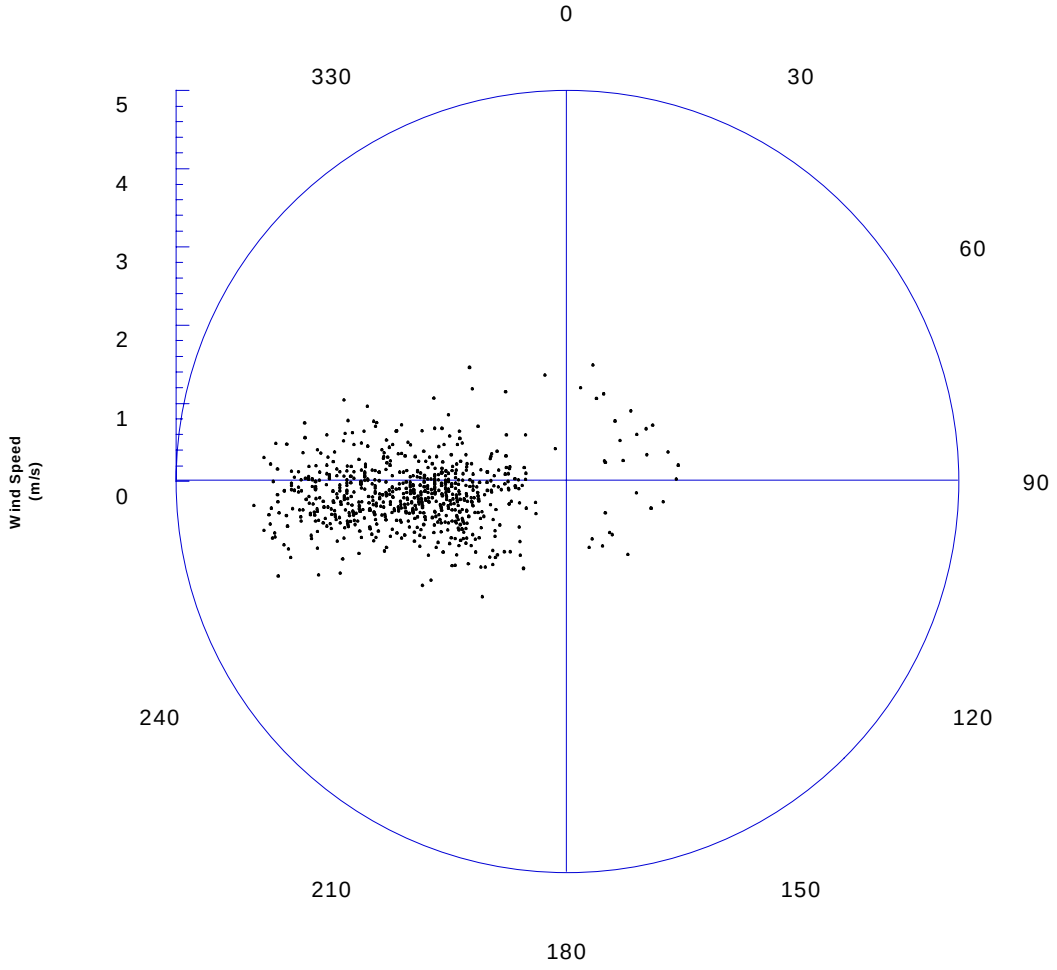


Figure 4-22. Summer Wind Speed Magnitude and Direction. Data Points Represent Tip of Wind Vector, with Tail at the Circle's Origin.

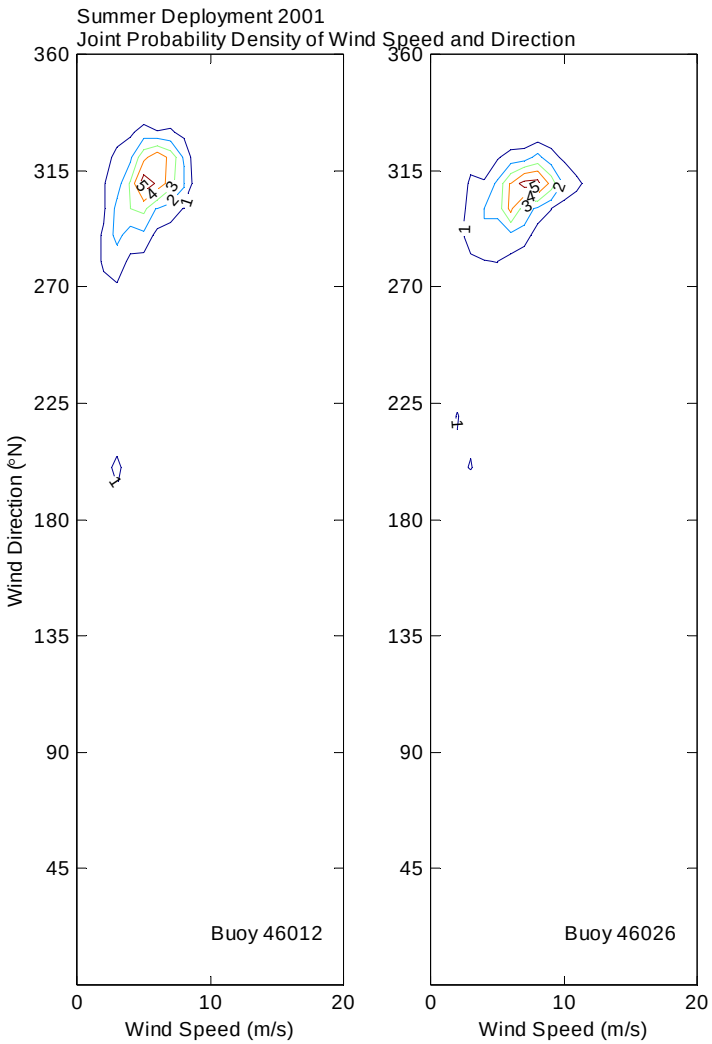


Figure 4-23. Joint Probability Density of Wind Speed and Direction During the Summer Deployment Period from Two Offshore Buoys.

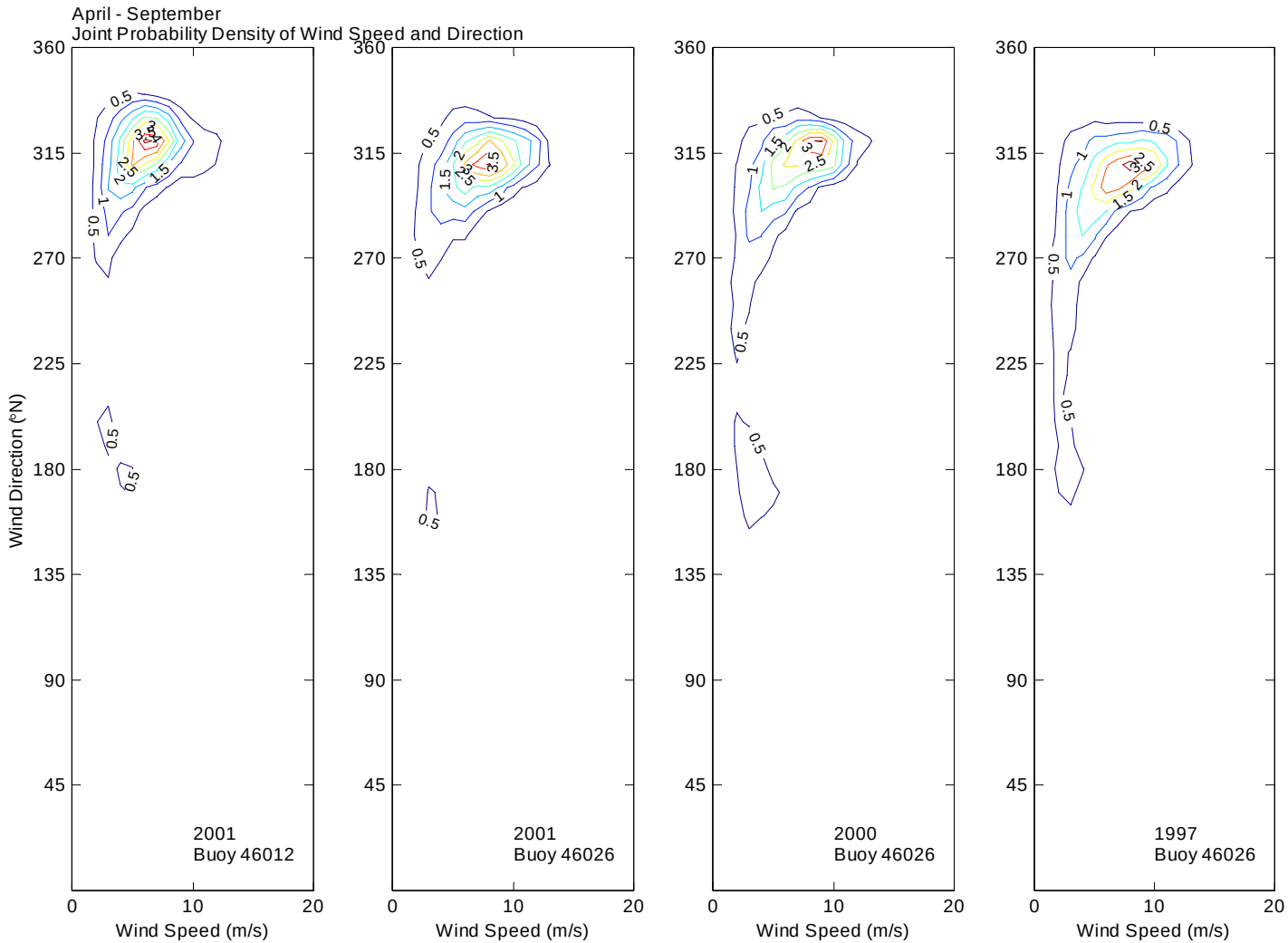


Figure 4-24. Joint Probability Density of Wind Speed and Direction During the Summer Season (April through September) for 2001, 2000, and 1997 from Two Offshore Buoys.

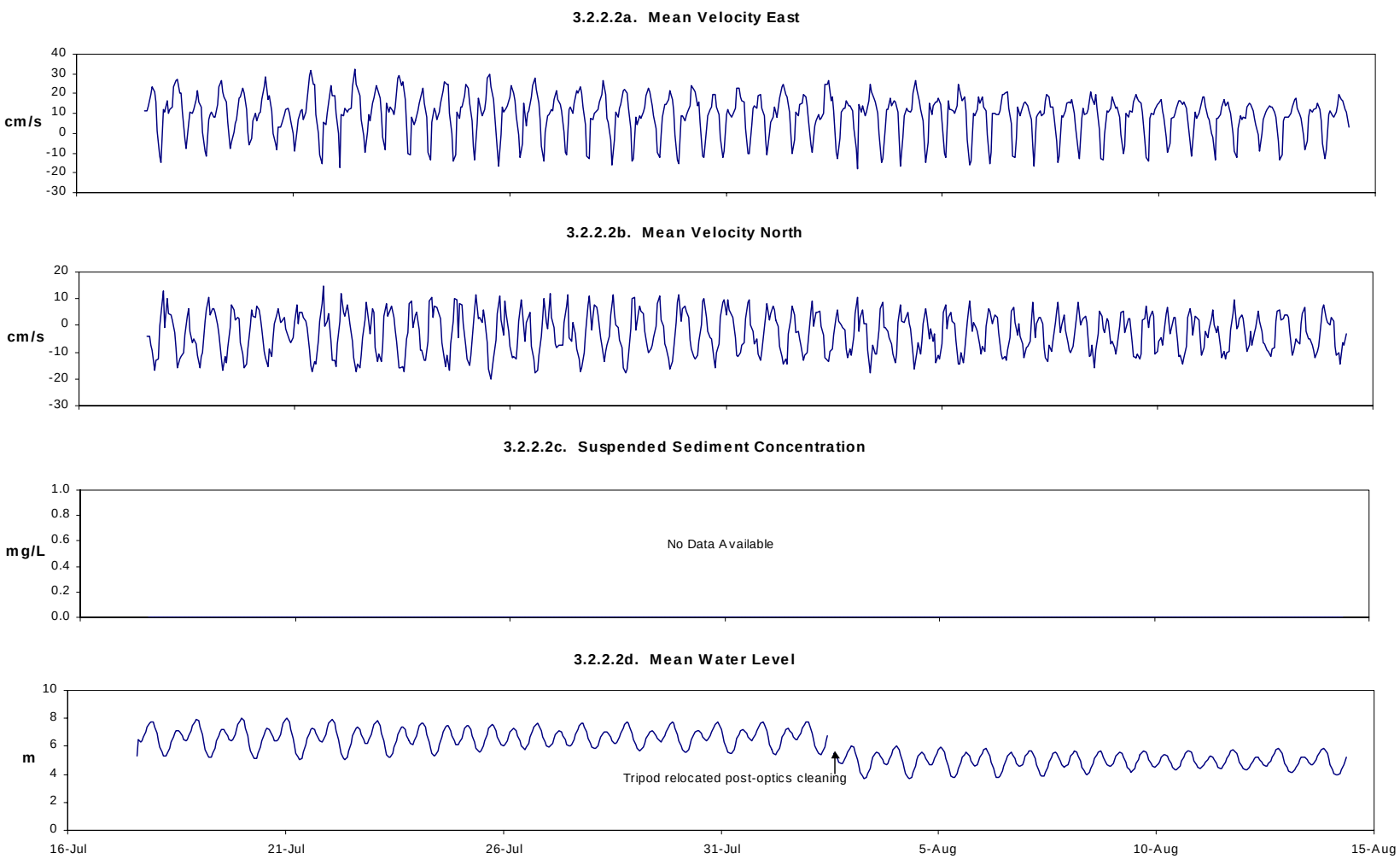


Figure 4-25. Station North 1 - Summer Current, SSC, and Depth Data

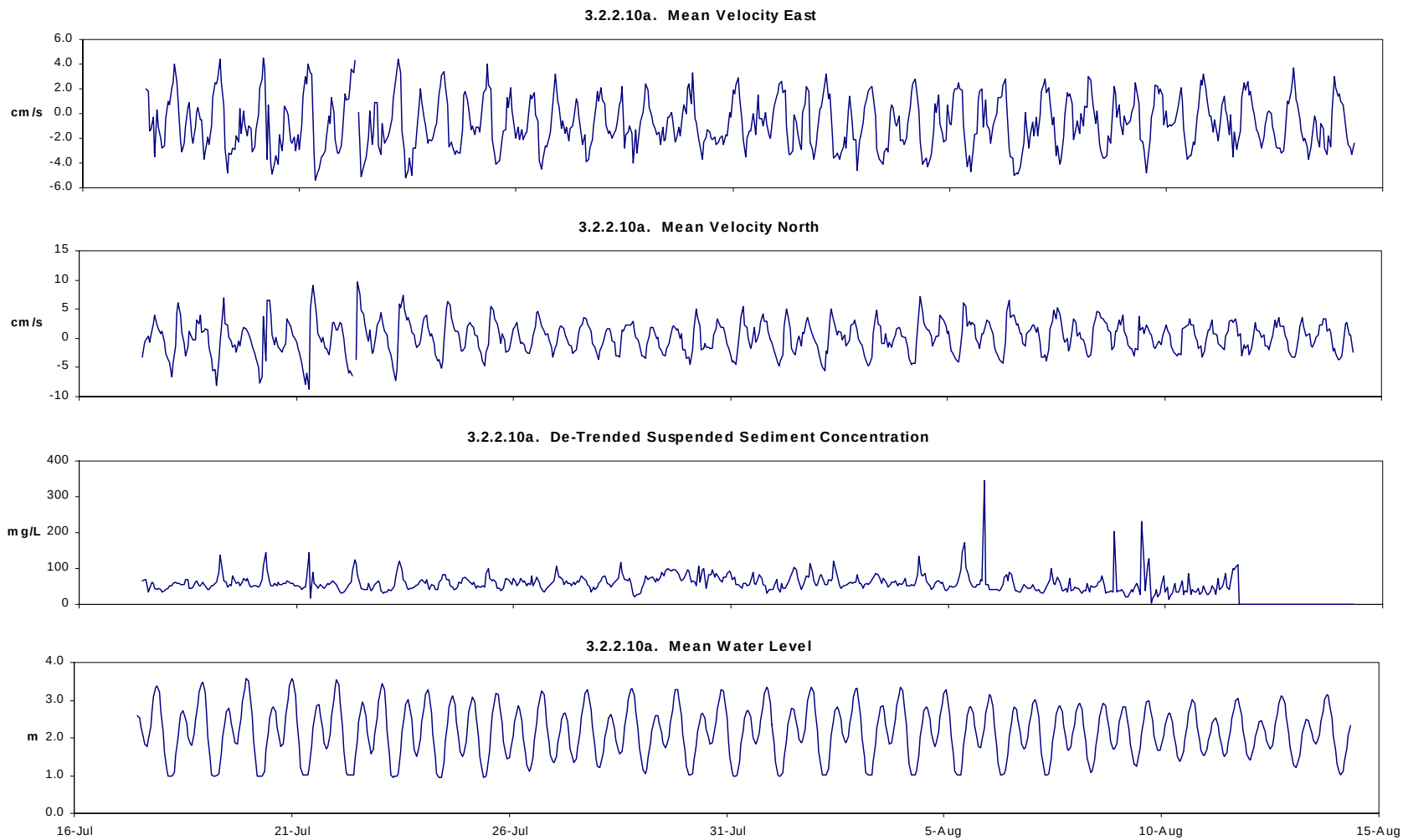


Figure 4-26. Station South 1 - Summer Current, SSC, and Depth Data

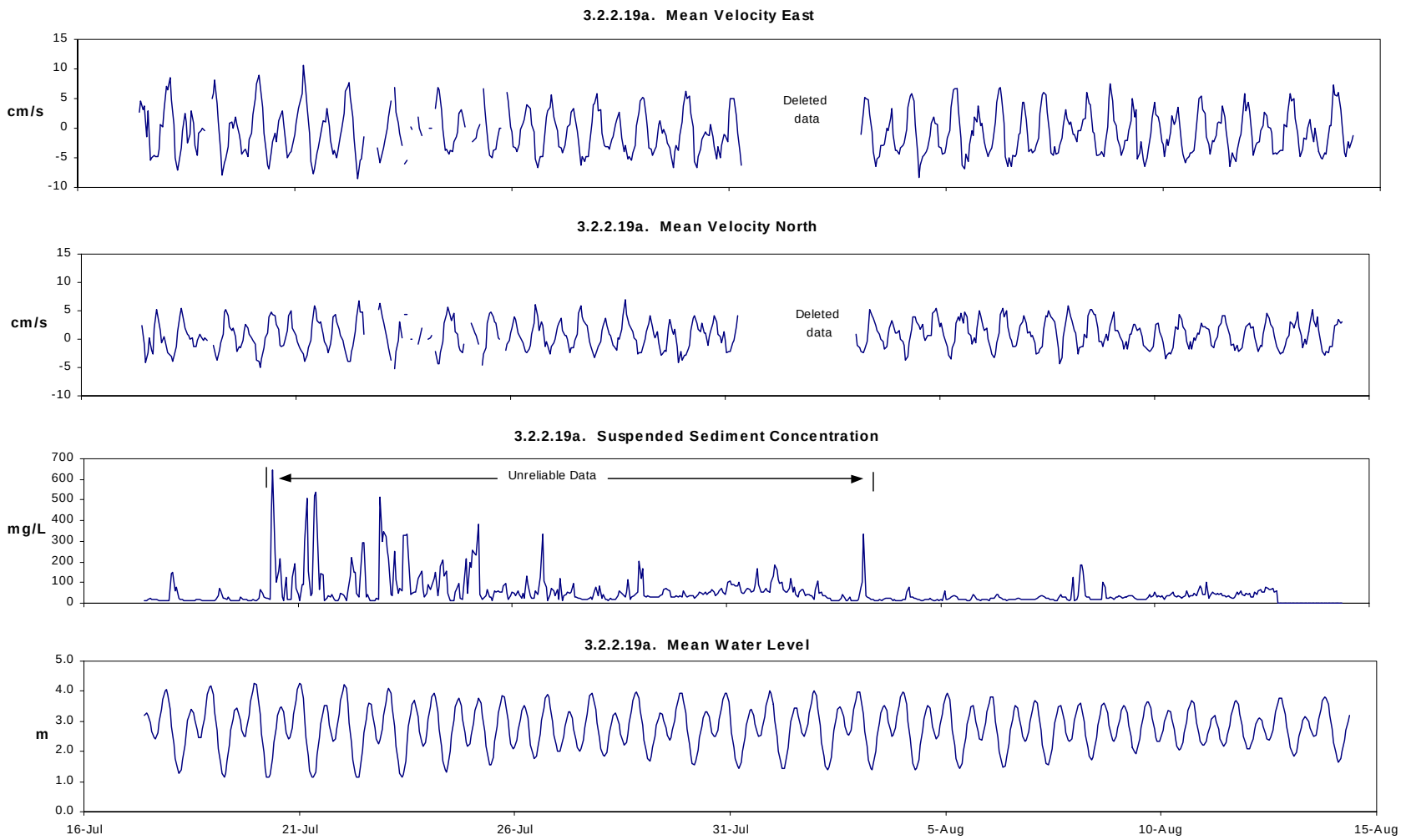


Figure 4-27. Station South 2 - Summer Current, SSC, and Depth Data

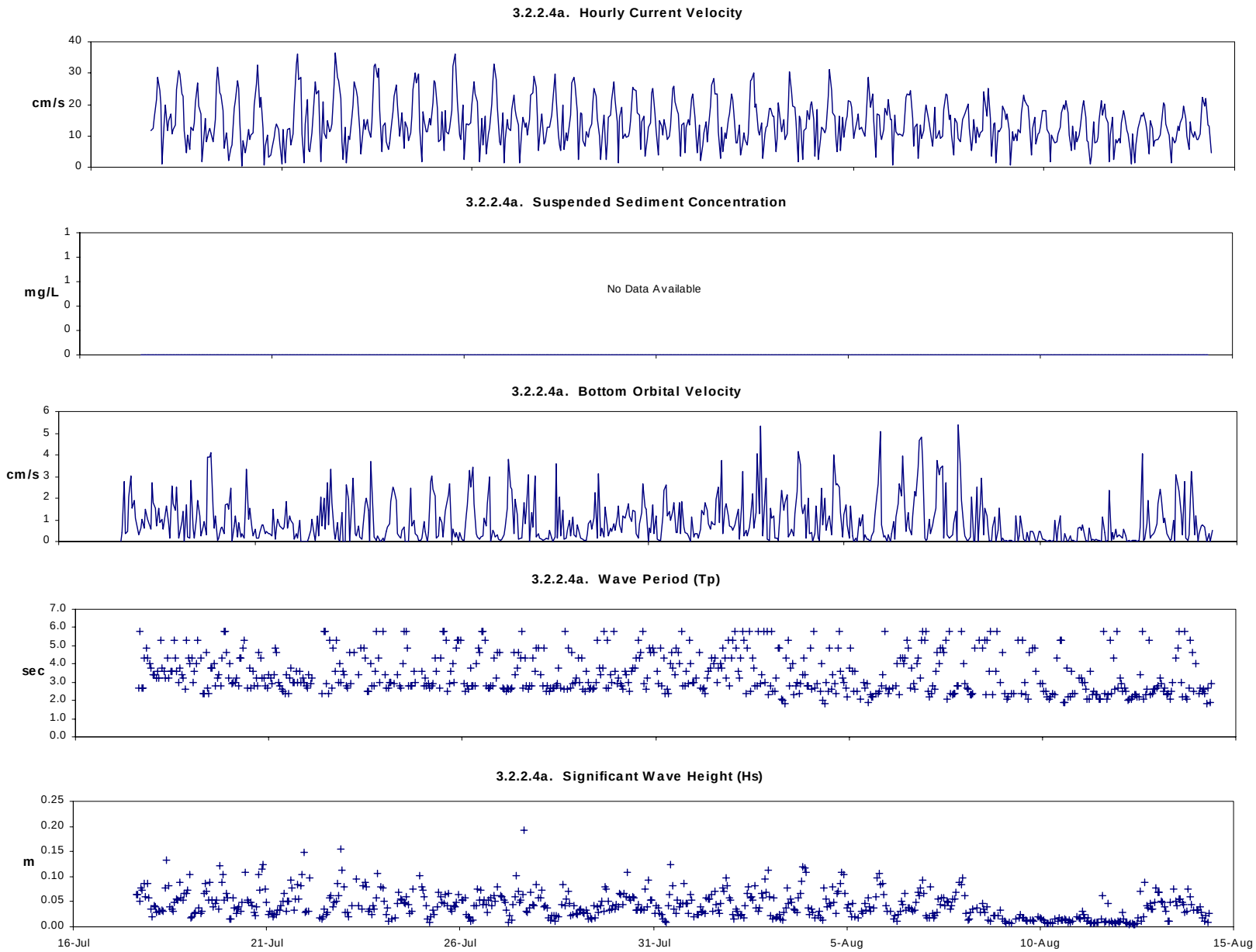


Figure 4-28. Station North 1 – Summer Current, SSC, and Wave Data

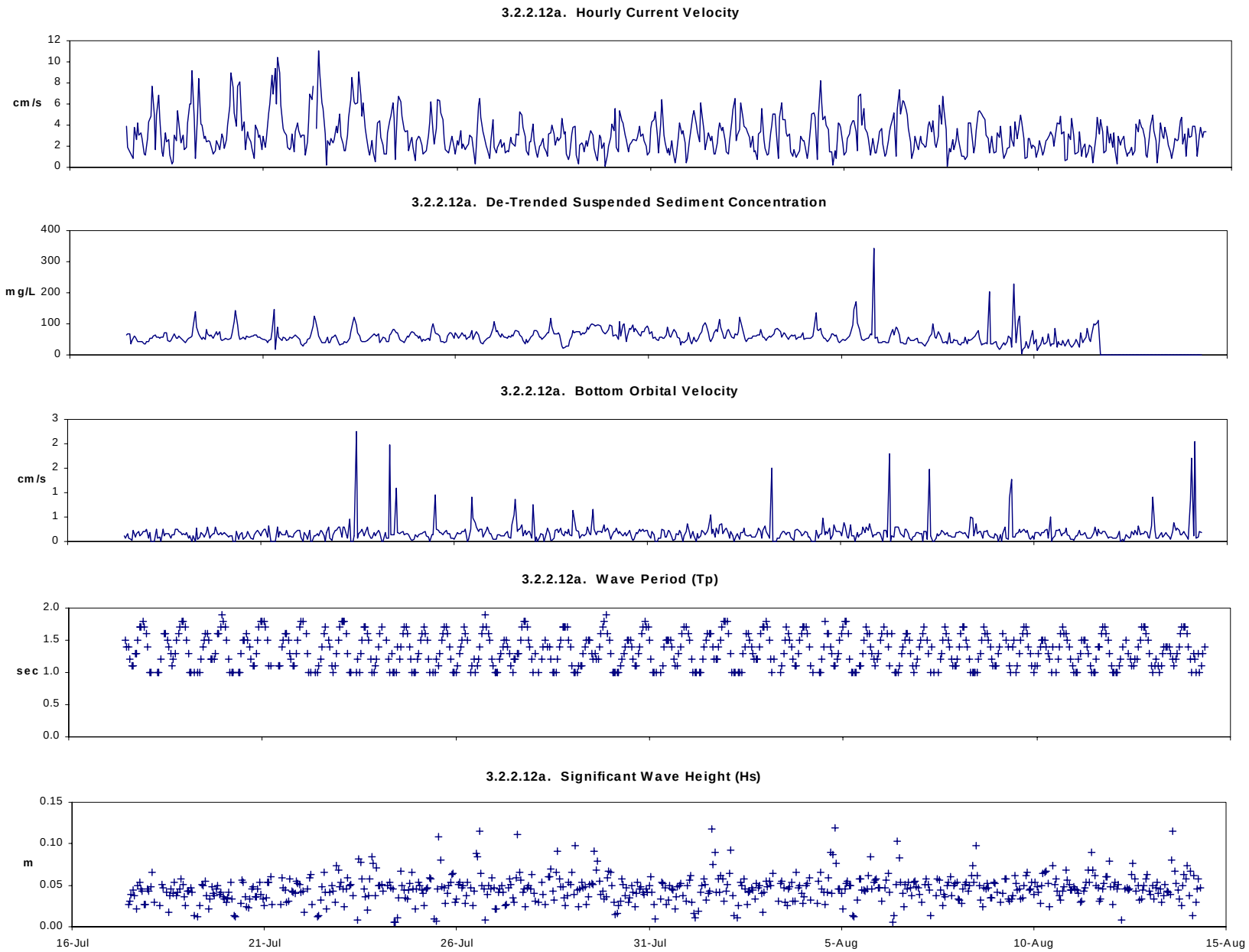


Figure 4-29. Station South 1 - Summer Current, SSC, and Wave Data

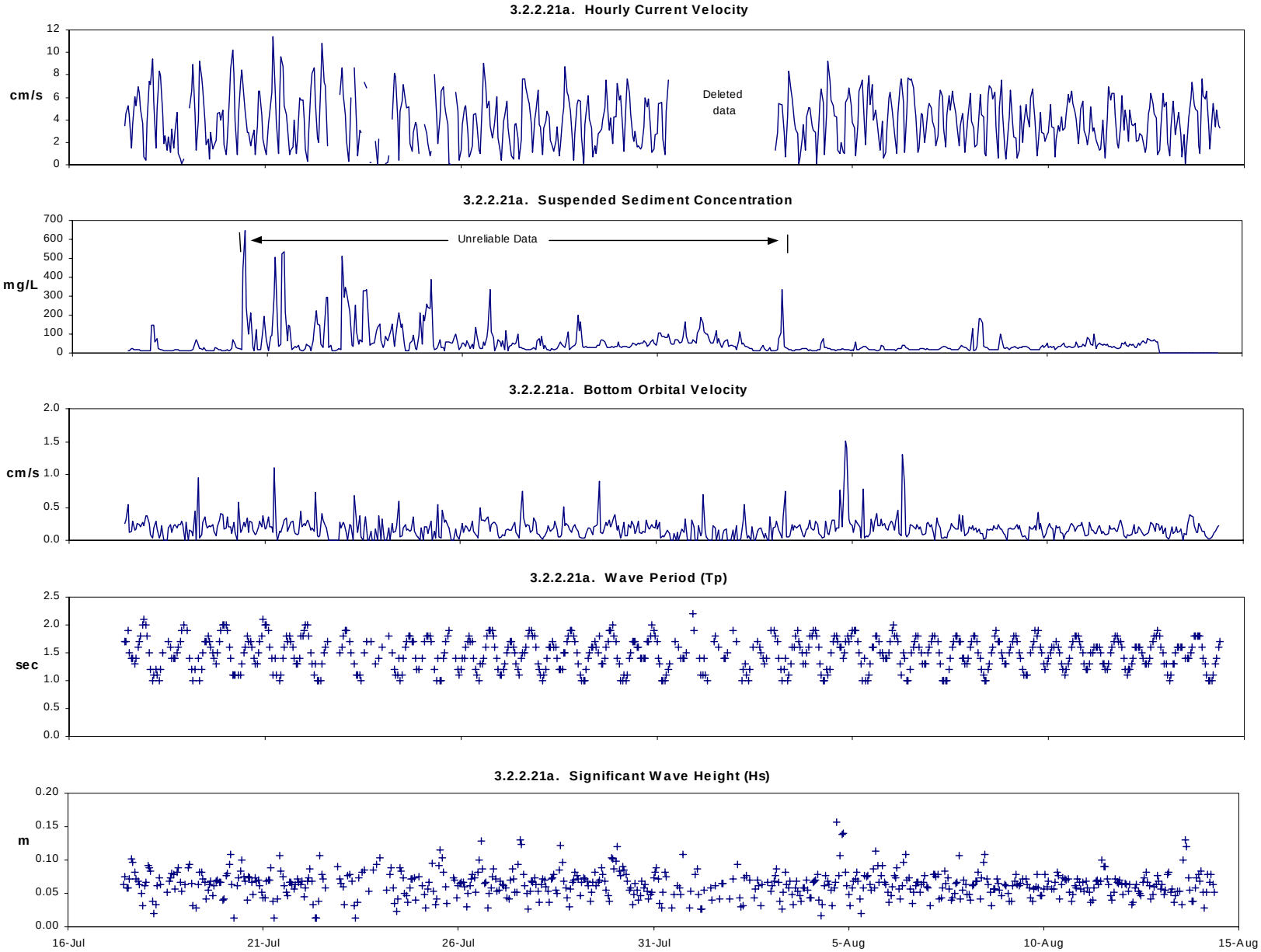


Figure 4-30. Station South 2 - Summer Current, SSC, and Wave Data

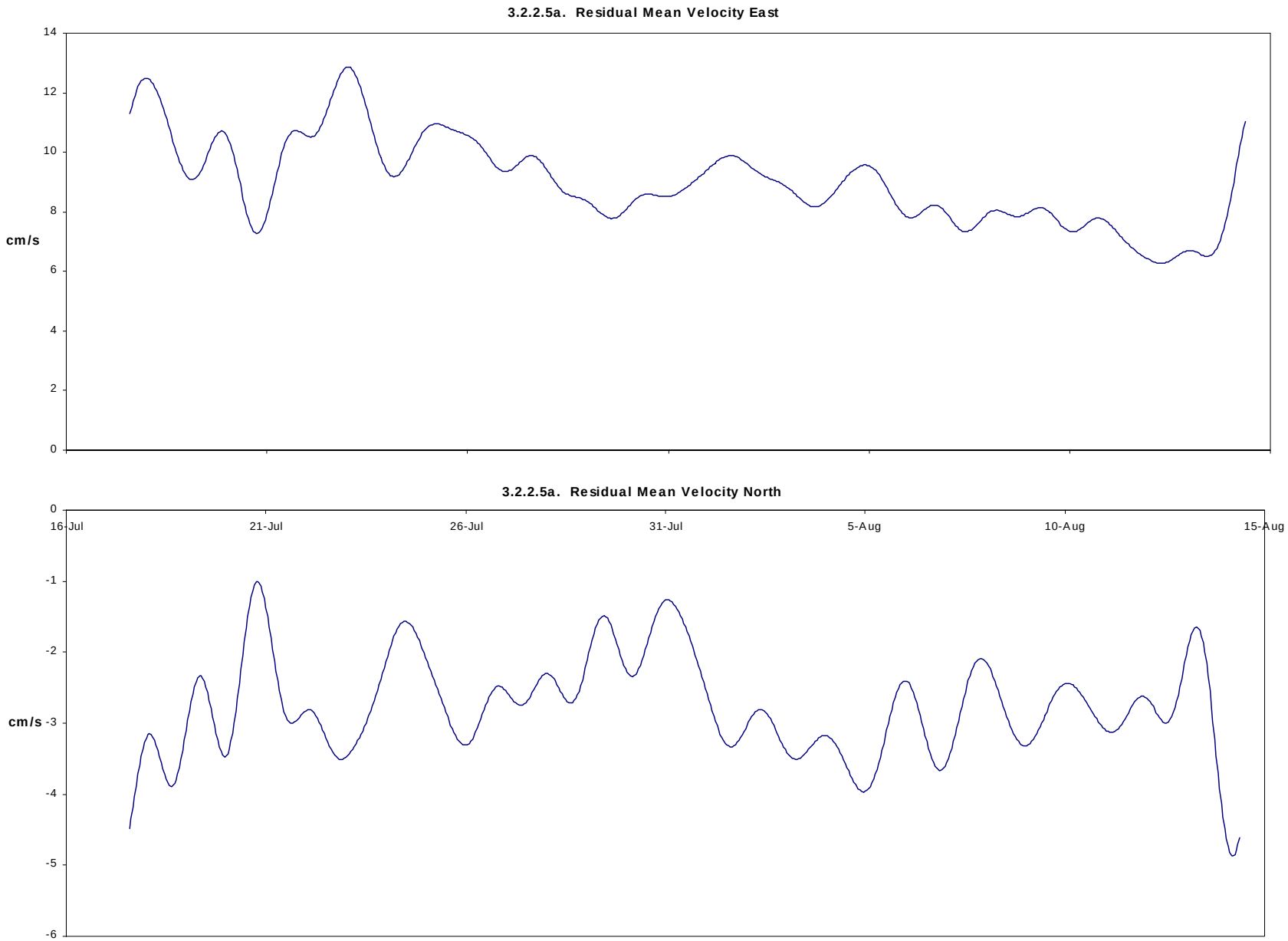


Figure 4-31. Station North 1 - Summer Residual Low Pass Frequency Current Velocities

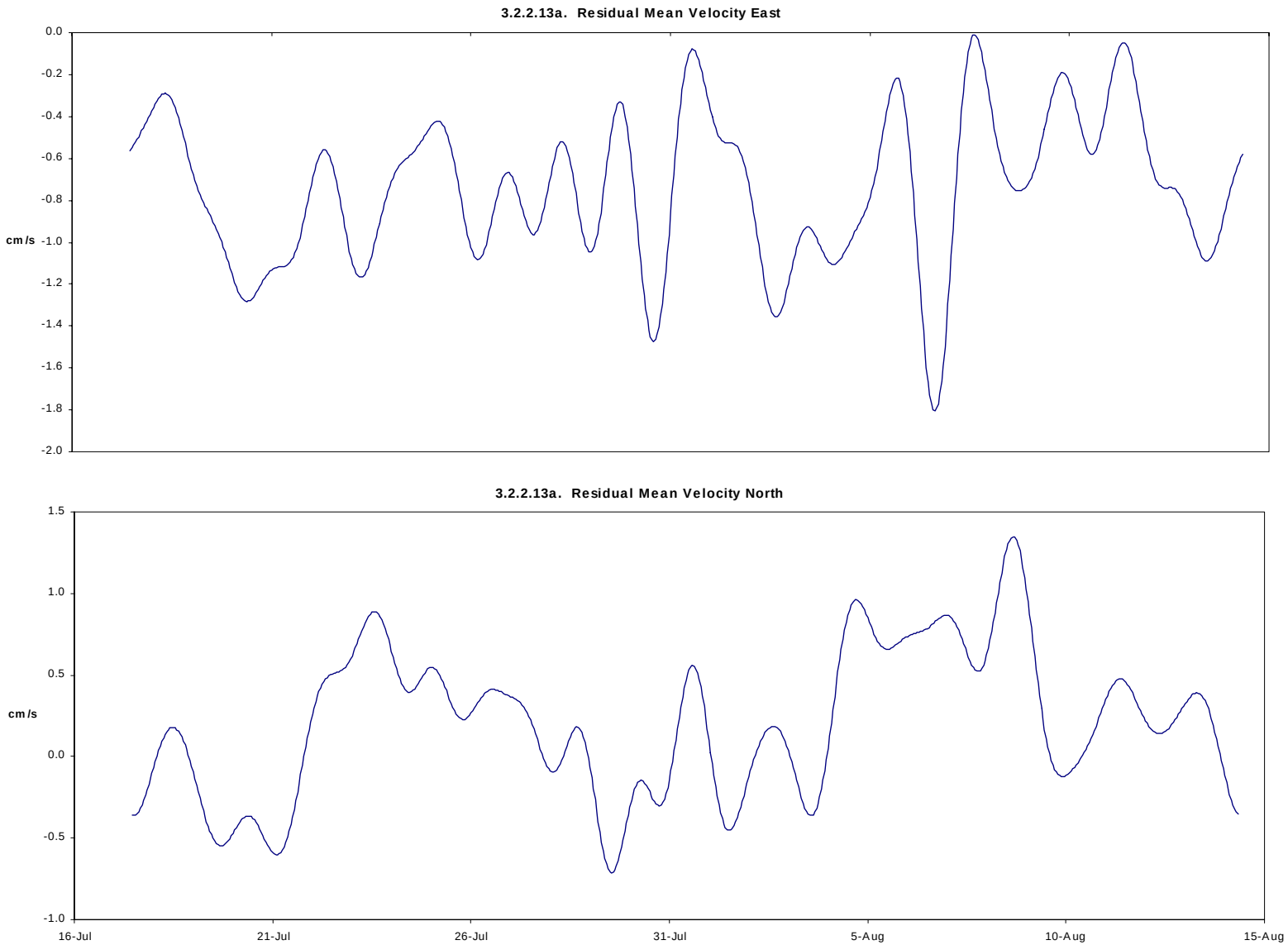


Figure 4-32. Station South 1 - Summer Residual Low Pass Frequency Current Velocities

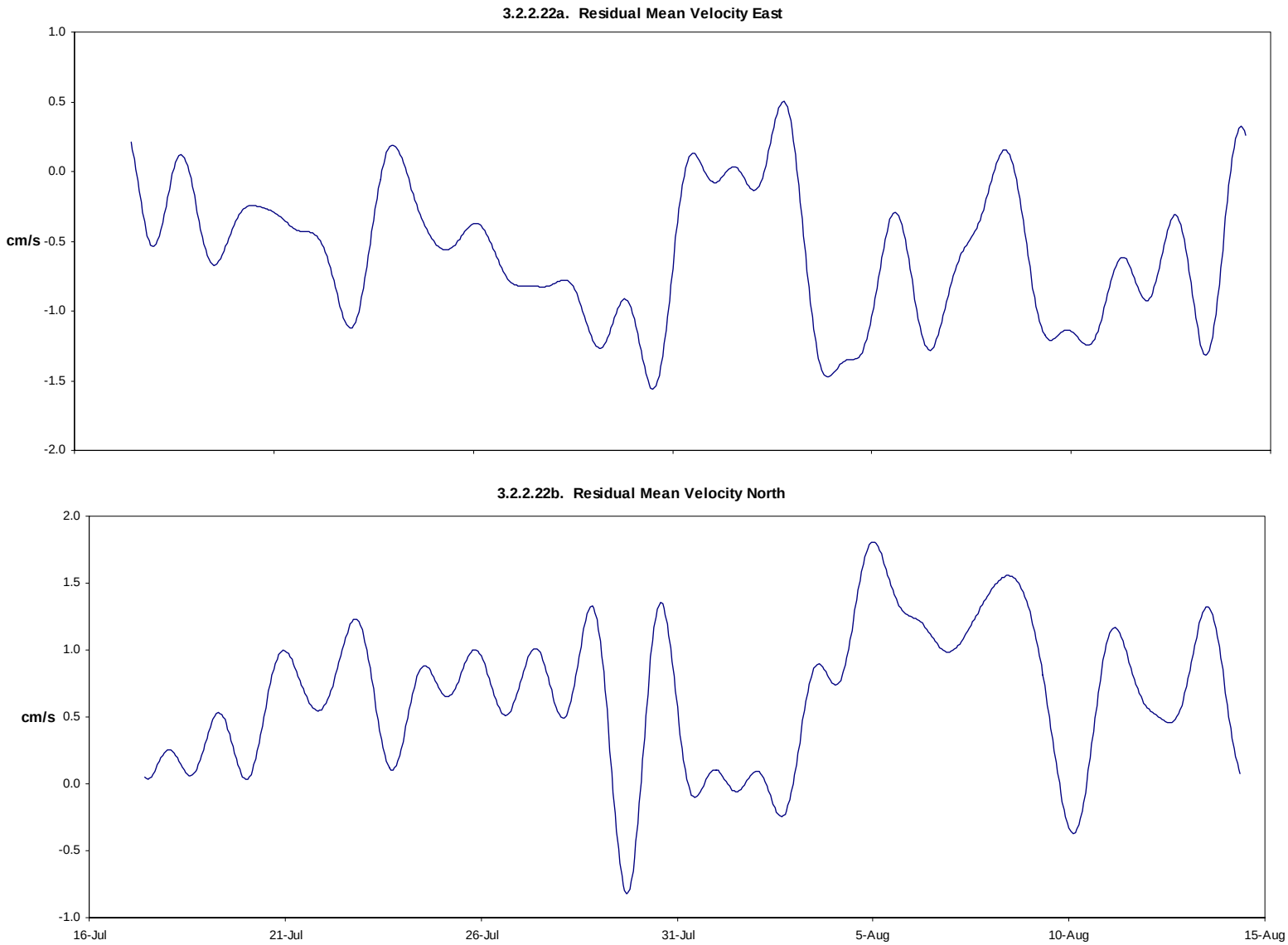


Figure 4-33. Station South 2 - Summer Residual Low Pass Frequency Current Velocities

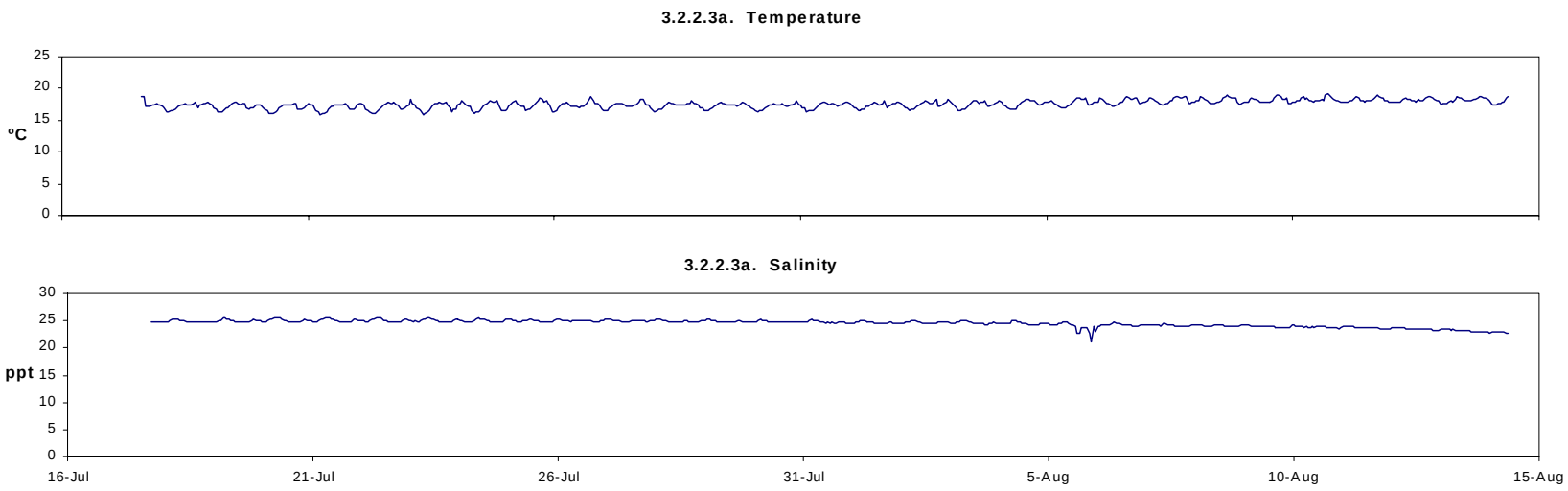


Figure 4-34. Station North 1 - Summer Temperature and Salinity

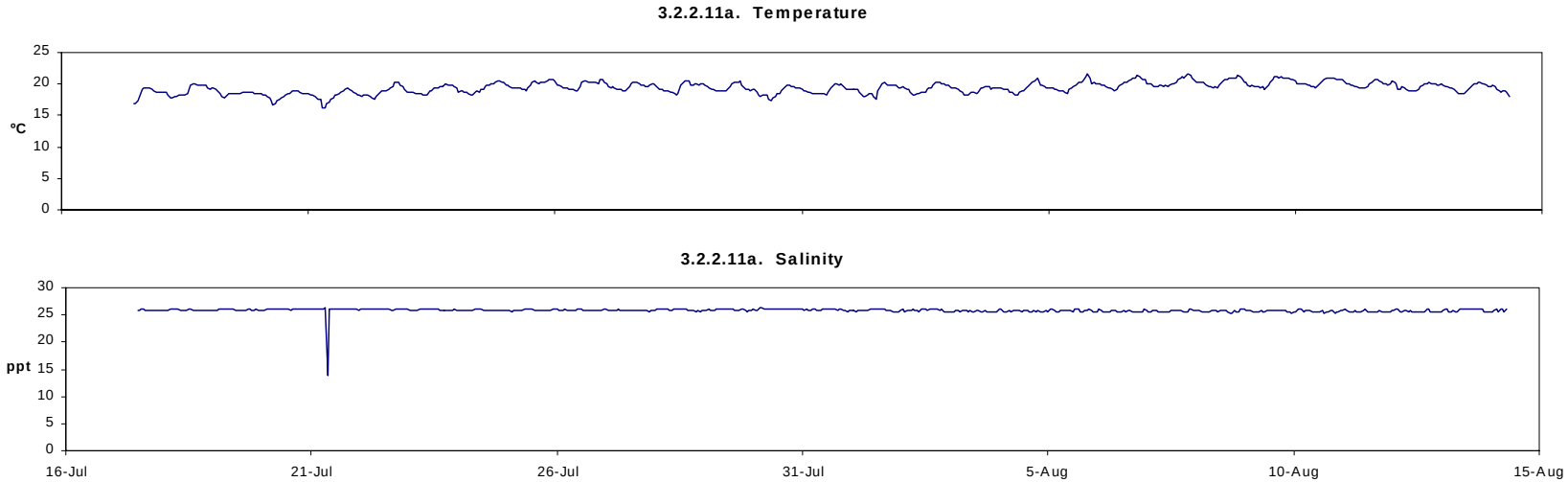


Figure 4-35. Station South 1 - Summer Temperature and Salinity

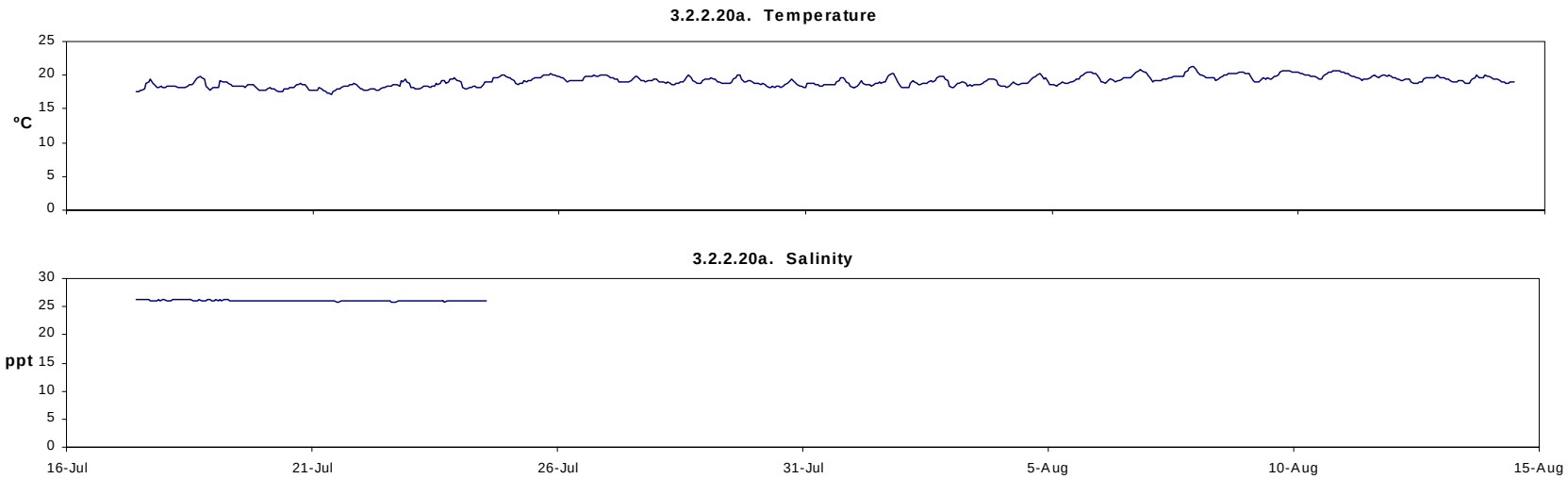


Figure 4-36. Station South 2 - Summer Temperature and Salinity

Figure 5-1. Station North 1 - Winter Residual Advective Sediment Flux

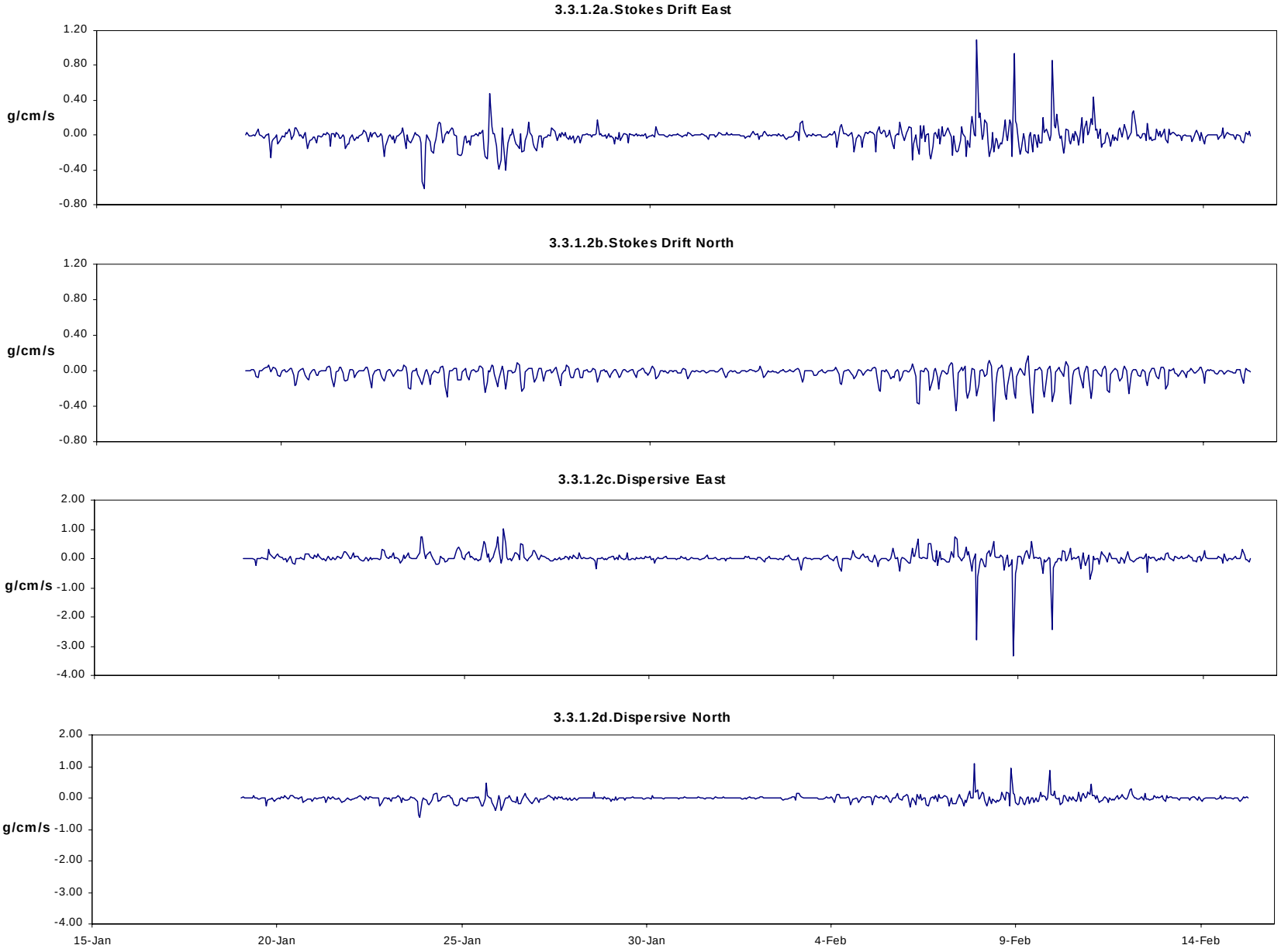


Figure 5-2. Station North 1 – Winter Stokes Drift and Dispersive Sediment Flux

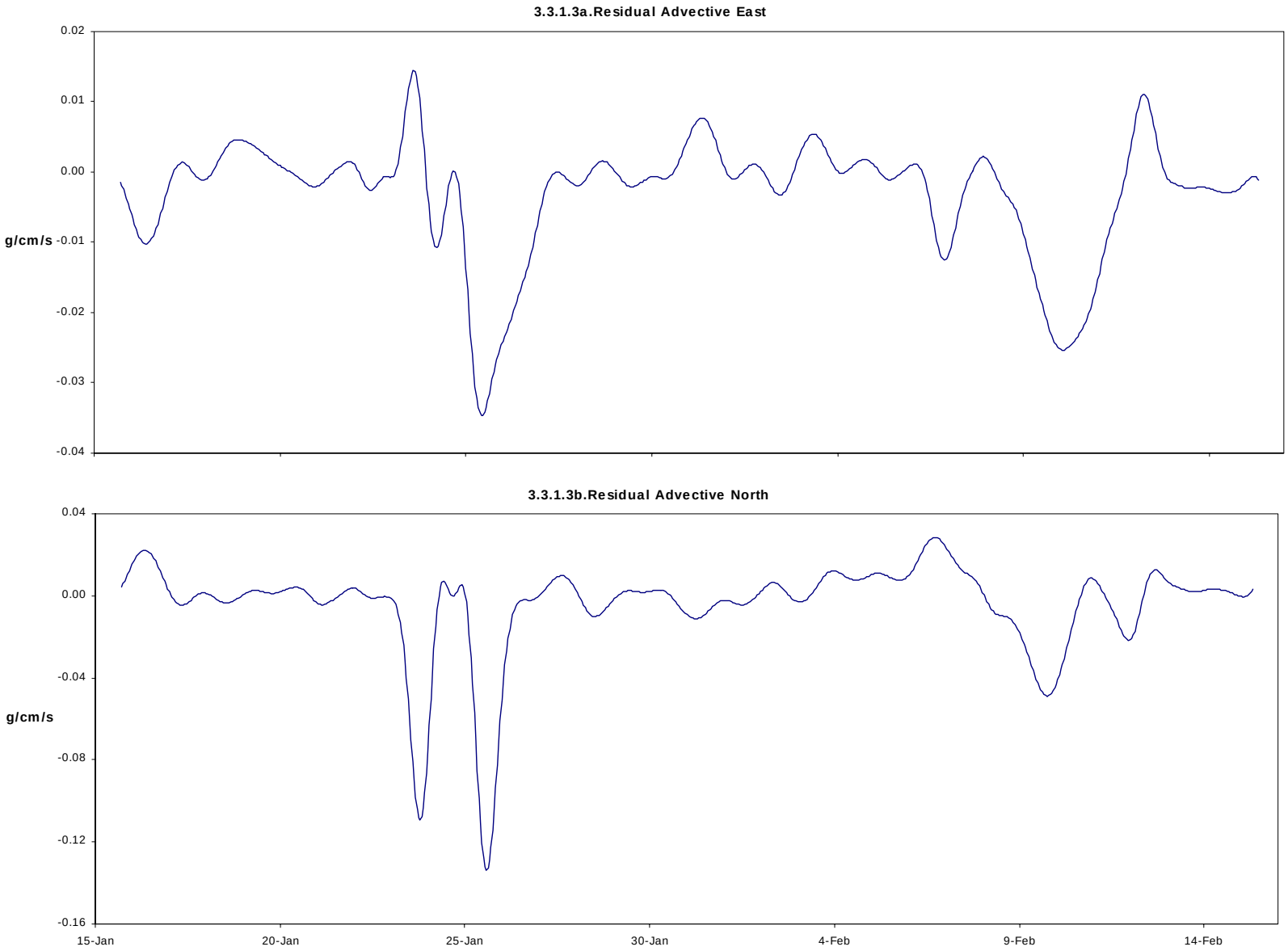


Figure 5-3. – Station South 1 - Winter Residual Advective Sediment Flux

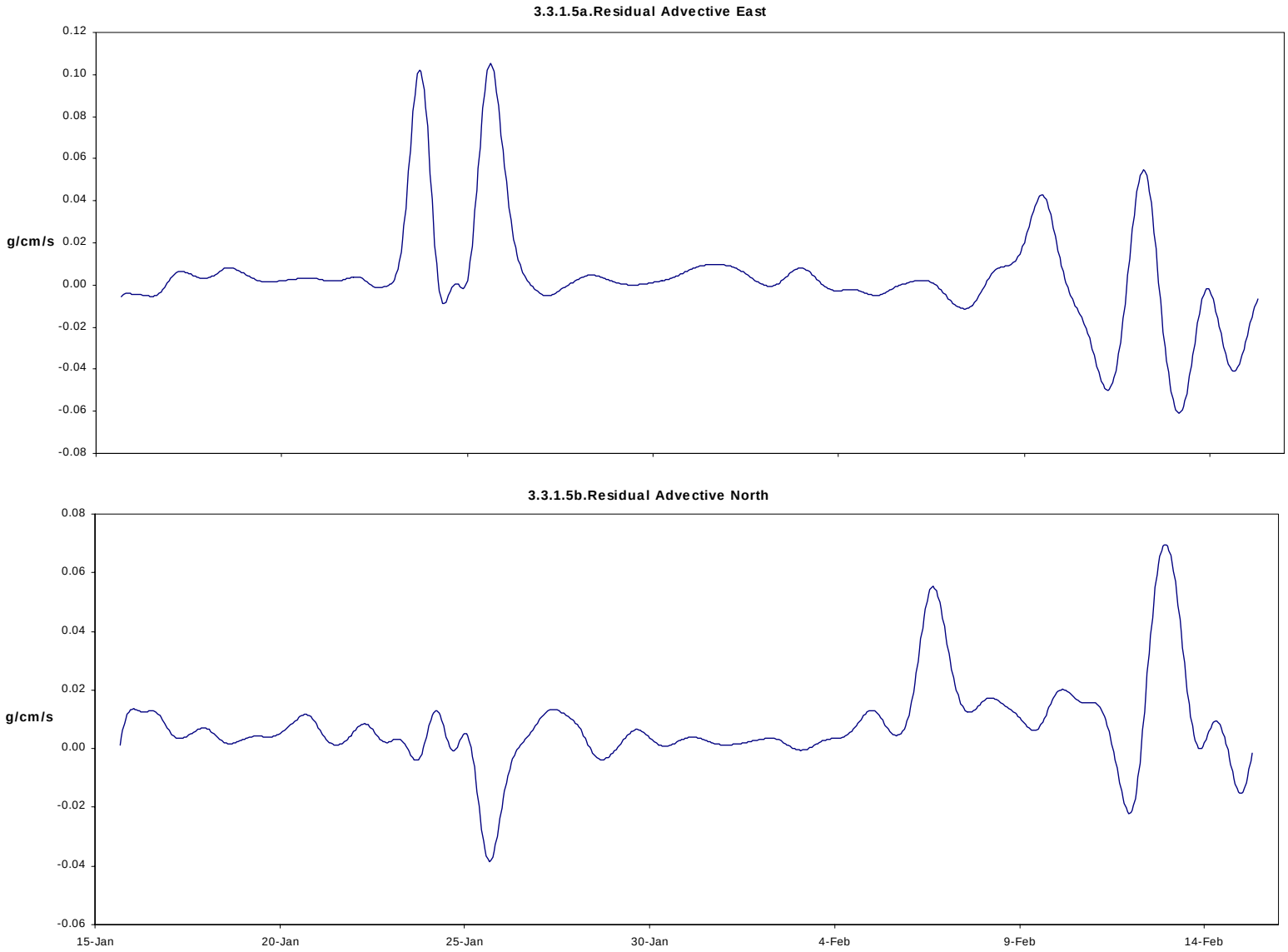


Figure 5-4. Station South 2 – Winter Residual Advective Sediment Flux

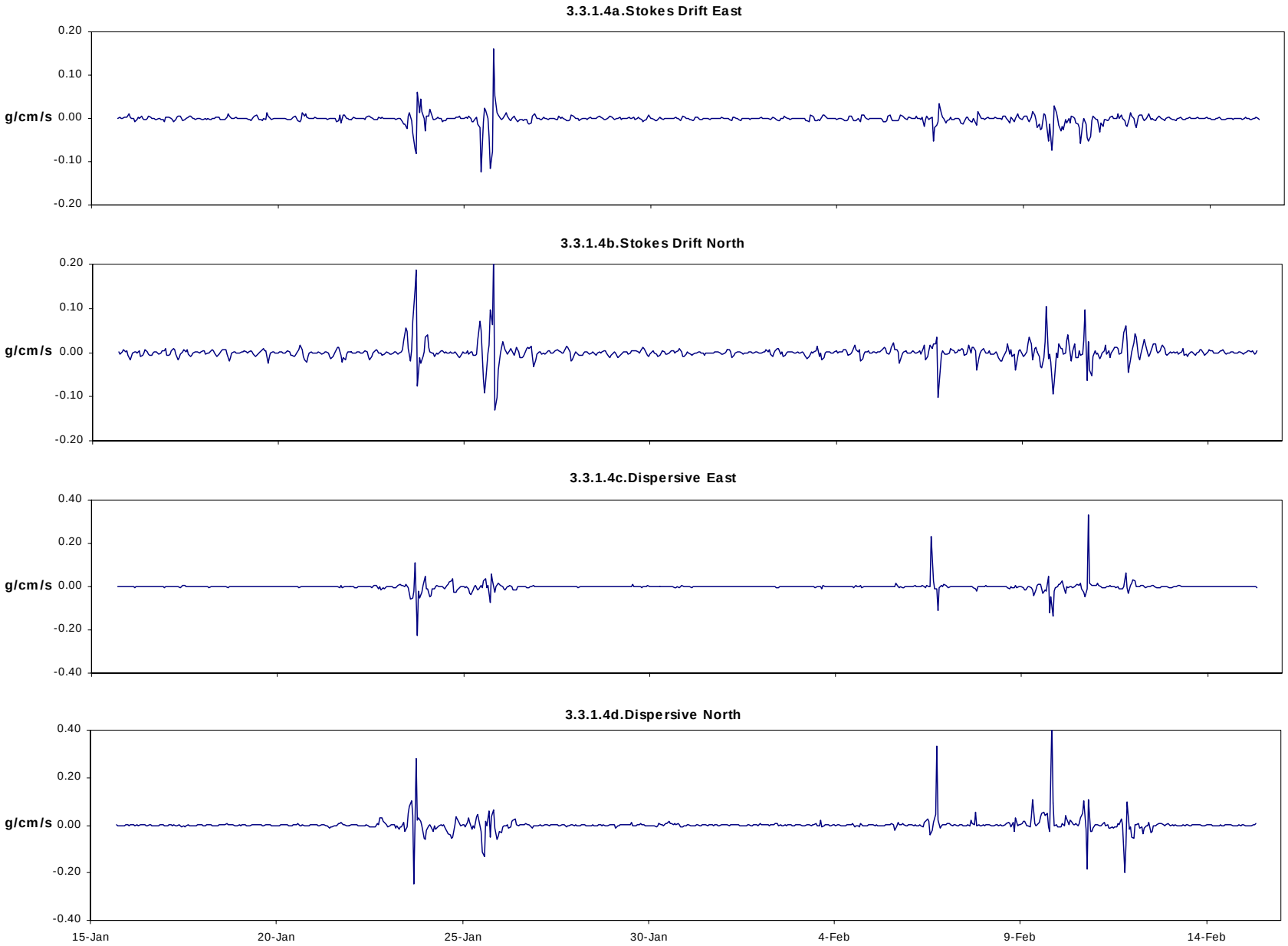


Figure 5-5. Station South 1 – Winter Stokes Drift and Dispersive Sediment Flux

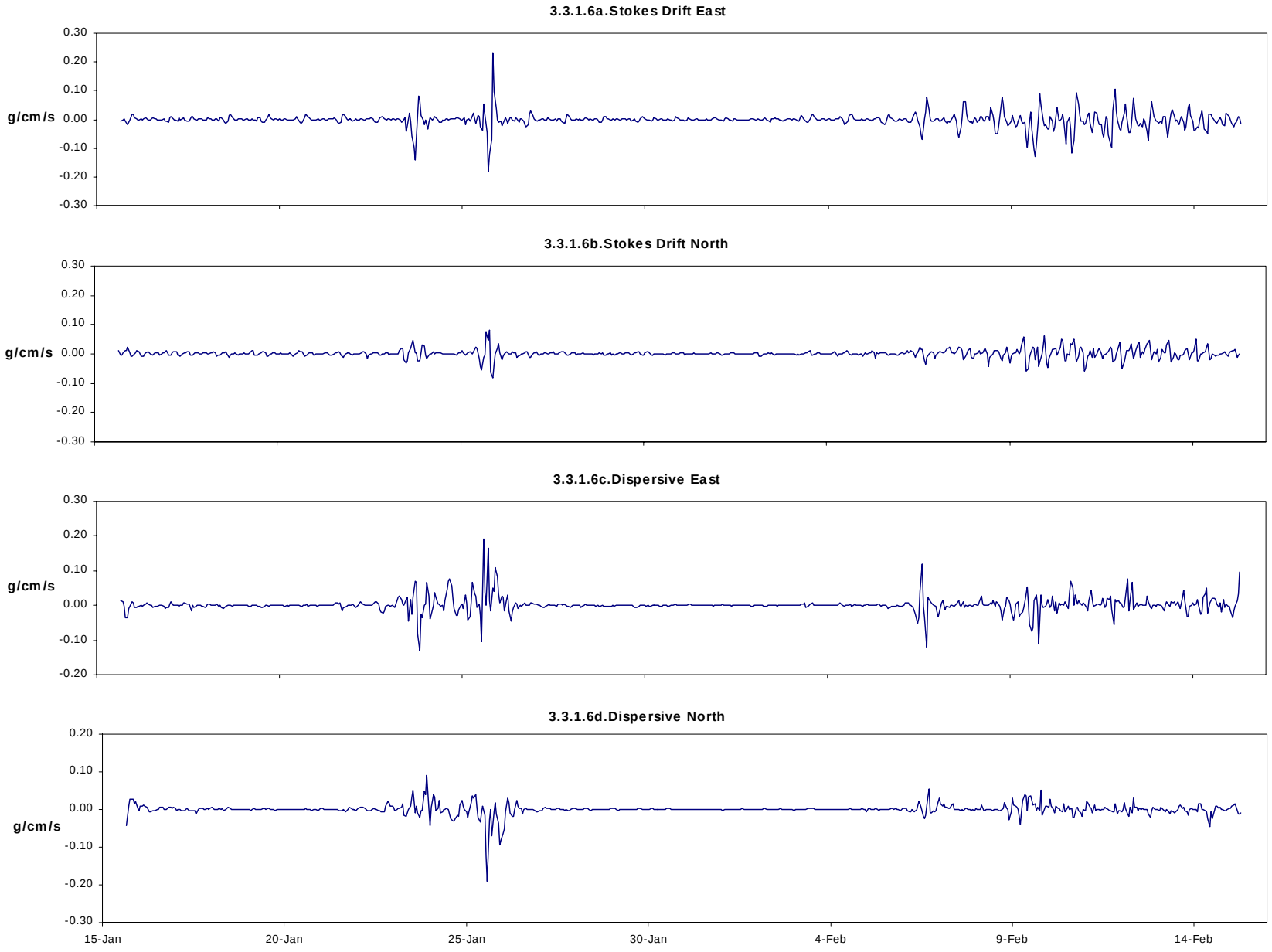


Figure 5-6. Station South 2 – Winter Stokes Drift and Dispersive Sediment Flux

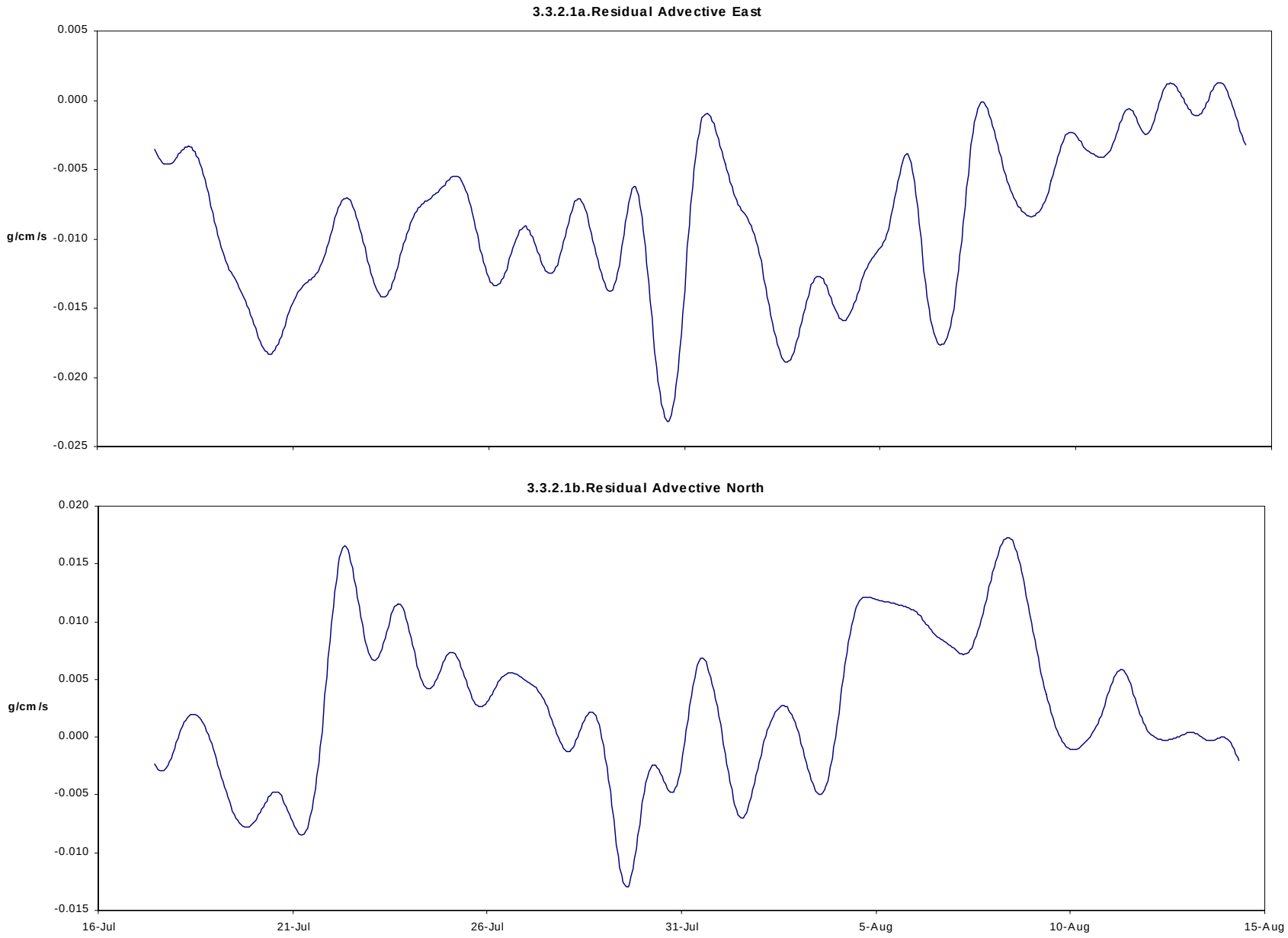


Figure 5-7. Station South 1 – Summer Residual Advective Sediment Flux

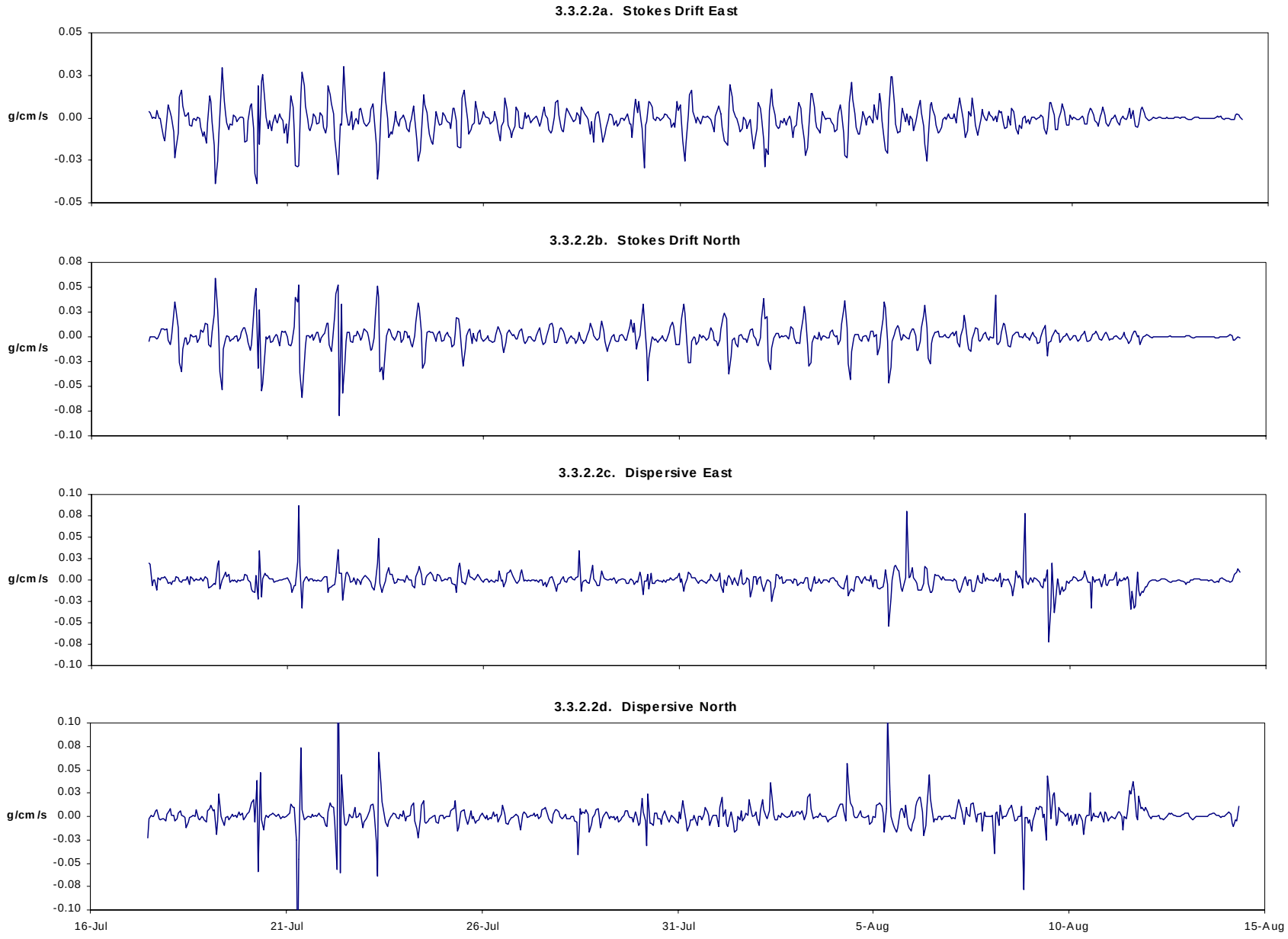


Figure 5-8. Station South 1 – Summer Stokes Drift and Dispersive Sediment Flux

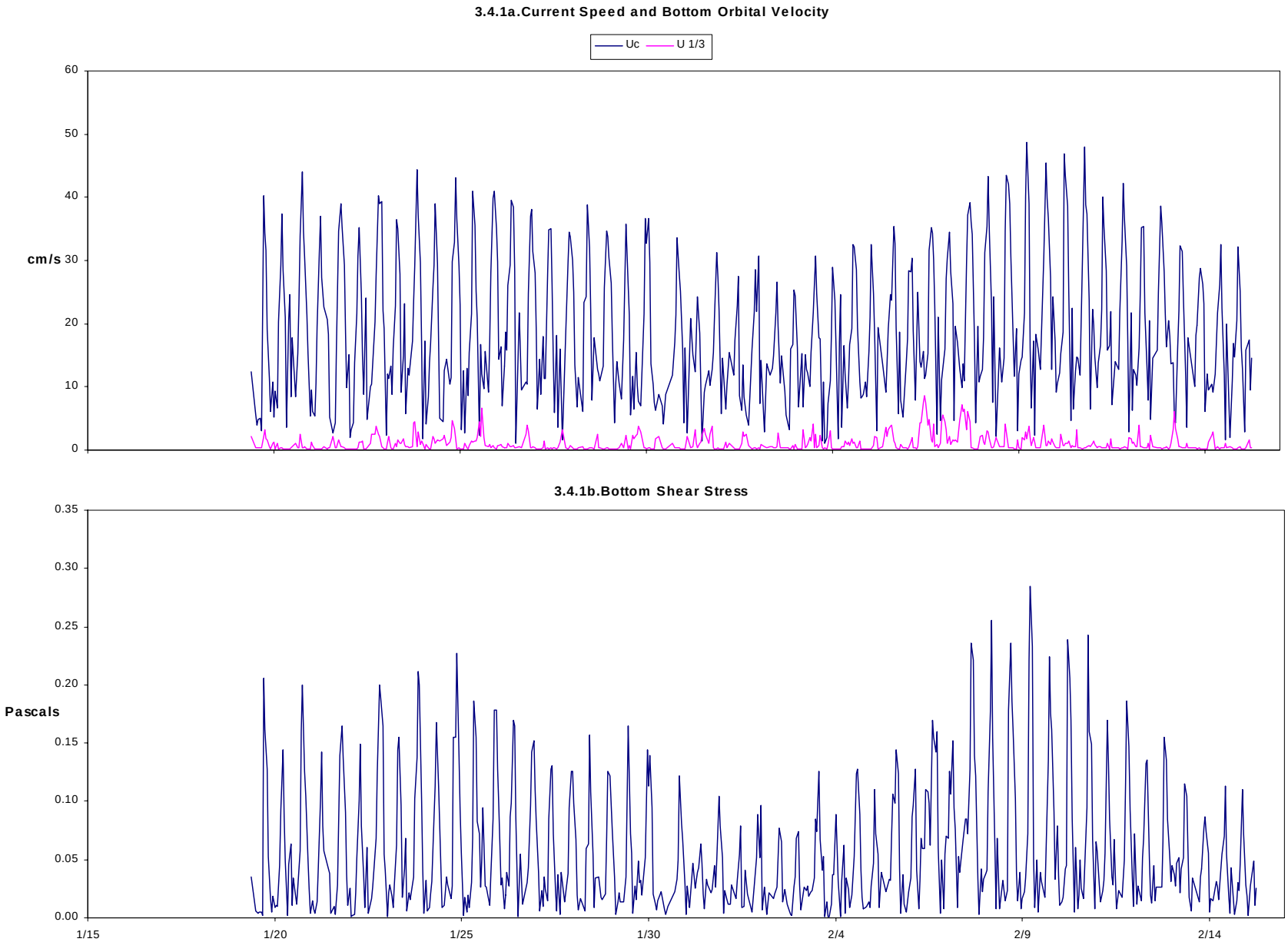


Figure 5-9. Station North 1 - Winter Current Speed, Bottom Orbital Velocity, and Bottom Shear Stress

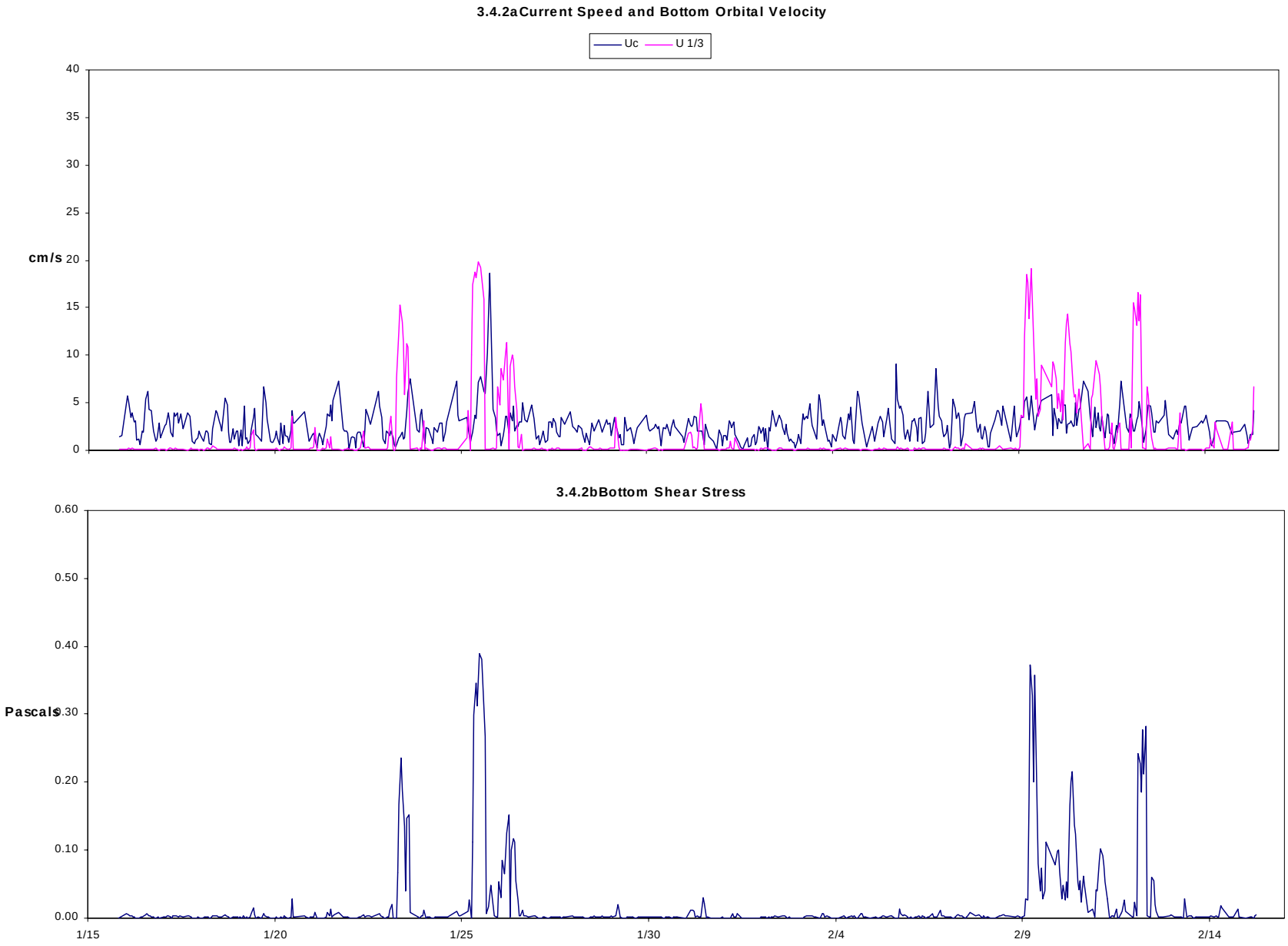


Figure 5-10. Station South 1 – Winter Current Speed, Bottom Orbital Velocity, and Bottom Shear Stress

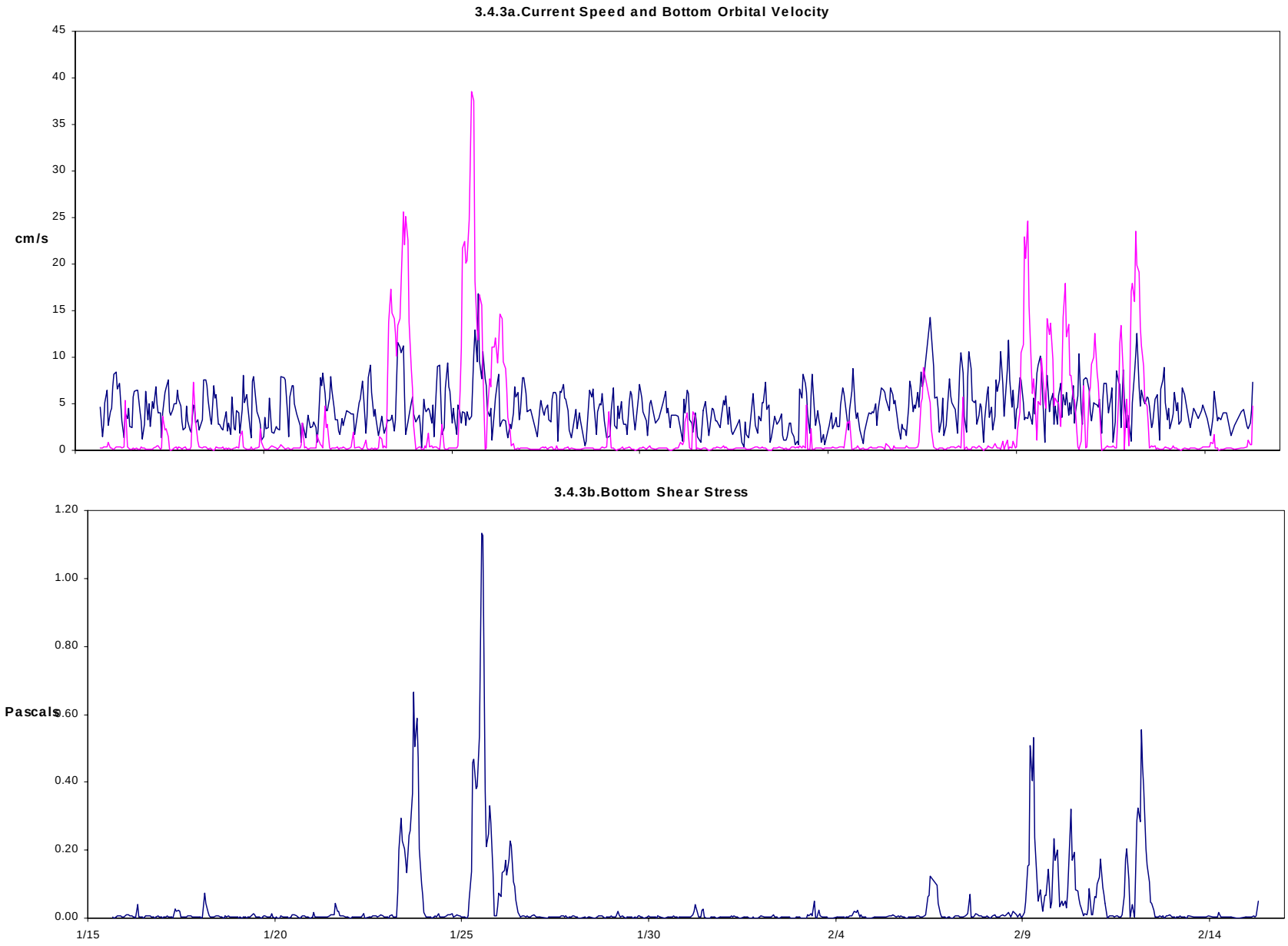


Figure 5-11. Station South 2 – Winter Current Speed, Bottom Orbital Velocity, and Bottom Shear Stress

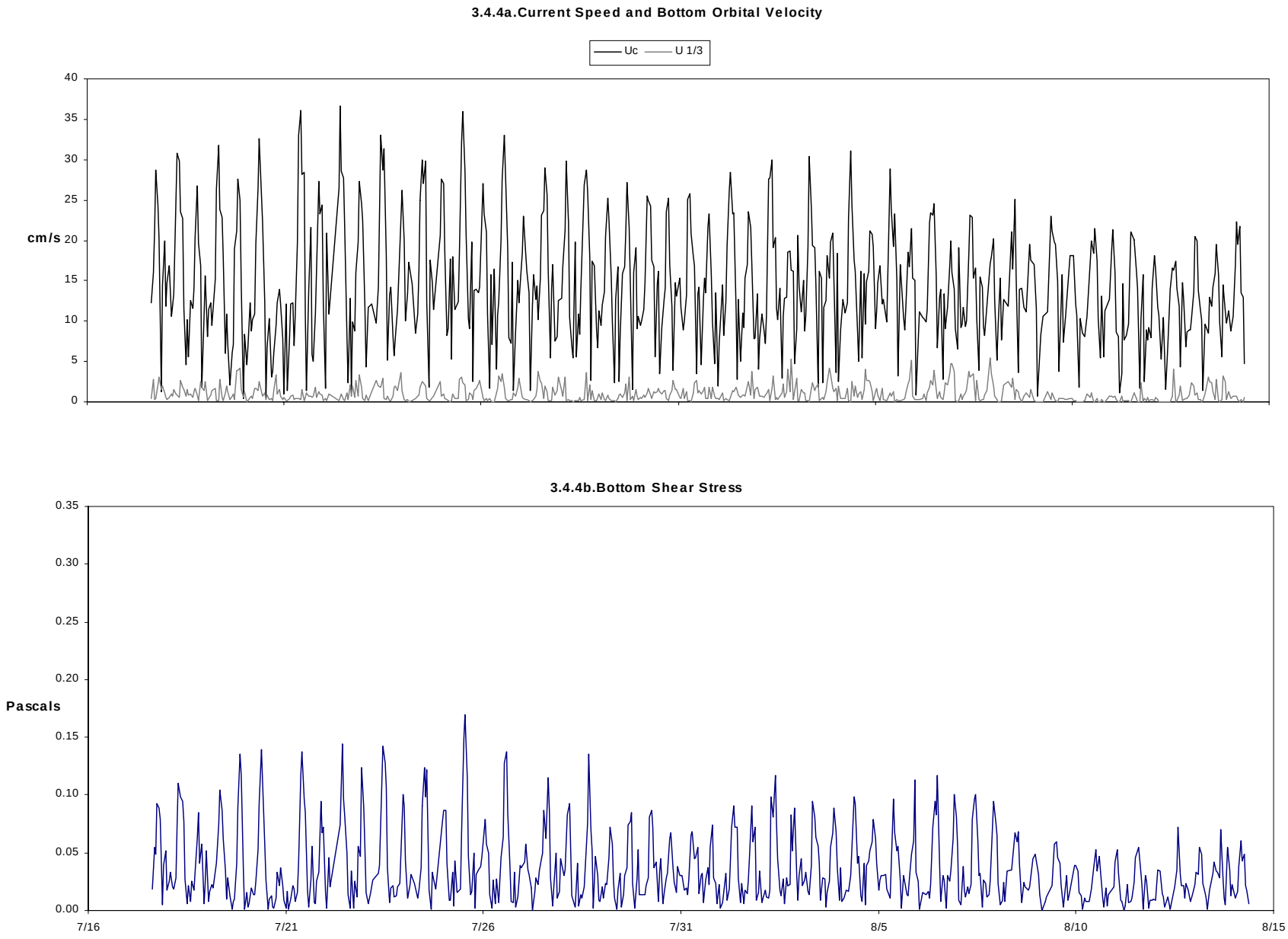


Figure 5-12. Station North 1 – Summer Current Speed, Bottom Orbital Velocity, and Bottom Shear Stress

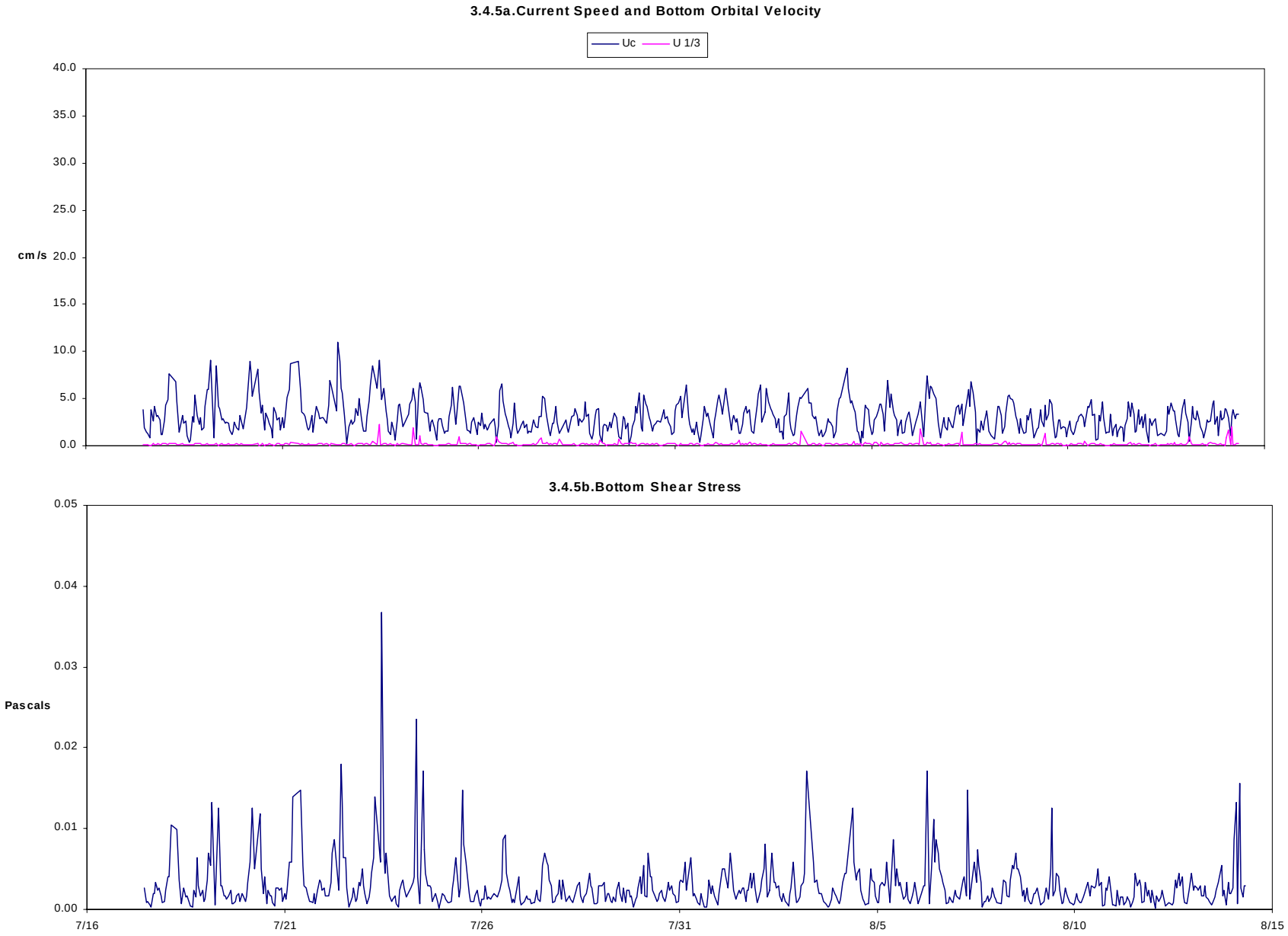


Figure 5-13. Station South 1 – Summer Current Speed, Bottom Orbital Velocity, and Bottom Shear Stress

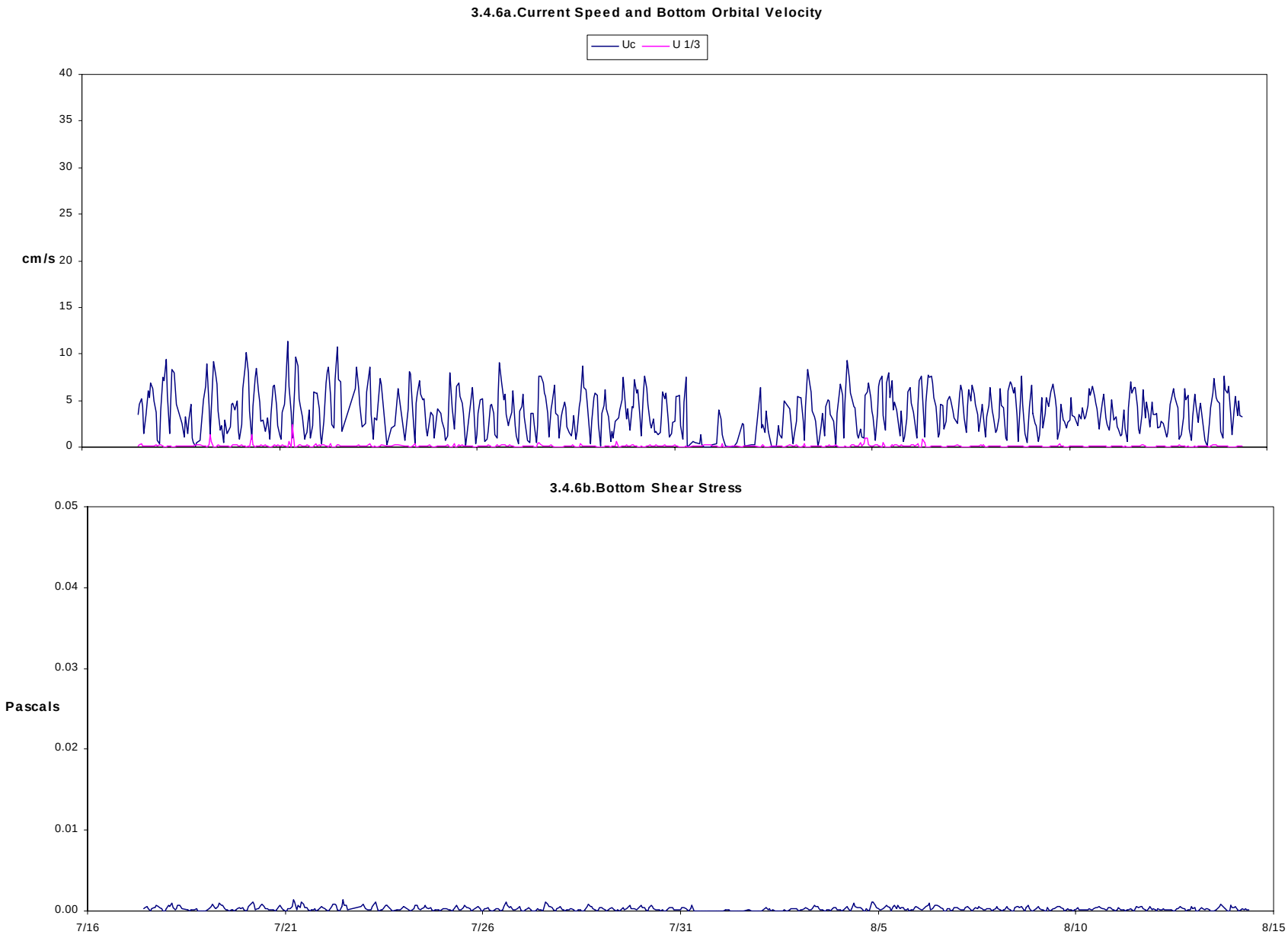


Figure 5-14. Station South 2 – Summer Current Speed, Bottom Orbital Velocity, and Bottom Shear Stress

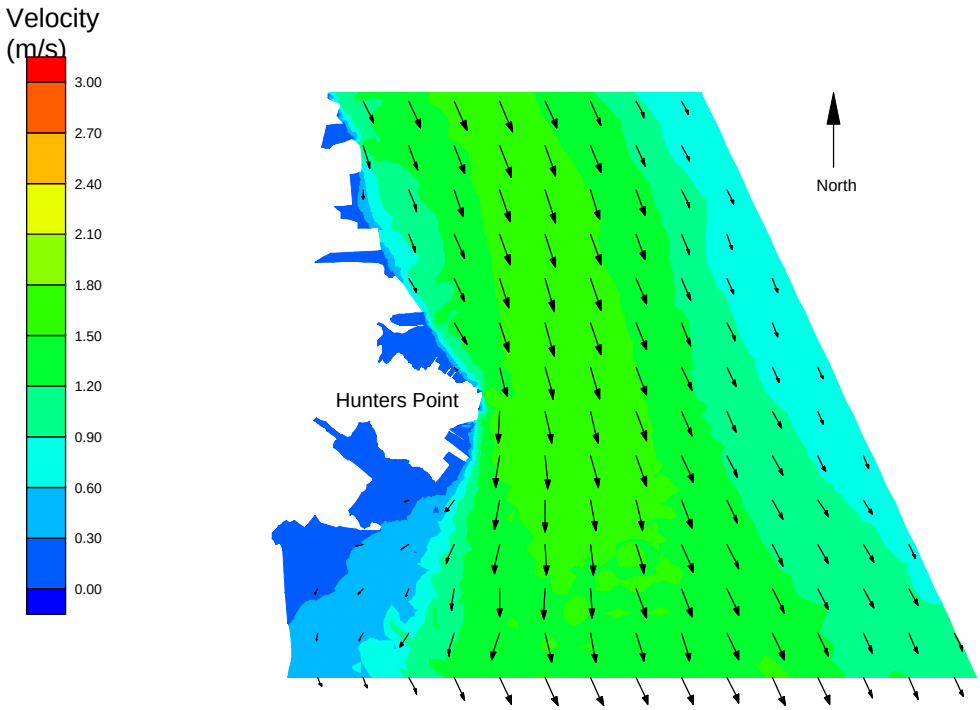


Figure 6-1. Maximum winter flood tide velocity contours and vectors (February 7th, 2001).

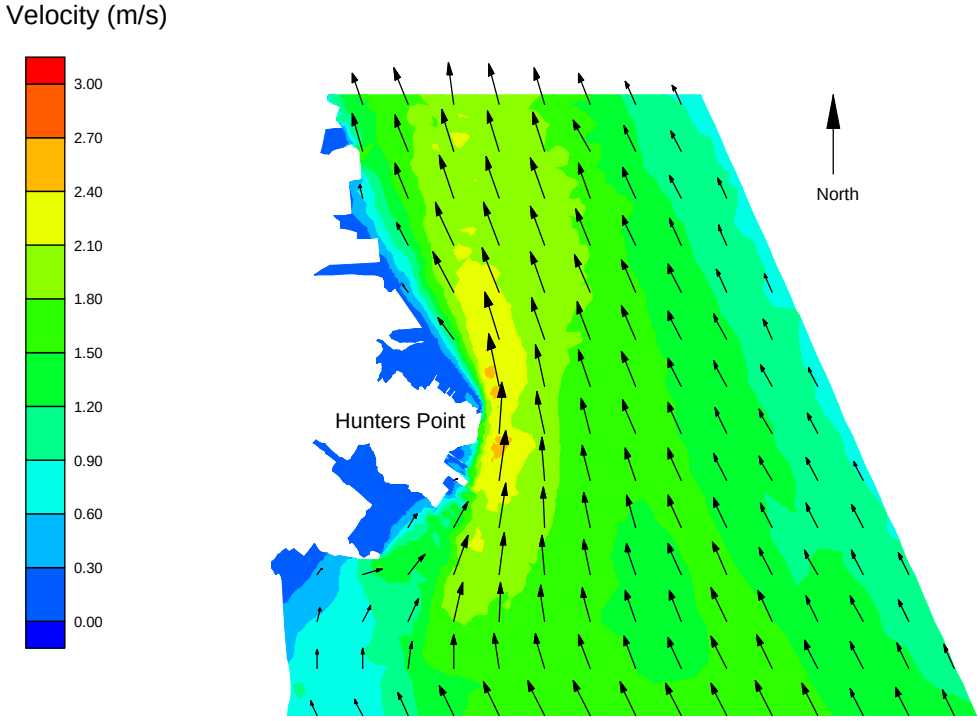


Figure 6-2. Maximum winter ebb tide velocity contours and vectors (February 7th, 2001).

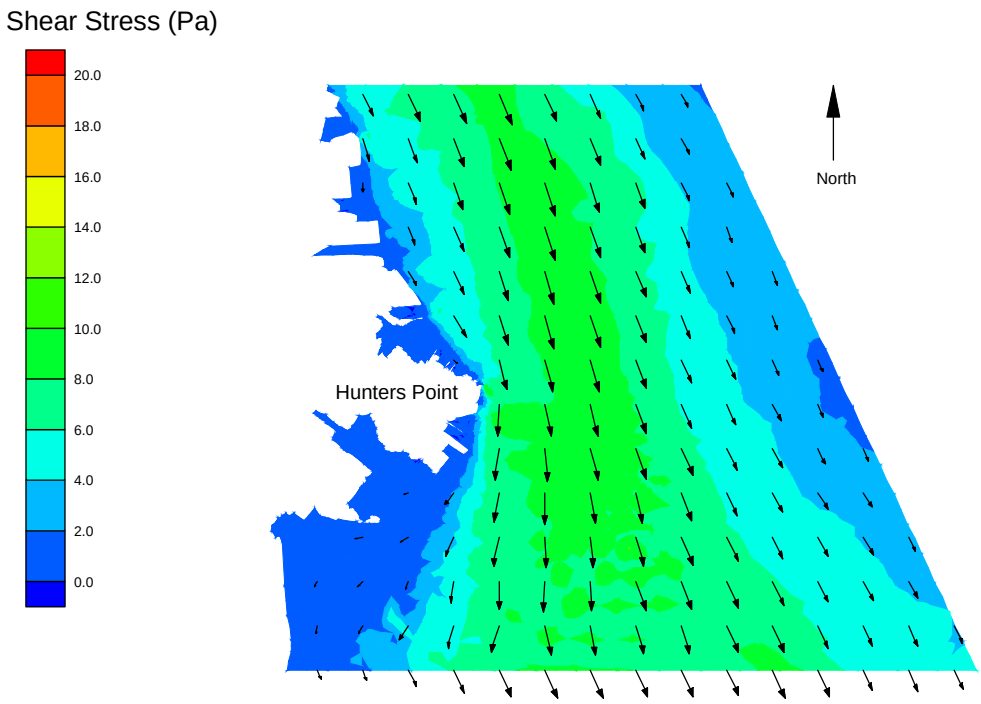


Figure 6-3. Maximum winter flood tide shear stress and velocity vectors (February 7th, 2001). Shear stress is due to only currents.

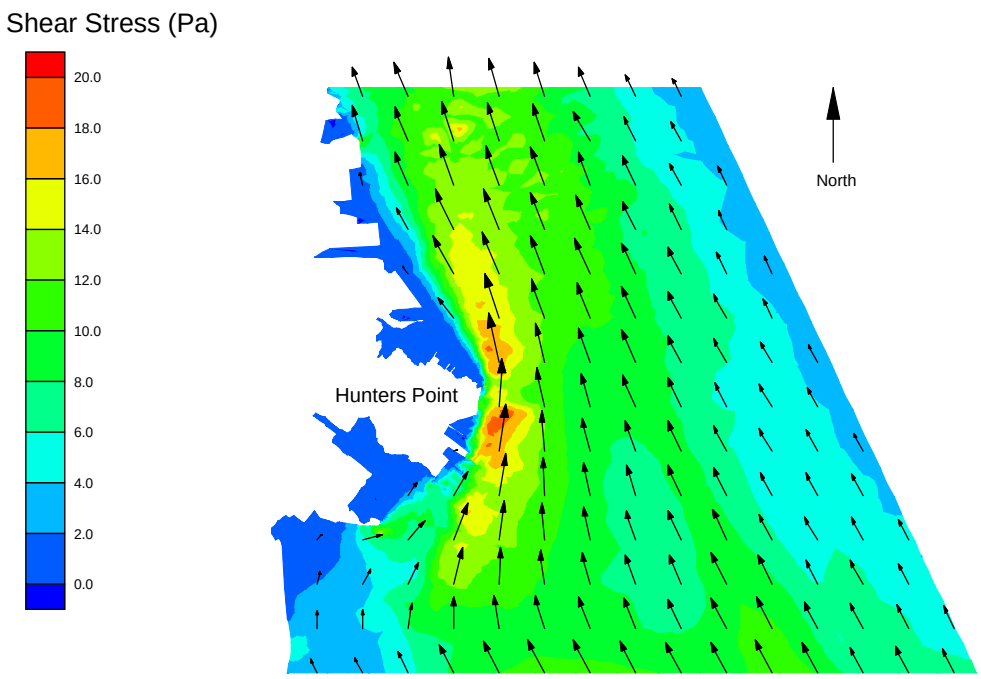


Figure 6-4. Maximum winter ebb tide shear stress and velocity vectors (February 7th, 2001). Shear stress is due to only currents.

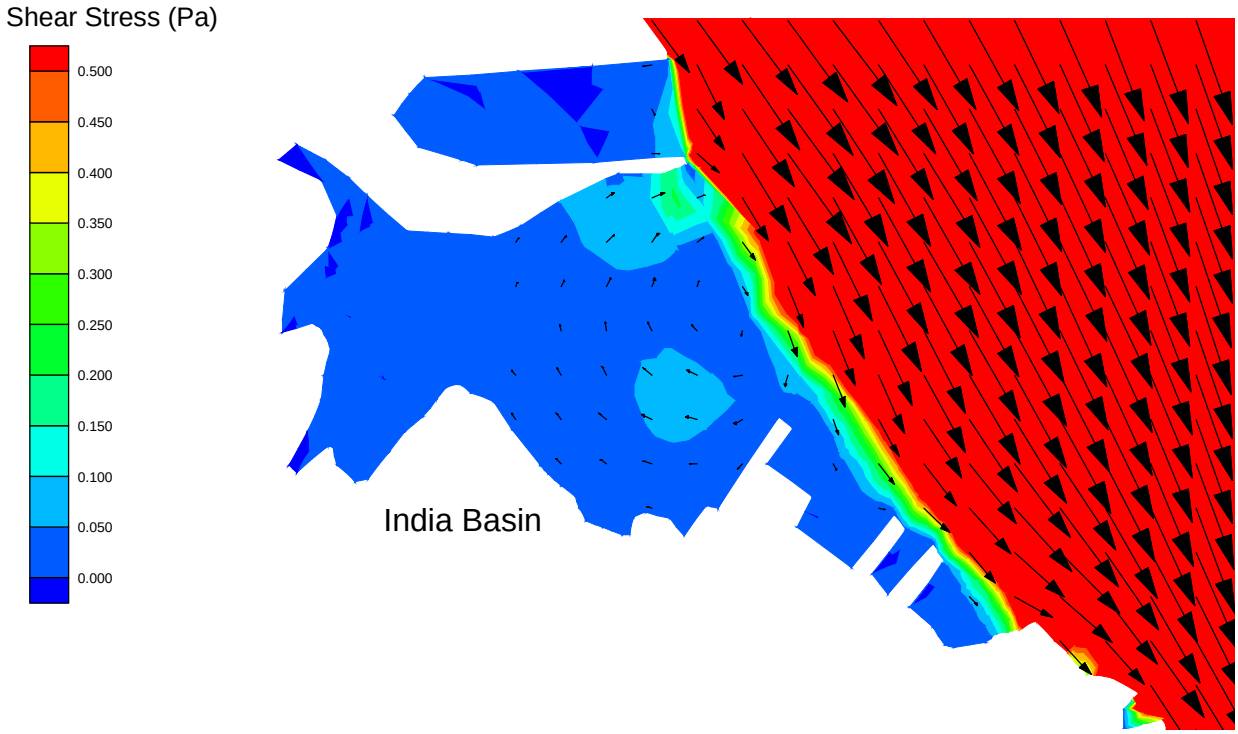


Figure 6-5. Maximum winter flood tide in India Basin shear stress and velocity vectors (February 7th, 2001). Shear stress is due to only currents.

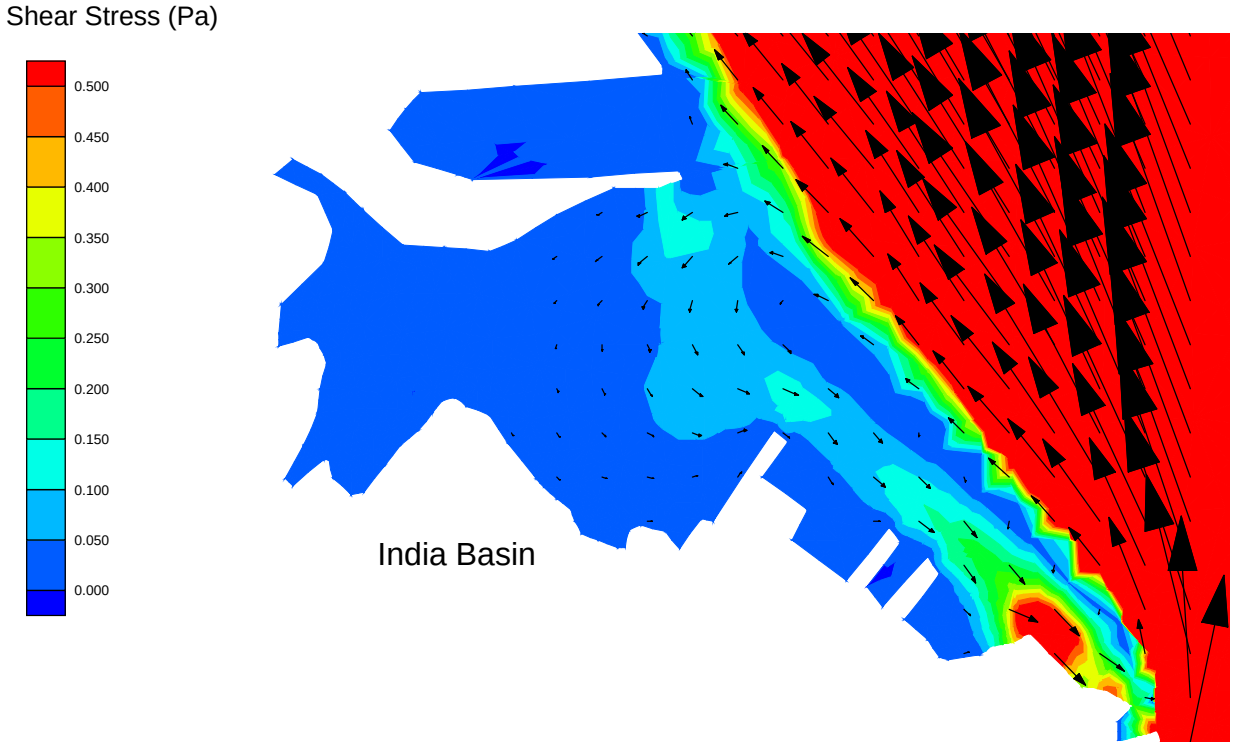


Figure 6-6. Maximum winter ebb tide in India Basin shear stress and velocity vectors (February 7th, 2001). Shear stress is due to only currents.

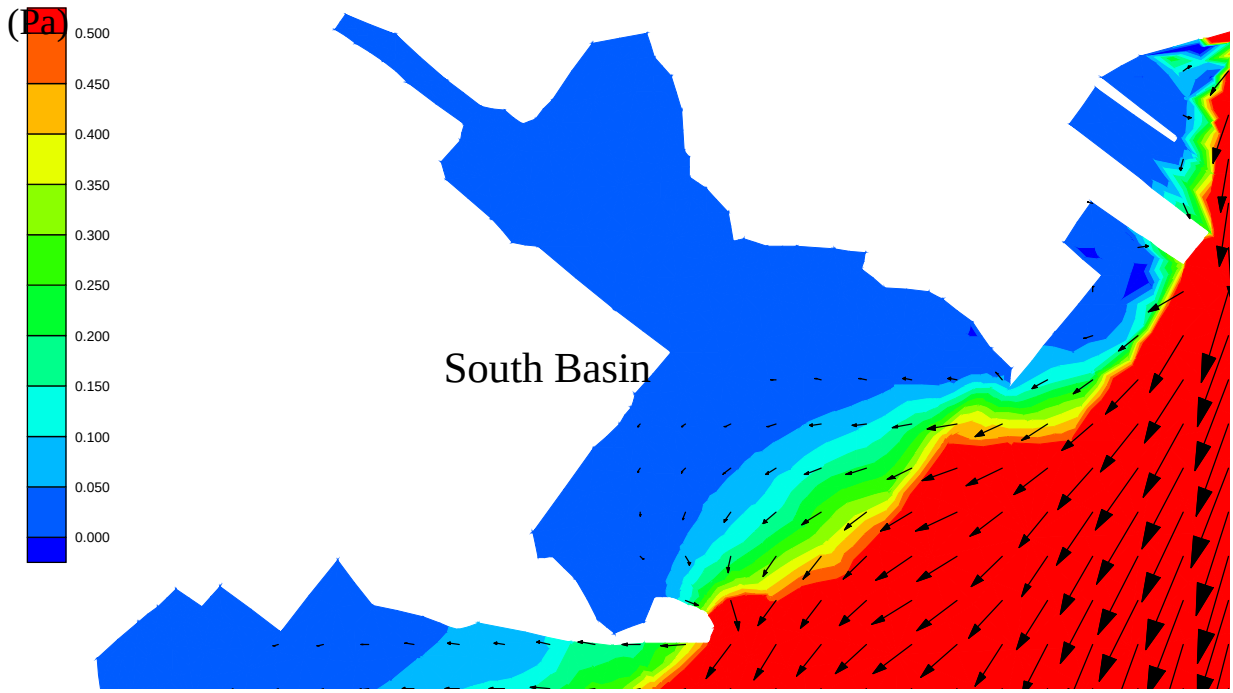


Figure 6-7. Maximum winter flood tide shear stress and velocity vectors in the South Basin (February 7th, 2001). Shear stress is due to only currents.

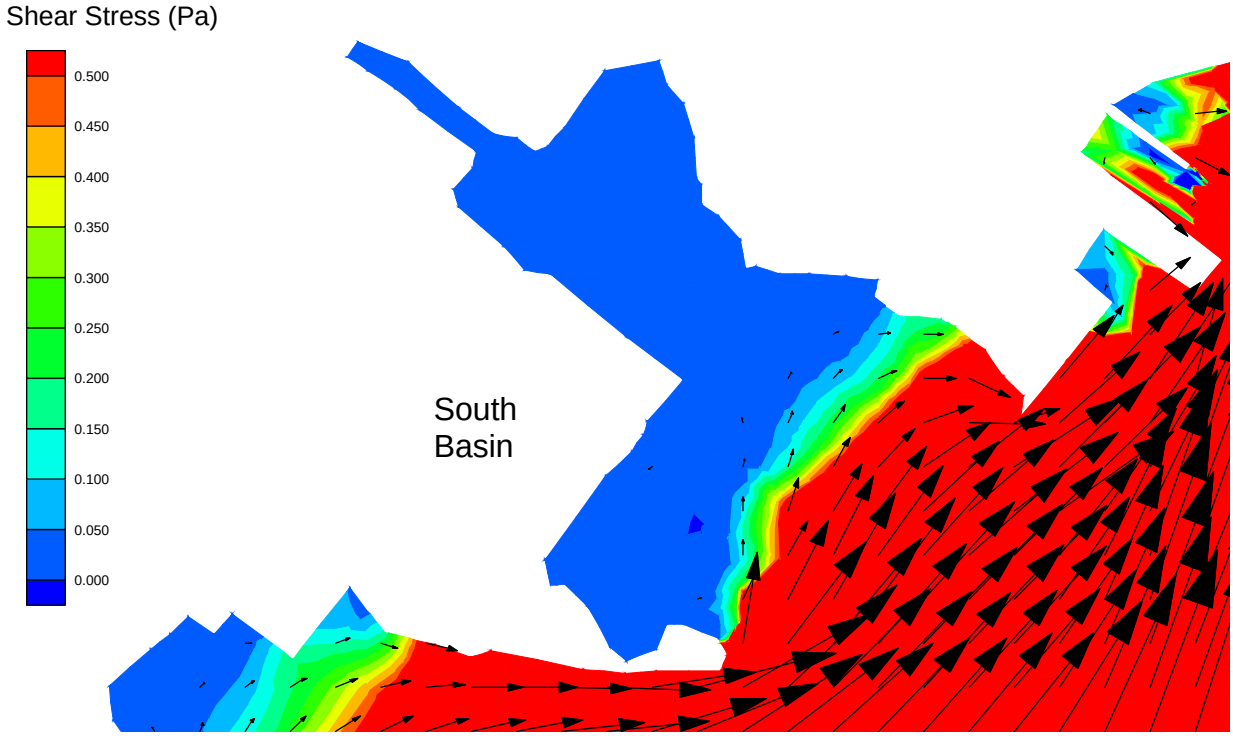


Figure 6-8. Maximum winter ebb tide shear stress and velocity vectors in the South Basin (February 7th, 2001). Shear stress is due to only currents.

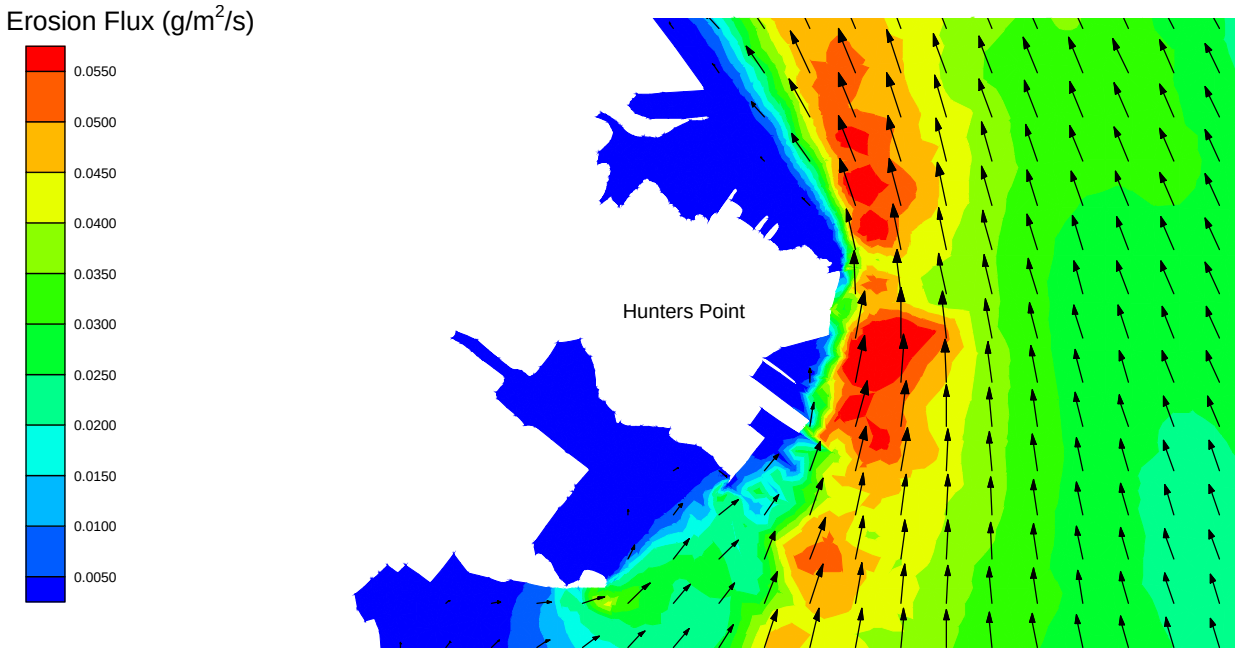


Figure 6-9. Maximum winter ebb tide erosion flux and velocity vectors (February 7th, 2001).

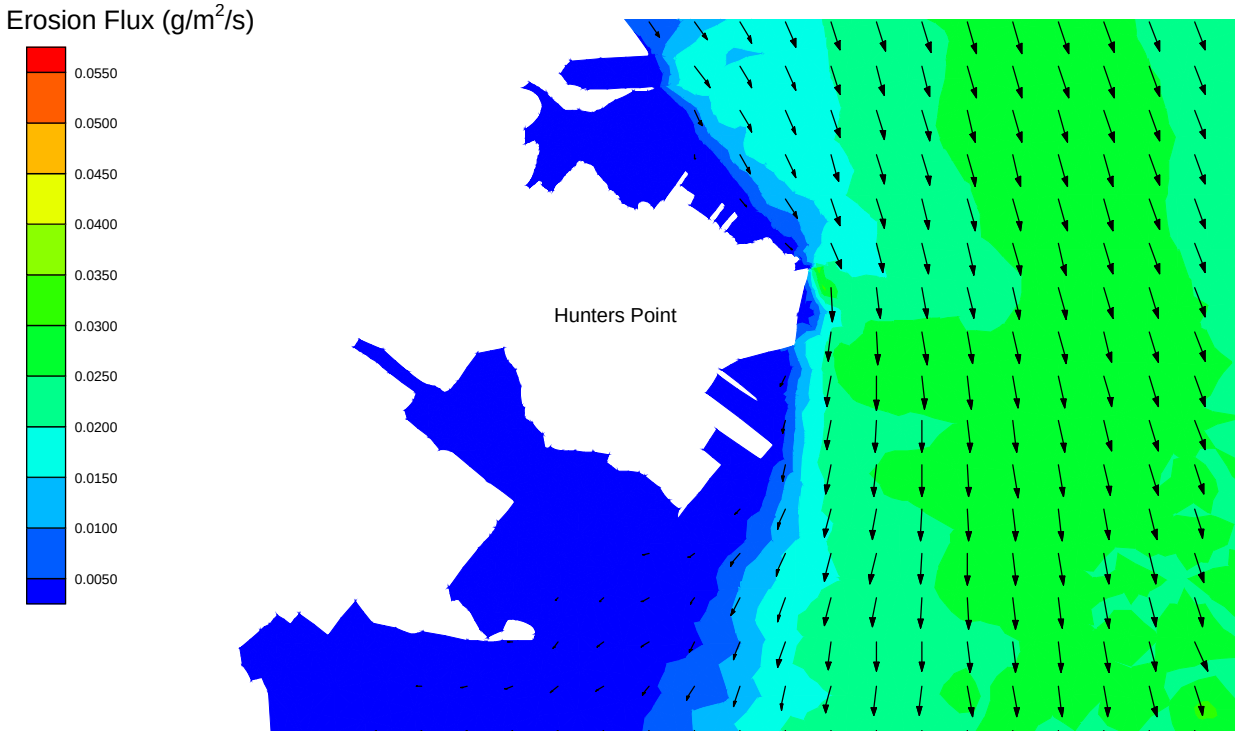
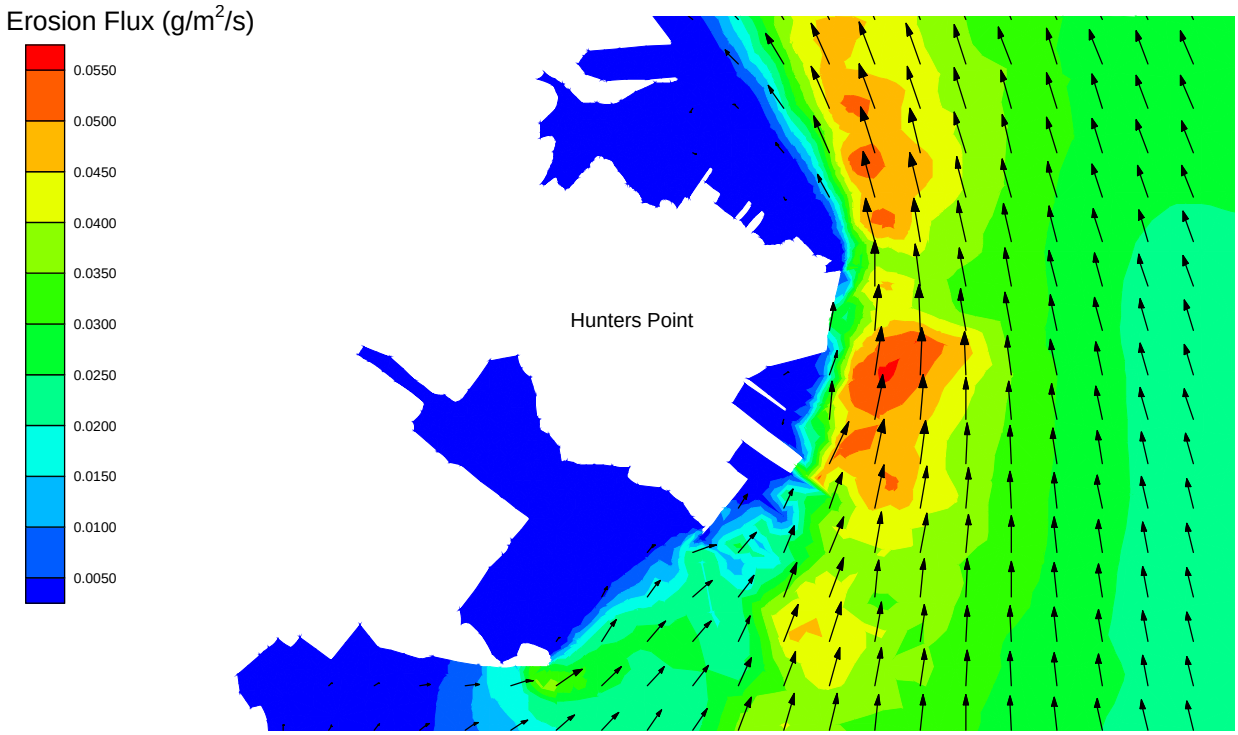


Figure 6-10. Maximum winter flood tide erosion flux and velocity vectors (February 7th, 2001).



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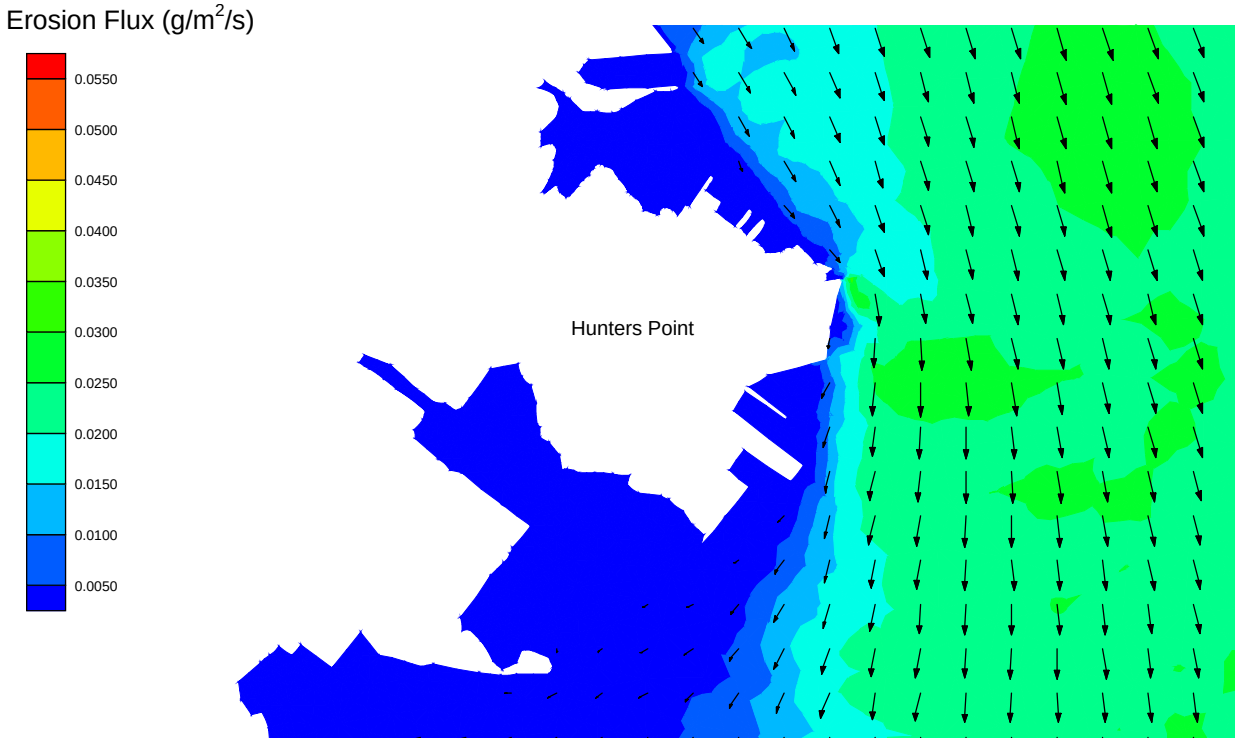

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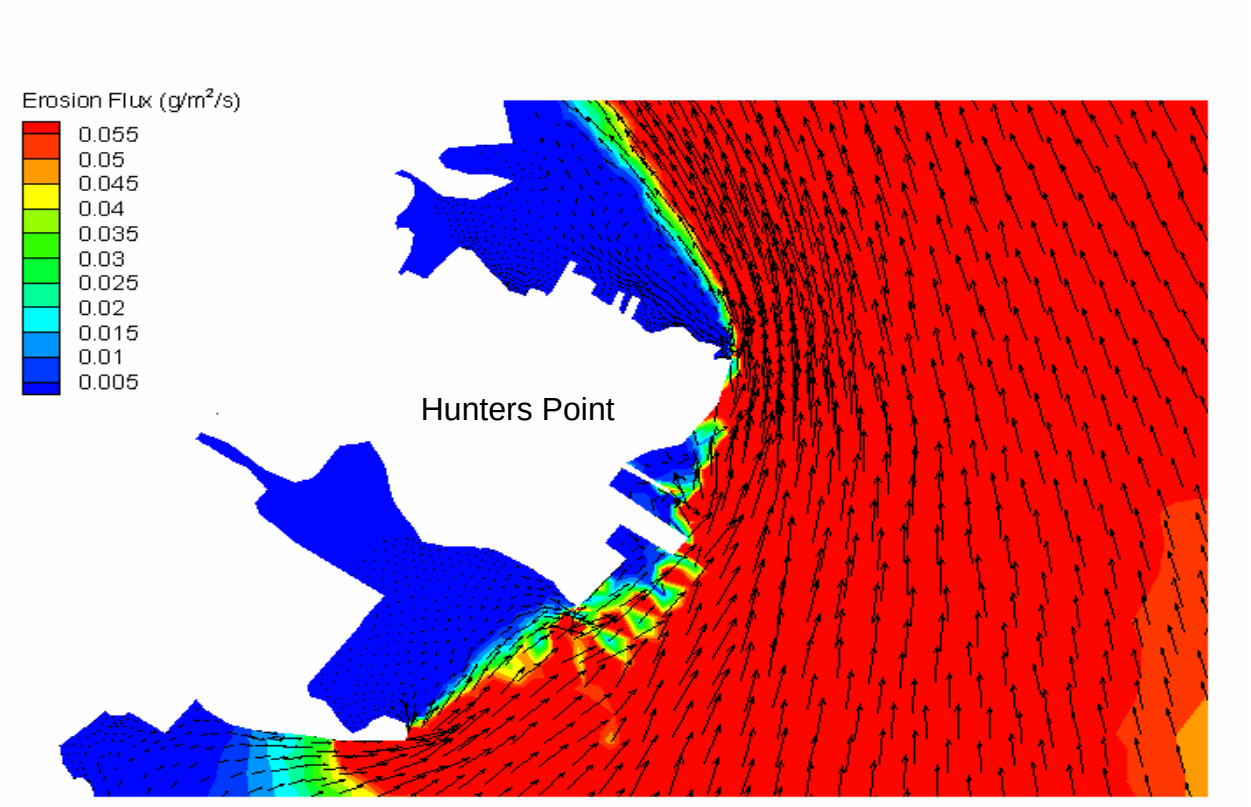

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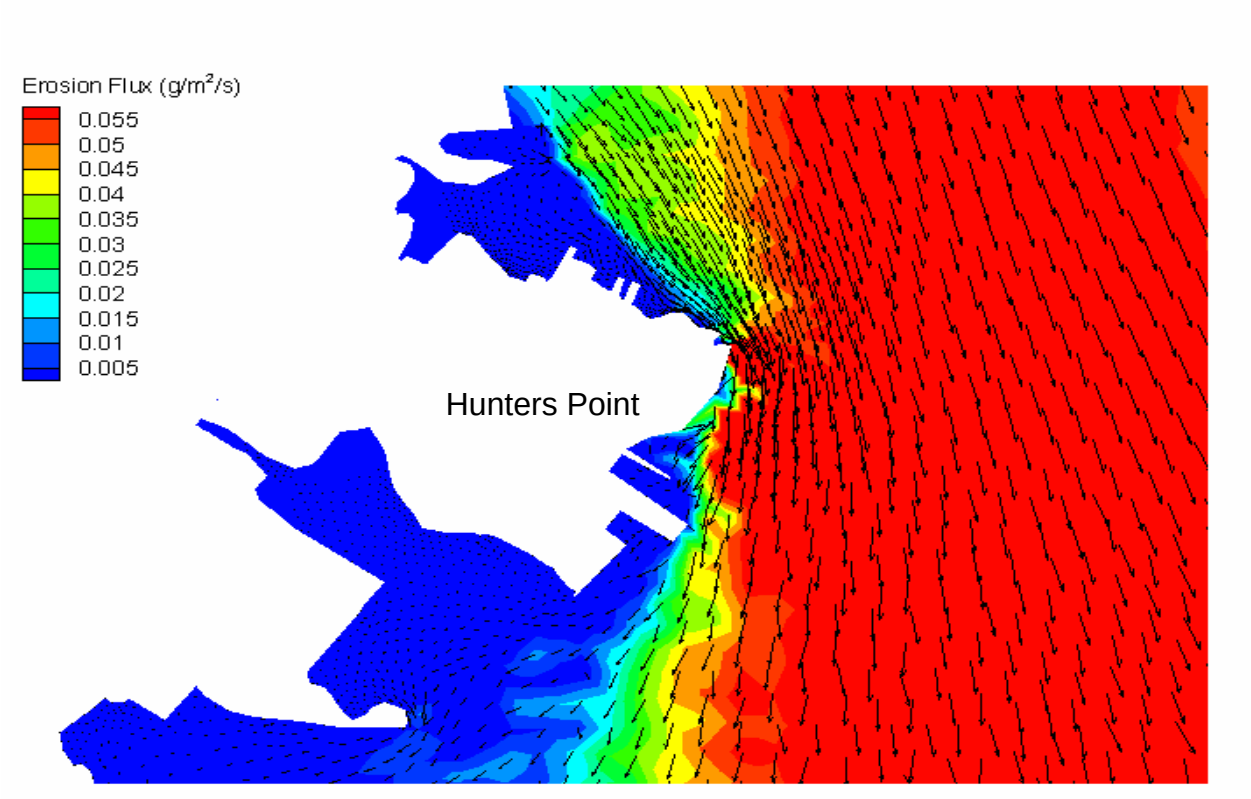

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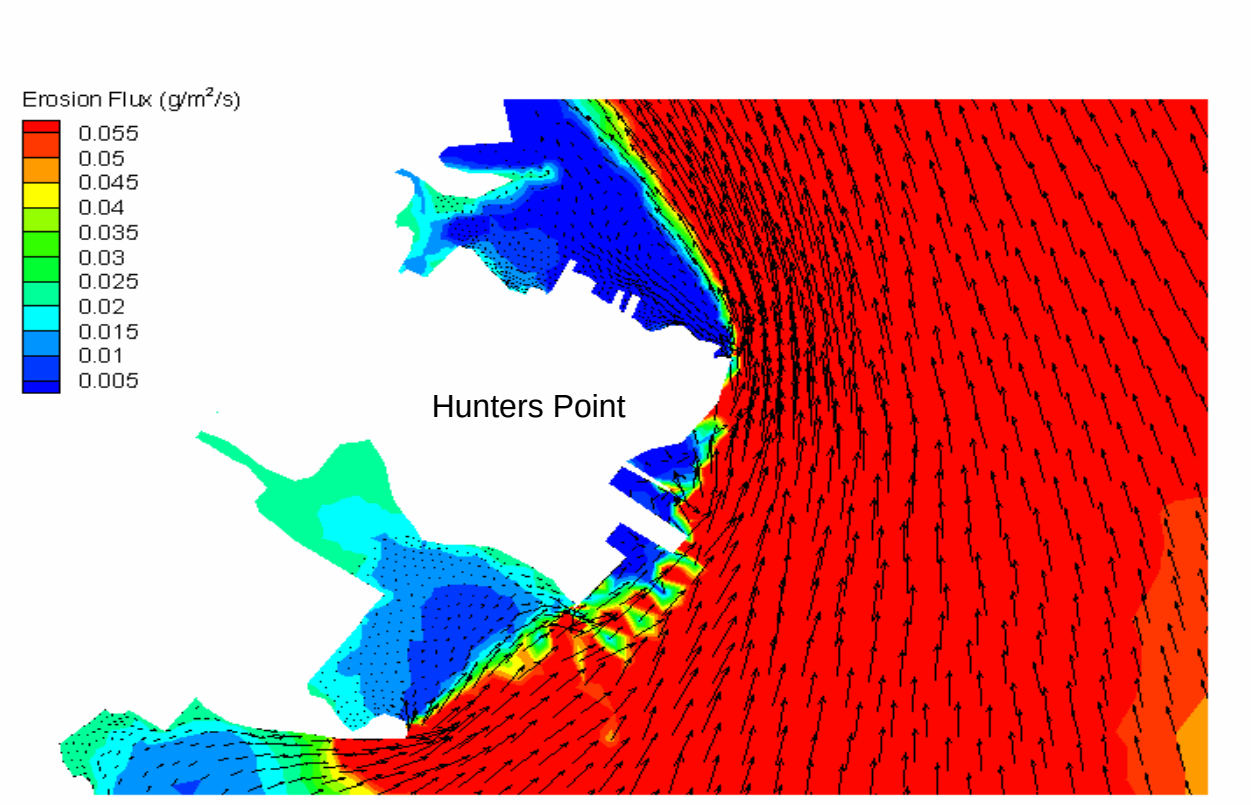

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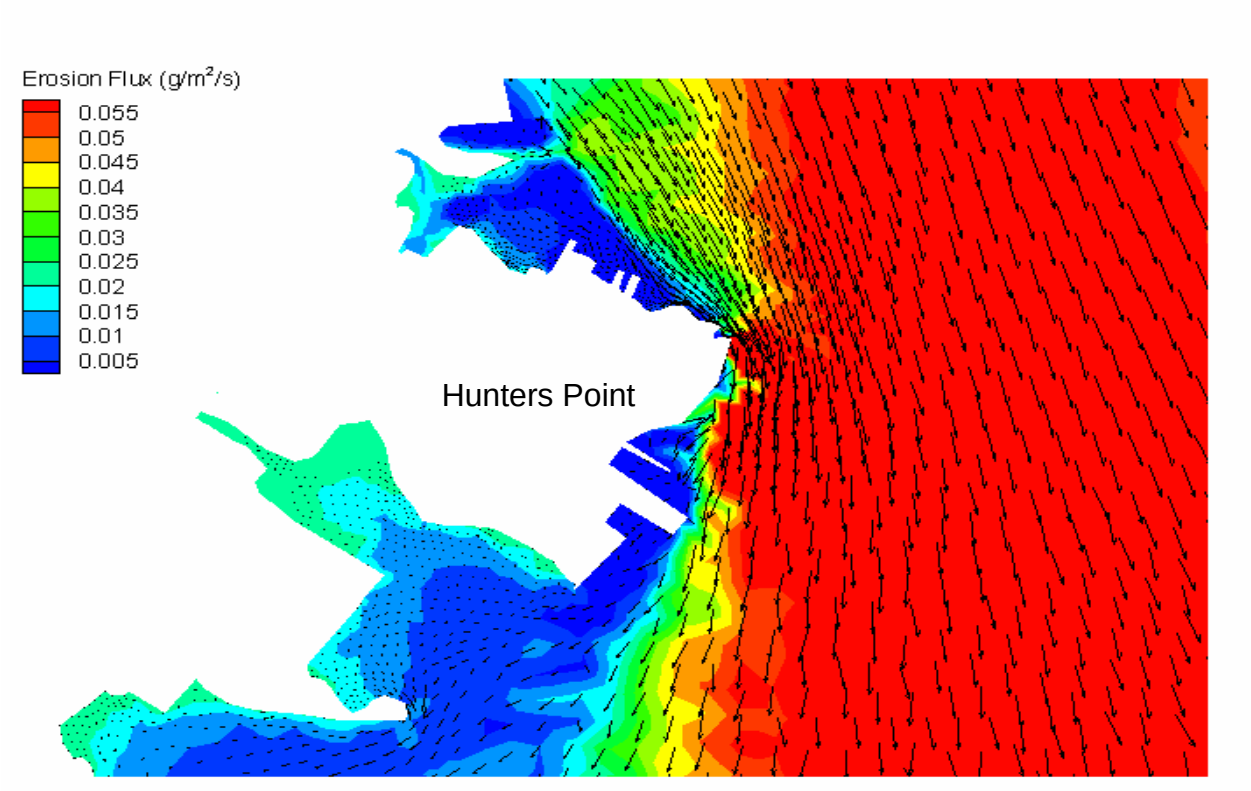

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APPENDIX M

Radioisotope Data

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Appendix M. Radioisotope Data

Seven sediment cores were collected as part of the HPS Validation Study and analyzed for the radioisotopes ^{210}Pb and ^{137}Cs to estimate the age of the sediment profile, to estimate sediment accumulation rates, and to establish the degree of vertical mixing. Cores were collected from five stations around HPS (i.e., Stations IB-56, PA-41, SB-03, SB-06, and SB-12). Radioisotope cores originally were planned to be analyzed from Area VIII; however, the cores were sandy and determined to be unsuitable for dating. An additional core from Area X was dated instead. Core sample locations are shown in Figures 3-1, 3-2, and 3-5 of the main document. Two cores for radioisotope analysis were collected in Yosemite Creek (i.e., YC-68 and YC-69; see Figure 3-6), as requested by the City and County of San Francisco. Benthic and epibenthic fauna composition and abundance data collected in the early 1990s were used to qualitatively evaluate bioturbation potential to support determination of the degree and depth of vertical mixing. DQOs for radioisotope profiling are provided in Table 2-13.

M.1 BACKGROUND

The use of radioisotope profiling to support the characterization of sediment dynamics is described in the paper *Short-Lived Isotopic Chronometers* (USGS, 1998). Briefly, ^{210}Pb forms by the radioactive decay of its gaseous parent, ^{222}Rn (^{222}Rn forms from the decay of radium). ^{210}Pb is removed from the atmosphere by precipitation, and is rapidly adsorbed to and deposited with sediment particles. This flux of ^{210}Pb from the atmosphere produces a concentration of "unsupported" ^{210}Pb (i.e., a concentration which exceeds the "supported" concentration resulting from radioactive decay of the sediment itself). The half-life of ^{210}Pb is 22.3 years, and dates of sediment deposition can be estimated by determining decrease of ^{210}Pb activity with depth. In an undisturbed sediment core, "unsupported" ^{210}Pb activity will decrease exponentially with increasing depth until it reaches the supported ^{210}Pb level. However, mixing of sediment by organisms or other processes will disrupt the smooth profile and reduce the accuracy of the estimated dates and sediment accumulation rates. The rate of sediment accumulation in cm/yr can be calculated based on the dated sediment column. The sedimentation rate in grams of dry sediment per year per cm^2 also can be calculated if the wet and dry densities of the sediment are determined.

Data for the radioisotope ^{137}Cs can be used to confirm dates estimated from the ^{210}Pb data for the following reasons: ^{137}Cs was present in the fallout from atmospheric nuclear tests, and first appeared in sediment cores around 1952-1955. Deposition of ^{137}Cs peaked in 1963-1964. In an undisturbed sediment core, ^{137}Cs activity levels will reflect ^{137}Cs production during period of atmospheric nuclear testing, with an initial appearance in the early to mid-1950s, a peak in the early 1960s, and a decrease in the early 1970s after atmospheric testing was halted.

M.2 DEPOSITIONAL ENVIRONMENT

Two key assumptions associated with the use of radioisotopes to estimate sediment age dates are that (1) the sediment accumulation rate is constant (i.e., sedimentation processes are constant), and (2) the grain size of the deposited sediment is uniform. Sediment texture and structure for all of the sediment cores collected at HPS and Yosemite Creek were examined to evaluate the validity of these assumptions (Table M-1). Sediment core logs are provided in Appendix A. Data from all cores were evaluated for this characterization effort, although only seven of the cores were dated.

Based on the macroscopic examination of sediment type and grain-size changes, Areas I, IX, and X (i.e., India Basin and South Basin) were determined to be low energy, quiescent environments. Sedimentation processes in these areas appear to be reasonably uniform, although polychaetes observed in many of the cores will disrupt the sediment profile and mix the surface and subsurface sediments. Worms generally were concentrated in the upper 1-2 ft of sediment. Cores from these areas were the best candidates for reliable age dating.

The presence of a few sand layers in the core from Station YC-68 indicates an overall low energy environment with episodic high energy events. Station YC-69, which is downstream of Station YC-68, appears to be characterized by a more uniform low energy environment.

Sediment characteristics in cores from Area III (Point Avisadero) indicate that the area is a dynamic environment. Many of the cores contained silty clay with sand laminae, indicating episodic high energy events. Station PA-40, located near the outfall of the drainage tunnel from Dry Dock 3 (see Section 1.2 of the main document), contained grit, sand, clay, and pebbles, which is not typical of naturally-deposited sediments. Given the apparently dynamic environment, sediment dates estimated in Area III should be considered less reliable than those obtained from Areas I and X. Nearshore stations from Area VIII (Stations EW-31 and EW-36) indicate a higher energy environment characterized by sand and shell hash. However, the Area VIII cores were determined to be unsuitable for dating.

M.3 SEDIMENT ACCUMULATION RATES

^{210}Pb and ^{137}Cs data for the dated cores are provided in Tables M-2 and M-3, respectively. Estimated core dates and sediment accumulation rates based on ^{210}Pb dating are provided in Table M-4. It should be noted that sedimentation rates in the uppermost samples appear to be higher than the rates for deeper samples because the sediment is less consolidated (i.e., less dense) in upper core areas. Average sediment accumulation rates ranged from approximately 1 cm/yr for the cores collected in South Basin to 6-8 cm/yr for the cores collected in Yosemite Creek. The rates calculated for cores from Area III (Station PA-41) and Yosemite Creek (YC-68) should be considered less reliable than those for the other cores because of evidence of variable sedimentation processes. Percent moisture data for the YC-68 core show a marked increase in dry weight below 50 cm, which suggests a discontinuity (i.e., erosional surface) at that depth.

The approximate depth that corresponded with the initiation of Navy activities at HPS (i.e., 1945) was determined for each core (Table M-5). In addition, the approximate depth that corresponded with 1952 also was determined based on the earliest detection of ^{137}Cs in order to confirm the age dates obtained from ^{210}Pb (it should be noted that this depth is an upper bound; the first appearance of ^{137}Cs could be present in the core between two measured intervals). Comparisons of depths obtained from the two methods are provided in Table M-5. With the exception of Station SB-12, the ^{137}Cs dates confirm the ^{210}Pb dates.

M.4 DEGREE OF VERTICAL MIXING

Radioisotope profiles for each core are presented in Figures M-1 through M-5. The ^{210}Pb profiles for the cores from Stations SB-06 and SB-12 in South Basin most closely approximate the ideal profile of an exponential decrease to the supported concentration. The core from Station IB-56 shows the highest ^{210}Pb activity in the 10-12 cm sample, which suggests that biotic activity may have mixed the surface sediments down into the sediment column. The core from Station PA-41 shows a rapid decrease in ^{210}Pb activity in the 10-12 cm interval and a noisy profile below that depth. The ^{210}Pb profiles in the cores from Stations YC-68 and YC-69 are extremely variable, which indicates that the dates and sediment accumulation rates for these cores are unreliable.

The ^{137}Cs profiles are difficult to interpret. The profile in the core from Station SB-06 most closely approximates the ideal profile of a subsurface peak and decrease to non-detected levels deeper in the core. Profiles in other cores deviate from this pattern to various degrees. Evidence of mixing and disturbance can be seen in the profiles for all cores, with the greatest degree of disturbance observed in the cores from Stations YC-68 and YC-69 (Yosemite Creek) and the smallest degree in the South Basin cores.

An unusually high level of ^{137}Cs was measured in the 30-31 cm sample from Station YC-68 (2.2 dpm/g). This level was about five times higher than the peak activities measured in the other cores, and is higher than what would be expected from atmospheric fallout. The source of this ^{137}Cs is unknown; Station YC-68 is located at the upstream end of Yosemite Creek.

M.5 ASSESSMENT OF BIOTURBATION POTENTIAL IN SOUTH BASIN

Reconnaissance surveys of benthic and epibenthic fauna at HPS were conducted in 1993 to support ecological risk assessment activities (BioSystems Analysis Inc., 1994a and 1994b). Fauna composition and abundance data from these studies were used to qualitatively evaluate the potential effects of bioturbation, including an assessment of the depth of vertical mixing by resident biota. The most abundant taxa collected in the surveys were identified, and the bioturbation potential was assessed based on published information for the same or similar species. It should be noted that the types of organisms collected in these surveys would be influenced by the sampling equipment that was used. A trawl used in a epibenthic survey scrapes the surface and will not catch organisms that dig deep into the sediment. Additionally, the benthic survey report did not provide details on the size of the grab sampler used in the survey. A small van Veen grab sampler (surface area = 0.04 m^2) only penetrates about 8 cm into the sediment and therefore would miss anything at the depths below 8 cm. A 0.01 m^2 (surface area) van Veen grab sampler may penetrate as deep as 15 cm, but usually a little less. Therefore, the degree to which the data collected in 1993 accurately represent the resident biota in South Basin is uncertain.

Three activities of marine invertebrates contribute to bioturbation in varying degrees (Pearson, 2001):

> Motility: From sedentary animals to freely motile forms in permanent excavated burrow systems;
> Feeding: From carnivores or filter feeders to deep subsurface deposit feeders that egest sediment at the surface;
> Burrowing: From no burrowing activity to extensive horizontal or vertical burrows with net transport of sediment to the surface.

The infaunal and epibenthic data collected in 1993 (BioSystems Analysis Inc., 1994a and 1994b) allow some estimate of the potential for bioturbation in the study area to be made. The most abundant taxa (combined 0.5-mm and 1.0-mm fractions) at Transects 5 (sites A, B), Transect 6 (A, B, C), and 7 (A, B, C) are shown in the following table:

			Abundance per Grab							
		Station	**5A**	**5B**	**6A**	**6B**	**6C**	**7A**	**7B**	**7C**
Crustacea	Ostracod	*Sarsiella zostericola*	16	2	12	28	23	36	5	5
	Cumacean	*Hemileucon hinumensis*	12	15	102	100	186	486	61	96
	Amphipods	*Ampelisca abdita*	0	23	149	5	64	145	63	6
		Corophium heteroceratum	0	14	0	24	0	0	9	5
		Corophium insidiosum	0	0	0	13	0	0	0	0
		Corophiidae	1	5	1	15	5	7	15	0
		Grandidierella japonica	2	5	153	14	52	50	25	3
		Total Corophioids	3	24	154	66	57	57	49	8
Mollusca	Clams	*Musculista senhousia*	9	14	0	2	3	1	6	3
		Potamocorbula	0	2	0	6	0	2	4	5
		Nematoda	18	0	25	7	1	14	15	3
Annelida	Oligochaete	Tubificidae	11	7	3	641	61	121	295	98
	Syllidae	*Exogone lourei*	16	0	37	81	13	22	20	2
	Goniadidae	*Glycinde polygnatha*	26	11	14	12	22	22	41	8
	Orbiniidae	*Leitoscolopos elongatus*	0	1	98	7	0	0	1	1

Crustacea. The crustaceans identified above are not expected to be major bioturbators. The ostracod is a small, scurrying animal that probably spends most of its time in the very uppermost millimeters of the sediment. Many ostracods migrate into the plankton at night. Cumaceans are relatively small filter feeders that nestle into the uppermost parts of the sediment with the anterior part of the body extending slightly above the surface to feed. Many of this group also migrate into the plankton or hover above the bottom. Neither of the two is expected to have much of an effect on bioturbation. Ampelisca is a well-known tube-dwelling filter feeder. The tubes extend several millimeters into the sediment and can provide a conduit for oxygen to penetrate into the sediments. Their overall bioturbation effect is likely very small. The corophioid amphipods are capable of limited bioturbation, but probably cannot affect sediments below 2 cm deep (Peterson et al., 1998). The crustaceans show above also comprised a major portion of those captured by the epibenthic sled at Transect 5. There were no crustaceans capable of large-scale bioturbation, such as large crabs or burrowing shrimp, in the sled samples. Thus, even though relatively abundant, these crustaceans are not affected to have much overall bioturbation effects below about 2-cm depth.

Mollusca. Molluscs were fairly uncommon in the grab and sled samples at Transect 5, 6, and 7. Among the grab samples, the bivalves *Musculista* and *Potamocorbula* were the most abundant molluscs. Both are non-native species and are filter feeders. The former is a mussel that attaches to the upper layer of the sediment by weaving a byssal cocoon (Yamamuro et al., 2000). The latter species lives in the uppermost part of the sediment and was not very common at the site. Although capable of filter large volumes of water, neither clam probably has much mixing effect on the sediments. The trawl samples also contained many unidentified opisthobranchs. These snails crawl along the sediment surface and probably do disturb it more than a few millimeters depth.

Annelida. Annelid worms are typically among the major bioturbation taxa in soft-bottom benthic systems. Notable are the deep subsurface deposit feeders such as the bamboo worms (Maldanidae) and the very active errant forms such as the clam worms (Nereidae). Tubificids are small (2-5-cm long) oligochaete worms that are often abundant in contaminated sediments, but they were not particularly abundant in the study area. They are capable of substantial bioturbation effects, but these are generally restricted to the upper 1.5 cm of the sediment (Cunningham et al., 1999). Among the other most common worms, the syllid, *Exogone*, are motile and highly selective surface deposit feeders that may occasionally act as carnivores or carrion feeders (Fauchald and Jumars, 1979). *Glycinde* is also a carnivore, but is not very motile (Fauchald and Jumars, 1979). Neither would be expected to disturb the sediments to any great depth. *Leitoscoloplos* are non-selective subsurface deposit feeders (Pearson, 2001), that are therefore probably capable of disturbing sediments. Dense populations of another species in the genus, *L. robustus*, can reworked considerable amounts of sediment per day, but only to depths of 4-8 cm (Rice, 1986).

Are "heavy-duty" bioturbators present? Some invertebrate taxa are known to be particularly important bioturbators in marine sediments. Of particular note are some of the larger decapod crustaceans such as *Callianassa*, various sea urchins, and several polychaete worms. Among the worms, the chaetopterids, lug worms (*Arenicola*), and the maldanids (*Clymenella*, *Maldane*) are capable of disturbing sediments fairly deeply (e.g., Pearson, 2001). Active worms such as Nereids may also disturb sediments substantially (François et al. 2002). Among the samples from HPS, there were no callianassid or other large decapods, lug worms and chaetopterids were absent, and sea urchins were not present. Nereids were present in some samples, but were rare. One maldanid species, *Asychis elongata*, was present, but was also rare and did not occur at Transects 5, 6, and 7.

Based on these observations, the infaunal community present in the study is not expected to be capable of disturbing the sediments to any great extent, especially deeper than a few centimeters.

M.6 SUMMARY

Cores collected in Area I (India Basin) and Area X (South Basin) at HPS were the most suitable for radioisotope profiling because they exhibited a uniform fine-grained texture and homogeneous structure, reflecting a relatively constant depositional environment. The average sedimentation rate for the three cores collected in Area X was about 1 cm/yr. Area III is located in a dynamic environment and sediment age dates and accumulation rates are less reliable. The dates and sediment accumulation rates determined for the cores from Yosemite Creek should be considered unreliable given the disrupted radioisotope profiles.

The radioisotope profiles from South Basin most closely approximated the ideal profiles expected in undisturbed conditions. Existing data on the benthic and epibenthic fauna in South basin indicate that the infaunal community present in the study is not expected to be capable of disturbing the sediments to any great extent, especially deeper than a few centimeters. However, the studies conducted to date did not characterize fauna below about 8 cm. Worms were observed in the upper 1-2 ft of most cores collected in South Basin, which indicates that mixing of surface and subsurface sediments in the upper 2 ft should be expected.

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Table M-1. Summary of Depositional Environments

Station	Core Length (ft)	Sediment Texture and Structure	Inferred Depositional Environment	Organisms Present
Area I India Basin				
IB-56	0-8.4	Silty clay; homogeneous texture	Low energy	Numerous worms and worm tubes in upper 2 ft
IB-59	0-8.0	Silty clay; homogeneous texture	Low energy	Few worm tubes
Area III Point Avisadero				
PA-40	0-4.0	Sand and clay, sandblast grit in upper 2 ft; rocks and pebbles below 2 ft; refusal at 4 ft	Moderate to high energy	None noted
PA-41	0-8.0	Stratified sand and clay in upper 1.7 ft, including sandblast grit; homogeneous silty clay below 1.7 ft	Dynamic; episodic high energy events above 1.7 ft); lower energy environment below 1.7 ft	Few
PA-44	0-7.5	Sandy to silty clay; homogeneous with some fine sand laminae	Dynamic; episodic high energy events	None noted
PA-47	0-8.4	Sandy clay in upper 1 ft; homogeneous silty clay below 1 ft	Moderate energy in upper 1 ft; low energy below 1 ft	Shell fragments in upper 1 ft and from 5.8 to 6.4 ft
PA-49	0-8.0	Silty clay with fine sand laminae	Dynamic; episodic high energy events	Numerous worms and worm tubes in upper 1.2 ft
PA-52	0-7.7	Uniform silty clay with fine sand laminae; wood fibers at 0.5 ft	Dynamic; episodic high energy events in upper 5.7 ft; low energy below 5.7 ft	None noted
Area VIII Eastern Wetland				
EW-31	0-8.2	Clayey sand and shell hash; sandy silty clay below 7.9 ft	High energy	Abundant shell fragments
EW-36	0-5.3	Clayey sand, sand and shell hash	High energy	Abundant clam shells and fragments
Area IX Oil Reclamation				
OR-24	0-9.8	Homogeneous silty clay; clay content increases below 6 ft	Low energy	Clam shells
OR-28	0-8.5	Homogeneous silty clay with black mottling in upper 1 ft	Low energy	Worms and worm tubes in upper 1.2 ft; abundant clam shell fragments from 3.8--5.5 ft.

Table M.1 (continued)

Station	Core Length (ft)	Sediment Texture and Structure	Inferred Depositional Environment	Organisms Present
Area X South Basin				
SB-01	0-9.5	Sandy clay to 4 ft; silty clay below 4 ft; evidence of hydrocarbon contamination in upper 2.5 ft	Low energy	Few worms and shells in upper 3.5 ft; abundant shells and shell hash below 3.5 ft
SB-03	0-9.5	Homogeneous silty clay	Low energy	Clam shells and fragments
SB-06	0-9.5	Homogeneous silty clay	Low energy	Worm tubes, clam shells, and fragments
SB-07	0-9.3	Homogeneous silty clay	Low energy	Worm tubes, clam shells, and fragments
SB-12	0-9.3	Homogeneous silty clay with black mottling	Low energy	Worm tubes, clam shells, and fragments
SB-16	0-9.7	Homogeneous silty clay	Low energy	Abundant shells and shell fragments
SB-20	0-7.5	Homogeneous silty clay	Low energy	Numerous worms in upper 1 ft and worm tubes to 3 ft; shells and shell fragments below 4.5 ft
SB-22	0-9.5	Homogeneous silty clay	Low energy	Few worm tubes and shell fragments
Yosemite Creek				
YC-68	0-4.4	Silty clay with few sand layers; hydrocarbon odor between 1-1.5 ft	Primarily low energy with episodic high energy events	Worms in upper 1 ft; shell fragments
YC-69	0-3.9	Homogeneous silty clay	Low energy	Worms, clam shells, and fragments

Shaded cores were radiodated.

Table M-2. Lead-210 Radioisotope Data

Battelle MSL Sample ID	Sponsor ID	Sample Descriptor	Depth (cm)	Activity Pb-210 (dpm/g)	RPD (%)
1658*180	AAB-318-M	IB-56-C	0-2	3.67	
1658*181	AAB-319-M	IB-56-C	10-12	3.73	
1658*182	AAB-320-M	IB-56-C	20-22	3.15	
1658*183	AAB-321-M	IB-56-C	30-32	2.96	
1658*184	AAB-322-M	IB-56-C	40-42	2.01	
1658*185	AAB-323-M	IB-56-C	50-52	1.94	
1658*186	AAB-324-M	IB-56-C	60-62	1.68	
1658*187	AAB-325-M	IB-56-C	70-72	1.11	
1658*188	AAB-326-M	IB-56-C	80-82	1.01	
1658*189	AAB-327-M	IB-56-C	90-92	1.16	
1658*112 R1	AAB-288-M	PA-41-C	0-2	4.17	
1658*112 R2	AAB-288-M	PA-41-C	0-2	4.25	2%
1658*114	AAB-290-M	PA-41-C	10-12	1.87	
1658*113	AAB-289-M	PA-41-C	20-22	1.80	
1658*115	AAB-291-M	PA-41-C	30-32	2.22	
1658*116	AAB-292-M	PA-41-C	42-44	1.59	
1658*117	AAB-293-M	PA-41-C	50-52	1.62	
1658*118	AAB-294-M	PA-41-C	60-62	1.49	
1658*119	AAB-295-M	PA-41-C	70-72	1.60	
1658*120	AAB-296-M	PA-41-C	80-82	1.28	
1658*121	AAB-297-M	PA-41-C	90-92	0.76	
1658*190 R1	AAB-328-M	SB-03-C	0-2	4.30	
1658*190 R2	AAB-328-M	SB-03-C	0-2	4.41	3%
1658*191	AAB-329-M	SB-03-C	10-12	3.15	
1658*192	AAB-330-M	SB-03-C	20-22	1.97	
1658*193	AAB-331-M	SB-03-C	30-32	1.95	
1658*194	AAB-332-M	SB-03-C	40-42	2.07	
1658*195	AAB-333-M	SB-03-C	50-52	1.64	
1658*196	AAB-334-M	SB-03-C	60-62	1.44	
1658*197 R1	AAB-335-M	SB-03-C	70-72	1.73	
1658*197 R2	AAB-335-M	SB-03-C	70-72	1.81	5%
1658*198	AAB-336-M	SB-03-C	80-82	1.45	
1658*199	AAB-337-M	SB-03-C	90-92	1.37	
1658*170 R1	AAB-308-M	SB-06-C	0-2	3.45	
1658*170 R2	AAB-308-M	SB-06-C	0-2	4.06	16%
1658*171	AAB-309-M	SB-06-C	10-12	3.04	
1658*172	AAB-310-M	SB-06-C	20-22	2.73	
1658*173	AAB-311-M	SB-06-C	30-32	2.03	
1658*174	AAB-312-M	SB-06-C	40-42	1.77	
1658*175	AAB-313-M	SB-06-C	50-52	1.40	
1658*176	AAB-314-M	SB-06-C	60-62	1.38	
1658*177	AAB-315-M	SB-06-C	70-72	1.68	
1658*178	AAB-316-M	SB-06-C	80-82	1.19	
1658*179	AAB-317-M	SB-06-C	90-92	1.22	
1658*124	AAB-298-M	SB-12-C	0-2	3.13	
1658*125	AAB-299-M	SB-12-C	10-12	3.41	
1658*126	AAB-300-M	SB-12-C	20-22	1.68	
1658*127	AAB-301-M	SB-12-C	30-32	2.21	
1658*128	AAB-302-M	SB-12-C	40-42	1.82	
1658*129	AAB-303-M	SB-12-C	50-52	1.52	
1658*130	AAB-304-M	SB-12-C	60-62	1.57	
1658*122	AAB-305-M	SB-12-C	70-72	1.22	
1658*123	AAB-306-M	SB-12-C	80-82	1.25	
1658*131	AAB-307-M	SB-12-C	90-92	1.46	
1658*200	AAB-338-M	YC-68-C	0-2	2.28	
1658*201	AAB-339-M	YC-68-C	10-12	2.32	
1658*202	AAB-340-M	YC-68-C	20-22	2.20	
1658*203	AAB-341-M	YC-68-C	30-32	2.69	
1658*204	AAB-342-M	YC-68-C	40-42	1.21	
1658*205	AAB-343-M	YC-68-C	50-52	1.94	
1658*206	AAB-344-M	YC-68-C	60-62	1.44	

Table M-3. Cesium-137 Radioisotope Data

Battelle MSL Sample ID	Sponsor ID	Sample Descriptor	Depth (cm)	Activity Cs-137 (dpm/g)		RPD (%)
1658*180	AAB-318-M	IB-56-C	0-2	0.211		
1658*181	AAB-319-M	IB-56-C	10-12	0.320		
1658*182	AAB-320-M	IB-56-C	20-22	0.267		
1658*183	AAB-321-M	IB-56-C	30-32	0.192		
1658*184	AAB-322-M	IB-56-C	40-42	0.198		
1658*185	AAB-323-M	IB-56-C	50-52	0.224		
1658*186	AAB-324-M	IB-56-C	60-62	0.265		
1658*187	AAB-325-M	IB-56-C	70-72	0.218		
1658*188	AAB-326-M	IB-56-C	80-82	0.244		
1658*189	AAB-327-M	IB-56-C	90-92	0.105		
1658*112	AAB-288-M	PA-41-C	0-2	0.323		
1658*114	AAB-290-M	PA-41-C	10-12	0.130		
1658*113	AAB-289-M	PA-41-C	20-22	0.116		
1658*115	AAB-291-M	PA-41-C	30-32	0.426		
1658*116	AAB-292-M	PA-41-C	42-44	0.205		
1658*117	AAB-293-M	PA-41-C	50-52	0.151		
1658*118	AAB-294-M	PA-41-C	60-62	0.081		
1658*119	AAB-295-M	PA-41-C	70-72	0.121		
1658*120	AAB-296-M	PA-41-C	80-82	0.074	U	
1658*121	AAB-297-M	PA-41-C	90-92	0.063	U	
1658*190	AAB-328-M	SB-03-C	0-2	0.337		
1658*191	AAB-329-M	SB-03-C	10-12	0.428		
1658*192	AAB-330-M	SB-03-C	20-22	0.430		
1658*193	AAB-331-M	SB-03-C	30-32	0.343		
1658*194	AAB-332-M	SB-03-C	40-42	0.551		
1658*195	AAB-333-M	SB-03-C	50-52	0.136		
1658*196	AAB-334-M	SB-03-C	60-62	0.135	U	
1658*197	AAB-335-M	SB-03-C	70-72	0.107		
1658*198	AAB-336-M	SB-03-C	80-82	0.072	U	
1658*199	AAB-337-M	SB-03-C	90-92	0.083	U	
1658*170	AAB-308-M	SB-06-C	0-2	0.318		
1658*171	AAB-309-M	SB-06-C	10-12	0.437		
1658*172	AAB-310-M	SB-06-C	20-22	0.384		
1658*173	AAB-311-M	SB-06-C	30-32	0.319		
1658*174	AAB-312-M	SB-06-C	40-42	0.286		
1658*175	AAB-313-M	SB-06-C	50-52	0.095	U	
1658*176	AAB-314-M	SB-06-C	60-62	0.101	U	
1658*177	AAB-315-M	SB-06-C	70-72	0.089	U	
1658*178 R1	AAB-316-M	SB-06-C	80-82	0.074	U	
1658*178 R2	AAB-316-M	SB-06-C	80-82	0.072	U	NA
1658*179	AAB-317-M	SB-06-C	90-92	0.095	U	
1658*124	AAB-298-M	SB-12-C	0-2	0.273		
1658*125	AAB-299-M	SB-12-C	10-12	0.303		
1658*126	AAB-300-M	SB-12-C	20-22	0.335		
1658*127	AAB-301-M	SB-12-C	30-32	0.114		
1658*128	AAB-302-M	SB-12-C	40-42	0.133	U	
1658*129	AAB-303-M	SB-12-C	50-52	0.233	U	
1658*130	AAB-304-M	SB-12-C	60-62	0.100	U	
1658*122	AAB-305-M	SB-12-C	70-72	0.160		
1658*123	AAB-306-M	SB-12-C	80-82	0.103	U	
1658*131 R1	AAB-307-M	SB-12-C	90-92	0.158	U	
1658*131 R2	AAB-307-M	SB-12-C	90-92	0.088	U	NA
1658*200	AAB-338-M	YC-68-C	0-2	0.314		
1658*201	AAB-339-M	YC-68-C	10-12	0.457		
1658*202	AAB-340-M	YC-68-C	20-22	0.666		
1658*203 R1	AAB-341-M	YC-68-C	30-32	2.208		
1658*203 R2	AAB-341-M	YC-68-C	30-32	2.212		0%
1658*204	AAB-342-M	YC-68-C	40-42	1.071		
1658*205	AAB-343-M	YC-68-C	50-52	0.046	U	
1658*206	AAB-344-M	YC-68-C	60-62	0.068	U	
1658*207	AAB-345-M	YC-68-C	70-72	0.051	U	
1658*208	AAB-346-M	YC-68-C	80-82	0.054	U	

Table M-4. Sedimentation Rate Calculations

Core IB-56
Supported Pb-210 (dpm/g) = 1.20

Sedimentation Rate
S = 1.63 g/cm^2/yr

Chemistry Lab Sample ID	Sponsor Code	Sample Descriptor	Segment Depth (cm)	Mean Depth (cm)	Time-Corrected Pb-210 (dpm/g)	ln unsupported Pb-210	% Dry Weight	Sediment Age (Years)	Year	Sediment Accumulation Rate (cm/yr)
1658*180	AAB-318-M	IB-56-C	0-2	1	3.67	0.91	45.6	1	2000	1.317
1658*181	AAB-319-M	IB-56-C	10-12	11	3.73	0.93	45.3	2	1999	4.845
1658*182	AAB-320-M	IB-56-C	20-22	21	3.15	0.67	54.3	7	1994	2.983
1658*183	AAB-321-M	IB-56-C	30-32	31	2.96	0.56	57.8	12	1989	2.480
1658*184	AAB-322-M	IB-56-C	40-42	41	2.01	-0.21 x	56.7	19	1982	2.183
1658*185	AAB-323-M	IB-56-C	50-52	51	1.94	-0.29 x	57.8	25	1976	2.017
1658*186	AAB-324-M	IB-56-C	60-62	61	1.68	-0.74 x	55.6	32	1969	1.924
1658*187	AAB-325-M	IB-56-C	70-72	71	1.11	-- x	53.0	38	1963	1.869
1658*188	AAB-326-M	IB-56-C	80-82	81	1.01	-- x	57.3	44	1957	1.840
1658*189	AAB-327-M	IB-56-C	90-92	91	1.16	-- x	55.9	50	1951	1.814
									Average	2.327

x indicates samples considered background Pb-210

IB-56 Sedimentation Calculations
(based on lnPb-210)
R2 = 0.9274
M (slope) = -0.0191
S=-0.0311/slope in (g/cm2/yr)

S(background =1.2) = 1.63

Core PA-41 **Not calculable**
Supported Pb-210 (dpm/g) = 1.20

Sedimentation Rate
S = 1.20 g/cm^2/yr

Chemistry Lab Sample ID	Sponsor Code	Sample Descriptor	Segment Depth (cm)	Mean Depth (cm)	Time-Corrected Pb-210 (dpm/g)	ln unsupported Pb-210	% Dry Weight	Sediment Age (Years)	Year	Sediment Accumulation Rate (cm/yr)
1658*112 R2	AAB-288-M	PA-41-C	0-2	1	4.21	1.10	45.4	1	2000	0.973
1658*114	AAB-290-M	PA-41-C	10-12	11	1.87	-0.40 x	63.2	4	1997	2.907
1658*113	AAB-289-M	PA-41-C	20-22	21	1.80	-0.52 x	65.7	13	1988	1.677
1658*115	AAB-291-M	PA-41-C	30-32	31	2.22	0.02 x	45.8	23	1978	1.378
1658*116	AAB-292-M	PA-41-C	42-44	41	1.59	-0.95 x	49.1	31	1970	1.328
1658*117	AAB-293-M	PA-41-C	50-52	51	1.62	-0.86 x	48.5	38	1963	1.360
1658*118	AAB-294-M	PA-41-C	60-62	61	1.49	-1.22 x	58.6	45	1956	1.363
1658*119	AAB-295-M	PA-41-C	70-72	71	1.60	-0.91 x	47.4	53	1948	1.352
1658*120	AAB-296-M	PA-41-C	80-82	81	1.28	-2.54 x	52.9	60	1941	1.342
1658*121	AAB-297-M	PA-41-C	90-92	91	0.76	-- x	55.3	68	1933	1.343
									Average	1.502

x indicates samples considered background Pb-210

PA-41 Sedimentation Calculations
(based on lnPb210)
R2 = 0.1786
M (slope) = -0.0260
S = -0.0311/slope in (g/cm2/yr)

S (background = 1.2) = 1.20

Table M-4. Sedimentation Rate Calculations

Core SB-03 **Calculated with averages**
Supported Pb-210 (dpm/g) = 0.70

Sedimentation Rate
S = 0.72 g/cm^2/yr

Chemistry Lab Sample ID	Sponsor Code	Sample Descriptor	Segment Depth (cm)	Mean Depth (cm)	Time-Corrected Pb-210 (dpm/g)	ln unsupported Pb-210	% Dry Weight	Sediment Age (Years)	Year	Sediment Accumulation Rate (cm/yr)
1658*190 R2	AAB-328-M	SB-03-C	0-2	1	4.41	1.31	40.1	1	2000	0.526
1658*191	AAB-329-M	SB-03-C	10-12	11	3.15	0.90	44.6	5	1996	2.380
1658*192	AAB-330-M	SB-03-C	20-22	21	1.97	0.24	45.5	14	1987	1.486
1658*193	AAB-331-M	SB-03-C	30-32	31	1.95	0.23	48.8	24	1977	1.264
1658*194	AAB-332-M	SB-03-C	42-44	45.5	1.86	0.15	46.6	35	1966	1.159
1658*195	AAB-333-M	SB-03-C	50-52	65.5	1.59	-0.12 x	47.6	46	1955	1.098
1658*196	AAB-334-M	SB-03-C	60-62	86.5	1.41	-0.34 x	46.9	57	1944	1.065
									Average	1.283

x indicates samples considered background Pb-210

SB-03 Sedimentation Calculations
(based on lnPb-210)
R2 = 0.7681
M (slope) = -0.0433
S = -0.0311/slope in (g/cm2/yr)

S (background = 1.2) = 0.72

Core SB-06
Supported Pb-210 (dpm/g) = 1.30

Sedimentation Rate
S = 0.63 g/cm^2/yr

Chemistry Lab Sample ID	Sponsor Code	Sample Descriptor	Segment Depth (cm)	Mean Depth (cm)	Time-Corrected Pb-210 (dpm/g)	ln unsupported Pb-210	% Dry Weight	Sediment Age (Years)	Year	Sediment Accumulation Rate (cm/yr)
1658*170	AAB-308-M	SB-06-C	0-2	1	3.76	0.90	41.7	2	1999	0.584
1658*171	AAB-309-M	SB-06-C	10-12	11	3.04	0.55	44.3	5	1996	2.076
1658*172	AAB-310-M	SB-06-C	20-22	21	2.728	0.36	45.9	16	1985	1.293
1658*173	AAB-311-M	SB-06-C	30-32	31	2.029	-0.32 x	52.2	28	1973	1.097
1658*174	AAB-312-M	SB-06-C	40-42	41	1.770	-0.76 x	48.1	41	1960	0.992
1658*175	AAB-313-M	SB-06-C	50-52	51	1.404	-2.27 x	42.0	54	1947	0.938
1658*176	AAB-314-M	SB-06-C	60-62	61	1.379	-2.54 x	43.6	66	1935	0.927
1658*177	AAB-315-M	SB-06-C	70-72	71	1.685	-0.96 x	44.7	77	1924	0.927
1658*178	AAB-316-M	SB-06-C	80-82	81	1.186	-- x	45.3	88	1913	0.922
1658*179	AAB-317-M	SB-06-C	90-92	91	1.218	-- x	43.4	99	1902	0.917
									Average	1.067

x indicates samples considered background Pb-210

SB-06 Sedimentation Calculations
(based on lnPb-210)
R2 = 0.8745
M (slope) = -0.0491
S = -0.0311/slope in (g/cm2/yr)

S(background = 1.3) = 0.63

Table M-4. Sedimentation Rate Calculations

Core SB-12 **Calculated with averages**
Supported Pb-210 (dpm/g) = 0.80

Sedimentation Rate
S = 0.74 g/cm^2/yr

Chemistry Lab Sample ID	Sponsor Code	Sample Descriptor	Segment Depth (cm)	Mean Depth (cm)	Time-Corrected Pb-210 (dpm/g)	ln unsupported Pb-210	% Dry Weight	Sediment Age (Years)	Year	Sediment Accumulation Rate (cm/yr)
1658*124/5	AAB-298/9-M	SB-12-C	0-12	5.5	3.27	0.90	42.9	3	1998	0.327
1658*126/7	AAB-300/1-M	SB-12-C	20-32	26.5	1.95	0.14	52.0	16	1985	0.674
1658*128	AAB-302-M	SB-12-C	42-44	41	1.82	0.02	52.5	29	1972	0.721
1658*129	AAB-303-M	SB-12-C	50-52	51	1.52	-0.33 x	49.5	43	1958	0.714
1658*130	AAB-304-M	SB-12-C	60-62	61	1.57	-0.26 x	40.0	53	1948	0.778
1658*122	AAB-305-M	SB-12-C	70-72	71	1.22	-0.87 x	32.4	62	1939	0.823
1658*123	AAB-306-M	SB-12-C	80-82	81	1.25	-0.80 x	38.9	69	1932	0.880
1658*131	AAB-307-M	SB-12-C	90-92	91	1.46	-0.42 x	39.8	77	1924	0.928
									Average	0.731

x indicates samples considered background Pb-210

SB-12 Sedimentation Calculations
(based on lnPb-210)
R2 = 0.8851
M (slope) = -0.0421
S = -0.0311/slope in (g/cm2/yr)

S (background = 1.3) = 0.74

Core YC-68
Supported Pb-210 (dpm/g) = 0.70

Sedimentation Rate
S = 6.75 g/cm^2/yr

Chemistry Lab Sample ID	Sponsor Code	Sample Descriptor	Segment Depth (cm)	Mean Depth (cm)	Time-Corrected Pb-210 (dpm/g)	ln unsupported Pb-210	% Dry Weight	Sediment Age (Years)	Year	Sediment Accumulation Rate (cm/yr)
1658*200	AAB-338-M	YC-68-C	0-2	1	2.28	0.46	54.8	0	2001	4.114
1658*201	AAB-339-M	YC-68-C	10-12	11	2.32	0.49	52.2	1	2000	15.464
1658*202	AAB-340-M	YC-68-C	20-22	21	2.20	0.40	50.1	2	1999	10.032
1658*203	AAB-341-M	YC-68-C	30-32	31	2.69	0.69 x	44.0	3	1998	9.230
1658*204	AAB-342-M	YC-68-C	42-44	41	1.21	-0.67 x	50.5	5	1996	9.040
1658*205	AAB-343-M	YC-68-C	50-52	51	1.94	0.22 x	78.3	6	1995	8.571
1658*206	AAB-344-M	YC-68-C	60-62	61	1.44	-0.31 x	66.4	8	1993	7.690
1658*207	AAB-345-M	YC-68-C	70-72	71	0.82	-2.12 x	78.3	10	1991	6.877
1658*208	AAB-346-M	YC-68-C	80-82	81	0.61	-- x	76.7	13	1988	6.378
1658*209	AAB-347-M	YC-68-C	90-92	91	0.69	-- x	78.1	15	1986	5.936
									Average	8.333

x indicates samples considered background Pb-210

YB-68 Sedimentation Calculations
(based on lnPb-210)
R2 = 0.6314
M (slope) = -0.0046
S = -0.0311/slope in (g/cm2/yr)

S (background = 0.7) = 6.75

Table M-4. Sedimentation Rate Calculations

Core YB-69
Supported Pb-210 (dpm/g) = 1.20

Sedimentation Rate
S = 5.84 g/cm^2/yr

Chemistry Lab Sample ID	Sponsor Code	Sample Descriptor	Segment Depth (cm)	Mean Depth (cm)	Time-Corrected Pb-210 (dpm/g)	ln unsupported Pb-210		% Dry Weight	Sediment Age (Years)	Year	Sediment Accumulation Rate (cm/yr)
1658*210	AAB-348-M	YC-69-C	0-2	1	2.28	0.08		62.4	0	2001	2.883
1658*211	AAB-349-M	YC-69-C	10-12	11	2.32	0.12		63.2	1	2000	10.495
1658*212	AAB-350-M	YC-69-C	20-22	21	2.20	0.00		56.9	3	1998	6.775
1658*213	AAB-351-M	YC-69-C	30-32	31	2.69	0.40	x	52.2	5	1996	6.210
1658*214	AAB-352-M	YC-69-C	42-44	41	1.21	-4.50	x	61.0	7	1994	6.098
1658*215	AAB-353-M	YC-69-C	50-52	51	1.94	-0.30	x	56.4	9	1992	5.997
1658*216	AAB-354-M	YC-69-C	60-62	61	1.44	-1.45	x	57.2	10	1991	5.879
1658*217	AAB-355-M	YC-69-C	70-72	71	0.82	--	x	51.4	12	1989	5.859
1658*218	AAB-356-M	YC-69-C	80-82	81	0.61	--	x	50.8	14	1987	5.888
1658*219 R1	AAB-357-M	YC-69-C	90-92	91	0.69	--	x	62.6	15	1986	5.923
										Average	6.201

x indicates samples considered background Pb-210

YB-69 Sedimentation Calculations
(based on lnPb-210)
R2 = 0.6383
M (slope) = -0.0053
S = -0.0311/slope in (g/cm2/yr)

S (background = 1.2) = 5.84

Table M-5. Comparison of Core Dates Based on ^{210}Pb and ^{137}Cs Data

Station	Depth Corresponding to ~1945 from ^{210}Pb Dating (cm)	Depth Corresponding to ~1952 from First Appearance of ^{137}Cs (cm)
IB-56	>91	>91
PA-41	76	71
SB-03	87	71
SB-06	53	41
SB-12	64	71
YC-68	>91	41
YC-69	>91	41

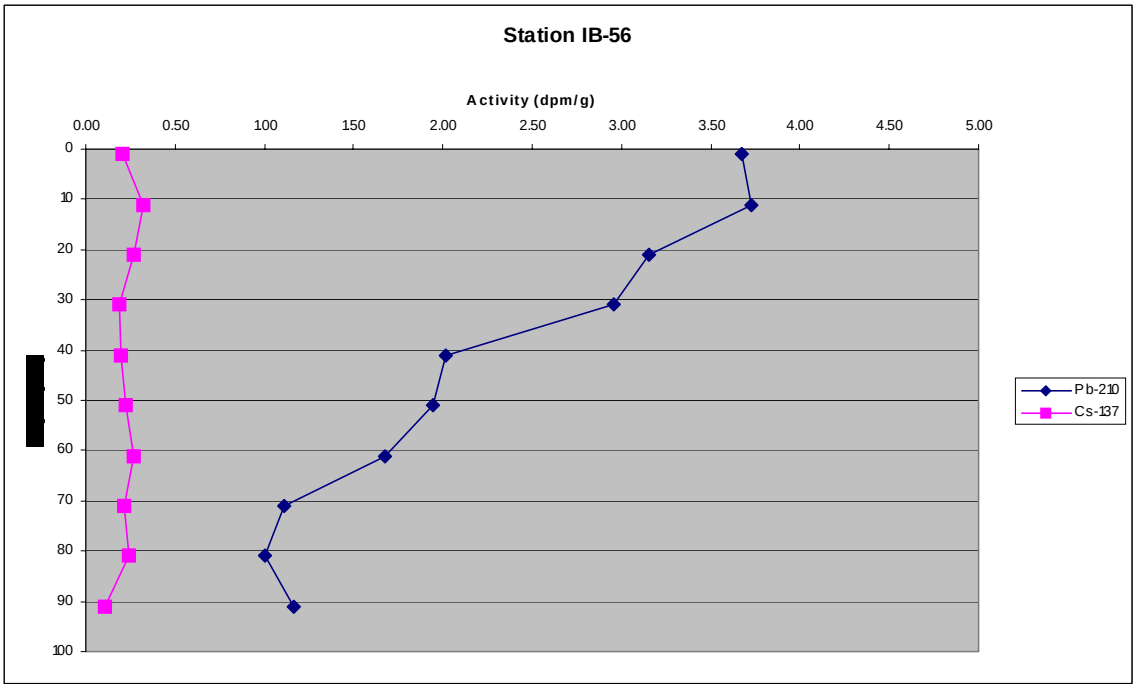

Figure M-1. ^{210}Pb and ^{137}Cs Activity in Core IB-56, Area I

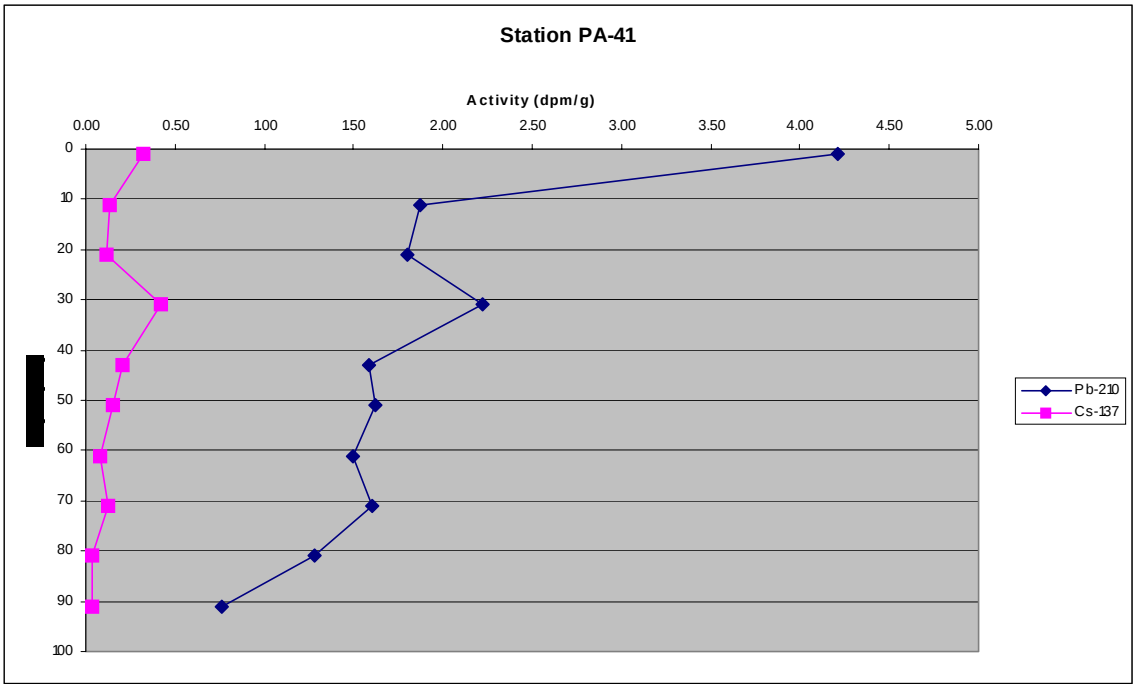

Figure M-2. ^{210}Pb and ^{137}Cs Activity in Core PA-41, Area III

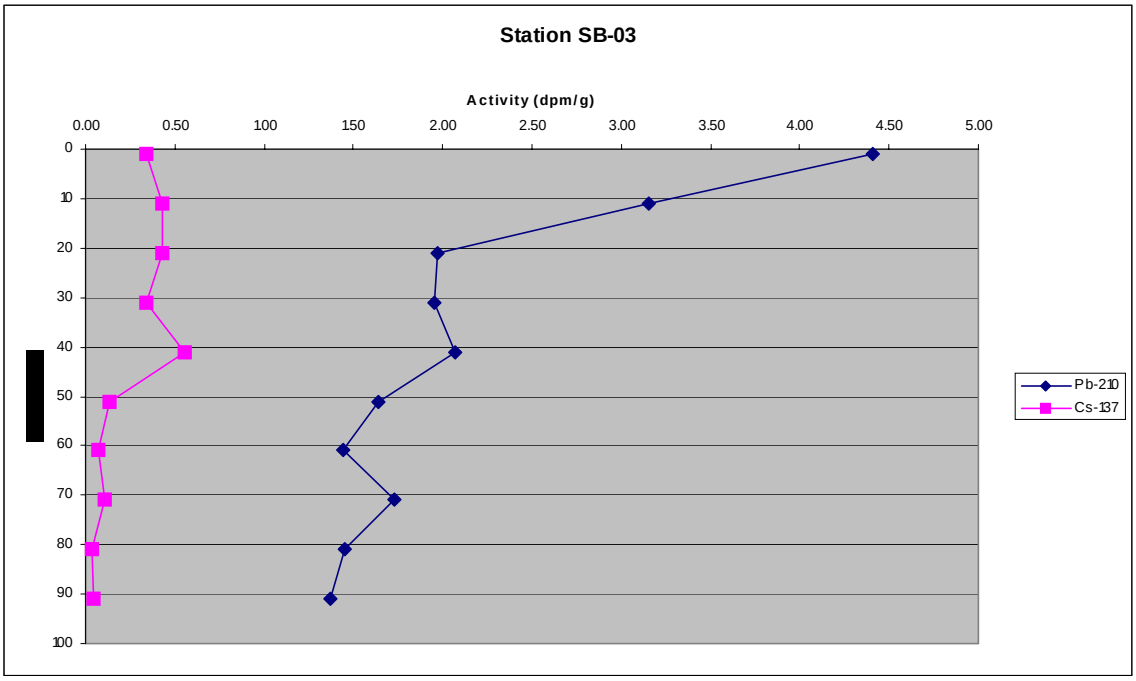

Figure M-3. ^{210}Pb and ^{137}Cs Activity in Core SB-03, Area X

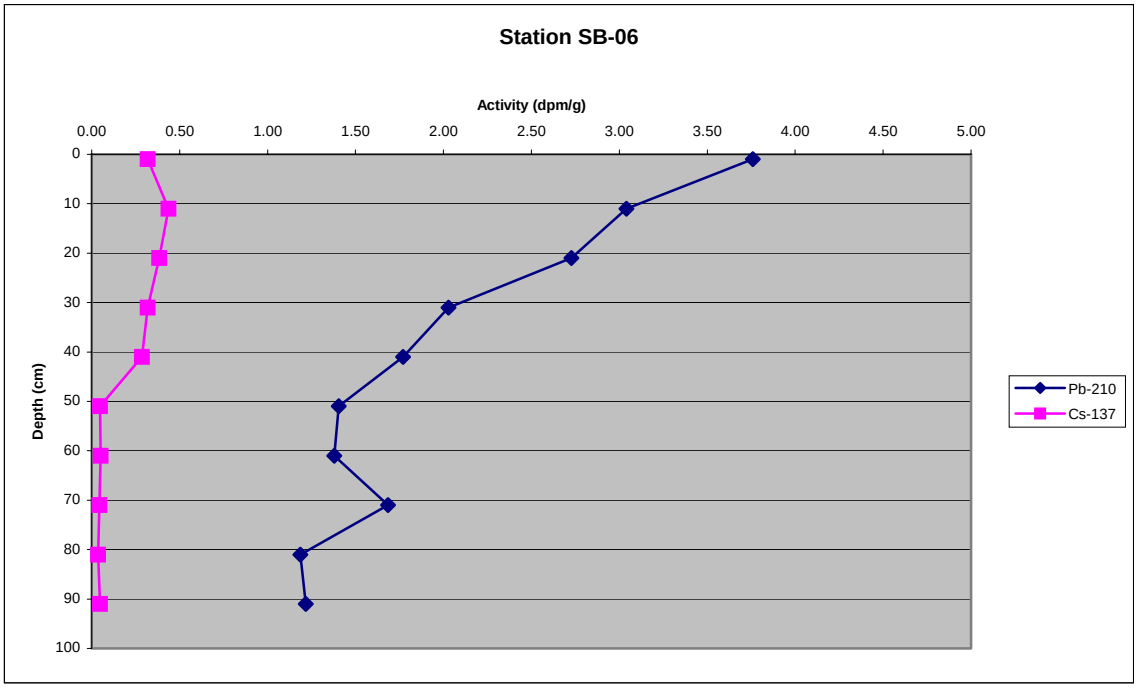

Figure M-4. ^{210}Pb and ^{137}Cs Activity in Core SB-06, Area X

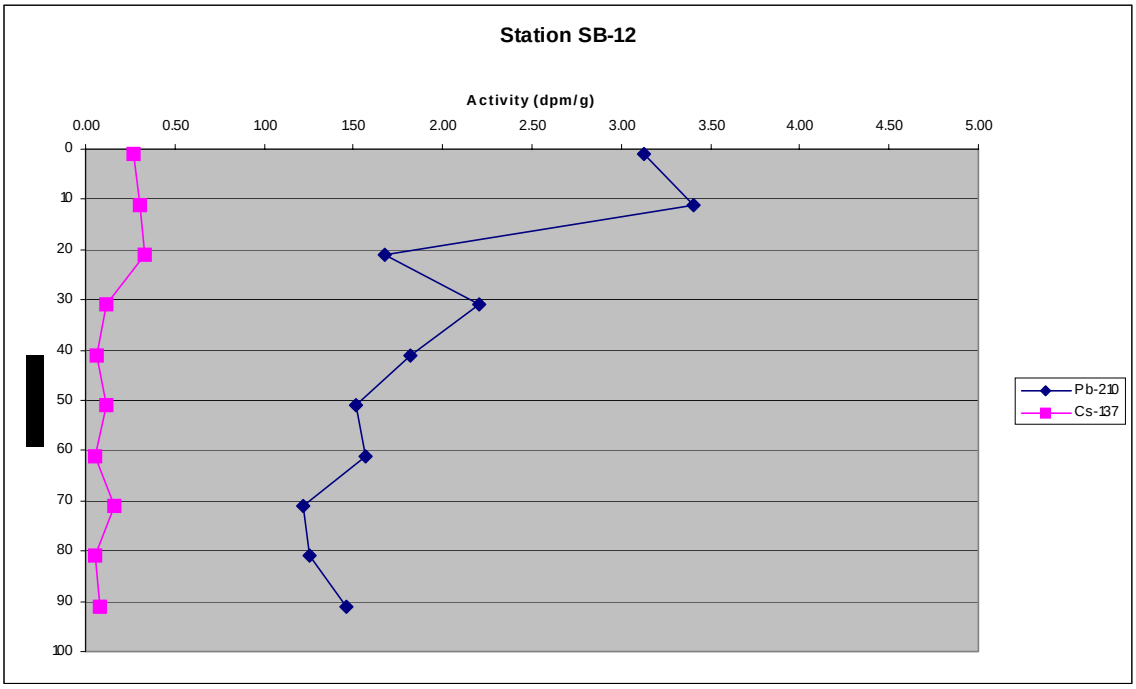

Figure M-5. ^{210}Pb and ^{137}Cs Activity in Core SB-12, Area X

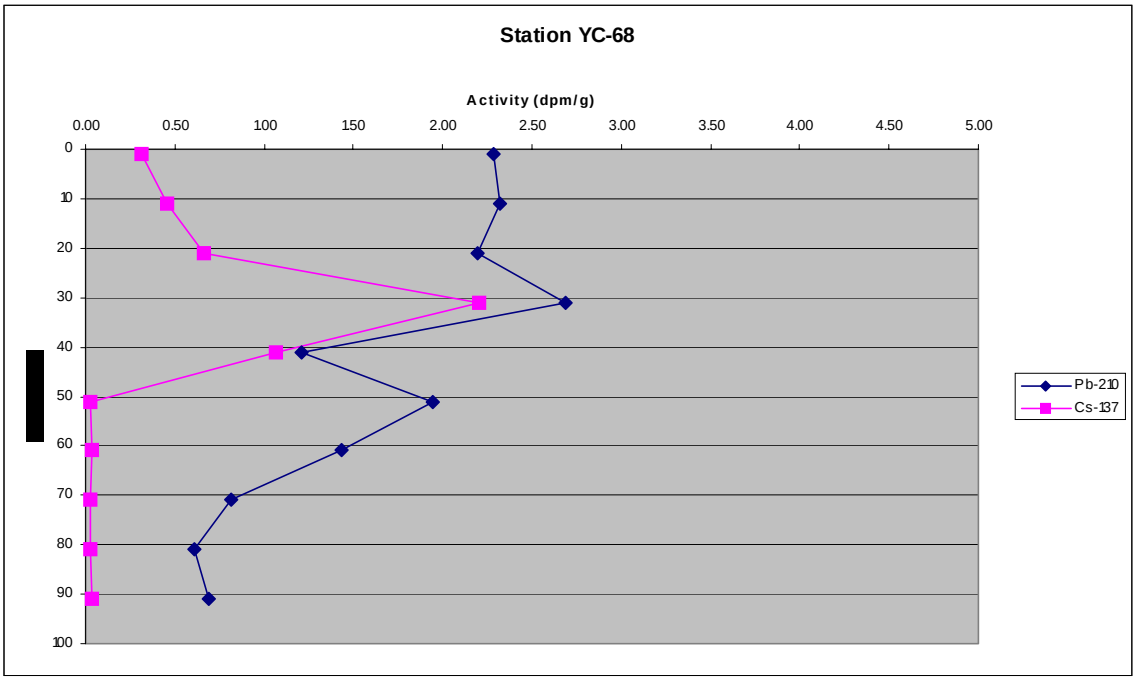

Figure M-6. ^{210}Pb and ^{137}Cs Activity in Core YC-68, Yosemite Creek

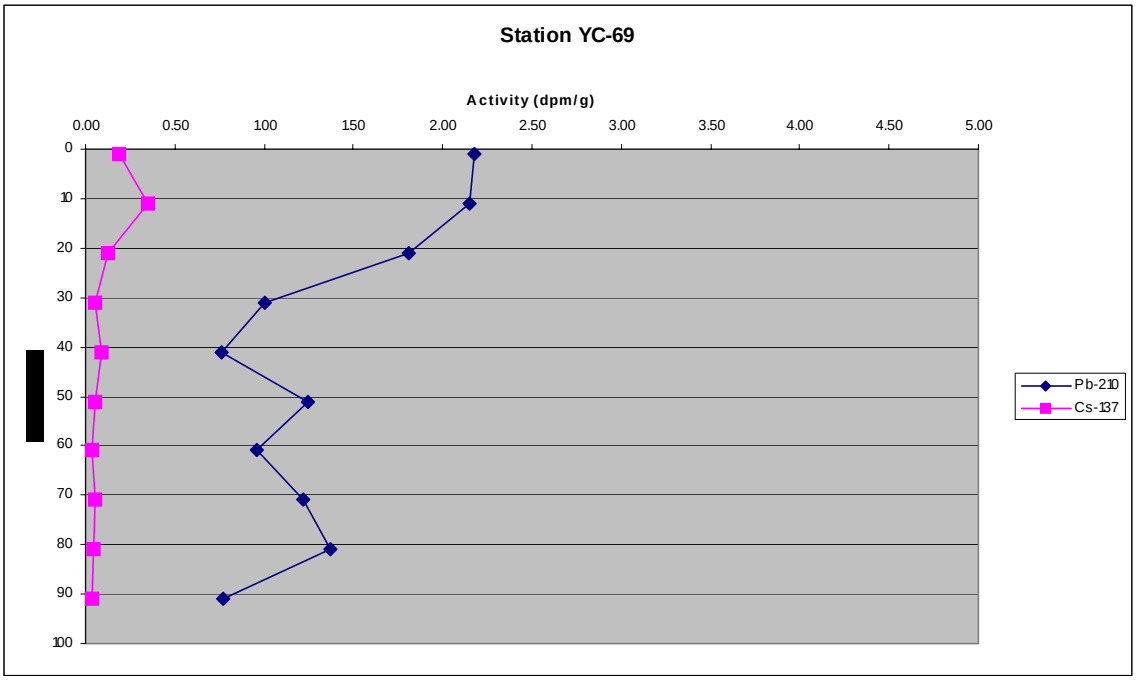

Figure M-7. ^{210}Pb and ^{137}Cs Activity in Core YC-69, Yosemite Creek

APPENDIX N

Physical and Chemical Sediment Characterization

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ATTACHMENT N-1

Appendix N. Physical and Chemical Sediment Characterization

Physical and chemical data needed to evaluate the potential effectiveness of various remedial technologies were collected during the Validation Study to support the feasibility study (FS) of offshore sediments. DQOs for the FS-related sediment characterization are provided in Table 2-14 of the main document. The FS-related characterization focused on Area III (Point Avisadero) and Area X (South Basin), which were considered to be the areas most likely to require remediation based on sediment screening data collected as part of the VS Work Plan (Battelle et al., 2001).

N.1 EVALUATION OF UPLAND DISPOSAL AND BENEFICIAL REUSE OPTIONS

Chemical concentrations were measured in sediment samples from Station PA-40 in Area III (Point Avisadero; see Figure 3-2) and Stations SB-20 and SB-22 in Area X (South Basin; see Figure 3-5) to evaluate upland disposal and beneficial reuse options. Sediment core samples from these three stations were analyzed for chemical contaminants and Toxicity Characteristic Leaching Procedure (TCLP) extract concentrations (see Table 3-2).

Hazardous waste determinations were conducted in accordance with Title 22, Division 4.5, Chapter 11 of the California Code of Regulations (CCR). In order to determine if the sediment would be classified as hazardous, chemical concentrations in sediment were compared to Total Threshold Limit Concentration (TTLC) Values (Table N-1), and TCLP concentrations were compared to TCLP limits (Table N-2). These comparisons indicate that the sediments in the vicinity of Stations PA-40, SB-20, and SB-22 are nonhazardous. All chemical concentrations were below CCR limits.

Chemical concentrations in sediment also were compared with beneficial reuse guidelines (San Francisco Bay Regional Water Quality Control Board [RWQCB], 2000) to evaluate potential reuse options. These remediation options included sediment reuse as a wetland surface material (Table N-3), and as a wetland foundation material, levee construction material, and construction fill (Table N-4). Based on this comparison, it is unlikely that sediment from these stations would be suitable for beneficial reuse. Concentrations of numerous metals and organic compounds exceeded reuse guidelines for wetland surface material, and several metals and PCBs in the samples from South Basin exceeded the guidelines for reuse as wetland foundation material or levee and construction fill (as previously noted, sediment from the vicinity of Station PA-40 in Area III will not be included in the FS footprint).

N.2 TREATABILITY TESTING

Composite sediment samples for treatability testing were collected from selected stations in Areas III and X. In Area III, Sample PA-00-TC was collected at and between Stations PA-38 and PA-39 (see Figure 3-2). In Area X, Sample SB-00-TC was collected from Stations SB-17, SB-18, SB-19, SB-20, SB-21, SB-22, and SB-23 (see Figure 3-5). These samples were sent to STS Consultants Ltd., of Vernon Hills, IL for determination of sediment dewatering and stabilization characteristics.

Treatability testing included the following:

- Evaluation of the effectiveness of three dewatering procedures;
- Physical characterization including grain-size analysis and Atterberg Limits testing; and
- Evaluation of the effectiveness of two stabilization amendments intended to increase load-bearing capacity: high calcium hydrated lime and power plant-generated fly ash.

Complete results are presented in the *Laboratory Testing Program for the Sediment Characterization, Parcel F, Hunters Point Shipyard Validation Study - STS Project No. 32037* (STS, 2001), and are summarized in the following two subsections.

N.2.1 Dewatering Characteristics

The dewatering properties of each sediment sample were evaluated using three techniques: air-drying, plate and frame compression, and centrifugation. Air drying consisted of placing a portion of each sediment sample in a mound on a nonabsorbent surface with a minimal amount of surface area exposed and left to air dry for five days. The moisture content was determined at 24-hour intervals. Plate and frame compression consisted of placing a portion of each sediment sample into a 4-inch-diameter rigid ring. Five separate axial loads (0.13, 0.25, 0.50, 1.00, and 2.00 TSF) were applied and maintained for a maximum of 24 hours. Porewater was allowed to drain, and was collected from both the top and bottom of the tested sample. The moisture content of the sample was calculated at the conclusion of each 24-hour interval. Centrifugation dewatering consisted of placing a portion of each sample in a centrifuge that was operated at a rotational speed of 1,400 rpm. The moisture content was measured at 15-minute intervals for one hour.

Results of the dewatering tests are presented in Figures N-1 and N-2. The tests indicated that the air drying and compression dewatering methods yielded similar results. The centrifuge dewatering method was the least effective of the three dewatering tests performed.

N.2.2 Physical Characteristics

The sediment samples were classified according to particle size using the Unified Soil Classification System (USCS). Samples also were tested for moisture content, organic content, maximum dry density, and plasticity characteristics. Testing methods and results are presented in Table N-5. The sediment from Area III (sample PA-00-TC) was determined to be an organic silty clay with trace fine-coarse sand. The sediment from Area X (sample SB-00-TC) was determined to be a clayey fine-coarse sand with some silt and trace fine gravel. The sample from Area X had a lower organic content, higher maximum density, and lower Atterberg Limits than the sample from Area III, which is consistent with its sandier composition.

N.2.3 Sediment Stabilization

Either fly ash or a high calcium hydrated lime was mixed with each of the sediment samples in 3, 5, and 7 percent of the dry weight of sediment, according to ASTM D 5102. The blended samples then were compacted in a split cylindrical mold to a density of 95 percent of the maximum standard Proctor compaction value and at optimum moisture as determined by ASTM D 698. The blended, compacted samples then were allowed to cure in an airtight moisture-proof container for a minimum of seven days before testing.

Consolidated Undrained Compression Tests (ASTM D 4767) and Unconfined Compressive Strength Tests (ASTM D 5102) were performed after compaction and curing of the blended samples. Cohesion and friction angle values as well as strength parameters were obtained from this testing. A California Bearing Ratio (CBR) test (ASTM D 1883) was performed on the 5 percent blends of each sample. Complete laboratory test results are provided in STS (2001) and are summarized in Attachment N-1.

The results of the stabilization amendment testing indicated a slight increase in soil strength properties for sample PA-00-TC, the organic silty clay, with the addition of either fly ash or high calcium hydrated lime.

The fly ash appeared to be slightly more effective at strengthening soil than the high calcium hydrated lime. Overall, both the power plant-generated fly ash and the high calcium hydrated lime seemed to have the most benefit at 5 percent of the dry weight of sediment. Both amendments appeared to have less of an effect on sample SB-00-TC, the clayey fine-coarse sand. When compacted, both samples exhibited only moderate strength. Therefore, the materials could be most effectively used in landscaping fills or other nonloaded or lightly-loaded sub-grade applications with relatively flat, if any, exposed side slopes. The strengths of the modified materials are not sufficient for use under high-traffic roadway pavements or in structural fills, where a high degree of stability or strength is required.

N.3 REFERENCES

San Francisco Bay Regional Water Quality Control Board (RWQCB). 2000. *Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines, Draft Staff Report*. May.

STS Consultants, Ltd. 2001. *Laboratory Testing Program for the Sediment Characterization, Parcel F Hunters Point Shipyard Validation Study - STS Project No. 32037*. November 8.

Table N-1. Comparison of Sediment Chemical Concentrations with TTLC1 values

Parameter	TTLC (mg/kg wet wt)	Concentration in mg/kg wet weight					
		PA-40 0-2'	PA-40 2-4'	SB-20 0-2'	SB-20 2-4'	SB-22 0-2'	SB-22 2-4'
Hg	20	0.27	0.31	0.8	0.7	0.5	0.3
Pb	1000	87.1	422	147.6	70.5	63.2	40.9
Mo	3500	5.0	2.6	1.5	1.3	1.2	0.9
Sb	500	2.6	1.2	4.3	1.4	2.0	0.9
As	500	12.2	9.1	7.0	6.2	7.6	6.6
Cd	100	0.16 J	0.30 J	1.7	1.2	0.9	0.9
Co	8000	10.7	16.7	9.4	7.7	9.5	8.6
V	2400	57.8	55.6	73.8	69.7	77.9	75.2
Ni	2000	65.8	161	64.4	50.8	62.2	53.8
Ba	10000	683	457	240	195	220	192
Cr[3]	500	267	661	277	236	165	148
Cu	2500	356	236	113	63.1	76.0	33.7
Zn	5000	309	155	218	181	131	91.8
Ag	500	0.25	0.27	0.56	0.55	0.33	0.22
Se	100	0.15 J	0.11 J	0.44 J	0.28 J	0.26 J	0.21 J
Total PCBs	50	0.0730	0.0880	2.2	0.216	0.611	0.062
a-Chlordane	2.5	0.0000 U	0.0000 U	0.0016	0.0000 U	0.0004 J	0.0000 U
g-Chlordane	2.5	0.0000 U	0.0000 U	0.0044	0.0000 U	0.0015	0.0000 U
Dieldrin	8	0.0000 U	0.0000 U	0.0007	0.0000 U	0.0023	0.0000 U
Endrin	0.2	0.0000 U	0.0000 U	0.0000 U	0.0000 U	0.0000 U	0.0000 U
Heptachlor	4.7	0.0000 U	0.0000 U	0.0000 U	0.0000 U	0.0000 U	0.0000 U
Total DDx	1.0	0.001	0.001	0.016	0.008	0.011	0.0002

[1]Total Threshold Limit Concentration Values from California Code of Regulations, Title 22, Division 4.5, Chapter 11, p. 1800.77

[2]TTLC for Chromium (III)

U = The value was less than the instrument detection limit or the analyte was not detected.

J = Estimated value.

Table N-2. Toxicity Characteristic Leaching Procedure (TCLP) Concentrations

Chemical	Reporting Limit[1]	Station and Depth					
		PA-40 0-2 ft	PA-40 2-4 ft	SB-20 0-2 ft	SB-20 2-4 ft	SB-22 0-2 ft	SB-22 2-4 ft
Arsenic (mg/L)	**5.0**	0.013	0.0087	0.025	0.012	0.017	0.017
Barium (mg/L)	**100.0**	0.57	0.52	0.77	0.82	0.74	0.85
Cadmium (mg/L)	**1.0**	0.0022	0.0022	0.0005	0.0005	0.0005	0.0005
Chromium (mg/L)	**5.0**	0.01	0.0097	0.027	0.035	0.016	0.018
Lead (mg/L)	**5.0**	0.043	0.2	0.018	0.0056	0.0082	0.0042
Selenium (mg/L)	**1.0**	0.015	0.013	0.011	0.0098	0.013	0.013
Silver (mg/L)	**5.0**	0.001	0.001	0.001	0.001	0.001	0.001
Mercury (mg/L)	**0.2**	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

[1] Reporting Limits from California Code of Regulations, Title 22, Division 4.5, Chapter 11, Table 1

Table N-3. Analysis for Sediment Reuse as Wetland Surface Material

Chemical	Wetland Surface Reuse Guideline[1] <40% fines	PA-40		Wetland Surface Reuse Guideline[1] <100% fines	SB-20		SB-22	
		0-2 ft	2-4 ft		0-2 ft	2-4 ft	0-2 ft	2-4 ft
Metals (mg/kg)								
Hg	0.25	**0.369**	**0.433**	0.43	**1.64**	**1.59**	**1.1**	**0.635**
Pb	20.3	**120**	**583**	43.2	**316**	**172**	**133**	**93.5**
As	13.5	**16.8**	**12.6**	15.3	**14.9**	**15.2**	**15.9**	**15.1**
Cd	0.25	**0.226**	**0.412**	0.33	**3.74**	**3.03**	**1.8**	**2.05**
Ni	92.9	**90.6**	**223**	112	**138**	**124**	**131**	**123**
Cr	91.4	**368**	**913**	112	**593**	**576**	**348**	**338**
Cu	31.7	**490**	**326**	68.1	**242**	**154**	**160**	**77.1**
Zn	97.8	**425**	**214**	158	**467**	**441**	**275**	**210**
Ag	0.31	**0.341**	**0.369**	0.58	**1.19**	**1.35**	**0.689**	**0.493**
Se	0.59	**0.201**	**0.155**	0.64	**0.935**	**0.678**	**0.556**	**0.47**
Organics (ug/kg)								
Total PCBs[3]	22.7	**101**	**122**	22.7	**4877**	**537**	**1332**	**144**
Chlordane"[2]	2.26	0.10	0.10	2.26	**13.1**	0.18	**4.06**	0.17
Dieldrin[2]	0.715	0.06	0.06	0.715	**1.49**	0.12	**4.94**	0.11
Endrin	0.31	0.06	0.06	0.78	0.09	0.11	0.09	0.10
DDT, DDE, DDD	2.8	1.79	1.58	7	**35.2**	**21.1**	**22.8**	1.05
Anthracene	9.3	**41.4**	**71.4**	88	**91.5**	**91.9**	35.9	24.5
Pyrene	64.6	**369**	**286**	665	**885**	**728**	**782**	394
Benzo(ghi)perylene	22.9	**143**	**133**	310	**498**	**445**	**469**	264
Indeno(123-cd)pyrene	19	**153**	**134**	382	**443**	**394**	**409**	230
Benzo(b)fluoranthene	32.1	**165**	**154**	371	**385**	310	308	154
Fluoranthene	78.7	**310**	**171**	514	500	505	302	214
Benzo(k)fluoranthene	29.2	**173**	**148**	258	**370**	254	**295**	132
Acenaphthylene	11.3	4.69	4.86	26.6	**28.5**	21.2	22.0	10.9
Chrysene	19.4	**176**	**192**	289	**362**	**348**	243	110
Benzo(a)pyrene	18.1	**207**	**178**	412	**529**	409	**491**	228
Dibenz(ah)anthracene	3	**30.2**	**26.1**	32.7	**78.8**	**52.0**	**57.3**	20.8
Benzo(a)anthracene	15.9	**163**	**108**	244	**278**	209.40	221.55	85.7
Acenaphthene	2.2	**13.8**	**9.4**	31.7	13.79	30.89	5.94	6.24
Phenanthrene	17.8	**163**	**90.9**	237	169.99	230.44	84.62	60.7
Fluorene	4	**17.5**	**9.4**	25.3	25.24	**40.0**	9.82	8.94
Naphthalene	8.8	**9.9**	**10.4**	55.8	**145**	**282**	**62.7**	33.7
2-Methyl naphthalene	9.4	5.9	5.6	19.4	**57.2**	**36.3**	**22.7**	8.07
Total PAHs[4]	211	**1511**	**1163**	3390	1947	3164	2342	1205
Total high molecular wt PAHs	256	**1255**	**961**	3060	1666	2632	2098	1052
Total low molecular wt PAHs	37.9	**256**	**202**	434	281	**532**	244	153

[1] These concentrations are all ambient values (RWQCB, 2000) unless otherwise indicated.
[2] ER-L value (Long et al., 1995)
[3] TEL value (Florida Department of Environmental Protection, 1994)
[4] Includes 7 PAHs that weren't tested for the Validation Study (1-methylnaphthalene, 1-methylphenanthrene, 2,3,5-trimethylnapthalene, 2,6 -dimethylnaphthalene, 2-methylphenanthrene, benzo(e)pyrene, biphenyl, and perylene)

Bolded values exceed guideline.

Table N-4. Analysis for Sediment Reuse as Wetland Foundation Material or Levee and Construction Fill

Chemical	Wetland Foundation, Levee and Construction Fill Reuse Guideline[1]	PA-40		SB-20		SB-22	
		0-2 ft	2-4 ft	0-2 ft	2-4 ft	0-2 ft	2-4 ft
Metals (mg/kg)							
Hg	0.71	0.369	0.433	**1.64**	**1.59**	**1.1**	0.635
Pb	218	120	**583**	**316**	172	133	93.5
As	70	16.8	12.6	14.9	15.2	15.9	15.1
Cd	9.6	0.226	0.412	3.74	3.03	1.8	2.05
Ni	51.6	**90.6**	**223**	**138**	**124**	**131**	**123**
Cr	370	368	**913**	**593**	**576**	348	338
Cu	270	**490**	**326**	242	154	160	77.1
Zn	410	**425**	214	**467**	**441**	275	210
Ag	3.7	0.341	0.369	1.19	1.35	0.689	0.493
Organics (ug/kg)							
Total PCBs	180	101	122	**4877**	**537**	**1332**	**144**
2,4'-DDE	27	0.09	0.09	0.14	0.16	0.14	0.15
Chlordane[2]	4.79	0.1	0.1	**13.1**	0.18	4.06	0.17
Dieldrin[2]	4.3	0.06	0.06	1.49	0.12	**4.94**	0.11
4,4'-DDE	27	0.7	0.52	5.4	10.55	16.68	0.42
Total DDX	46.1	1.79	1.58	35.19	21.12	22.83	1.05
Anthracene	1100	41.41	71.40	91.55	91.91	35.92	24.45
Fluoranthene	5100	309.92	170.86	499.60	504.59	301.95	213.81
Acenaphthylene	640	4.69	4.86	28.53	21.23	22.00	10.90
Chrysene	2800	175.70	192.31	361.55	347.61	243.23	109.87
Benzo(a)pyrene	1600	207.45	177.99	528.52	409.43	491.50	228.22
Dibenz(ah)anthracene	260	30.19	26.11	78.81	51.98	57.30	20.81
Benzo(a)anthracene	1600	162.76	108.46	278.18	209.40	221.55	85.74
Acenaphthene	500	13.83	9.36	13.79	30.89	5.94	6.24
Phenanthrene	1500	162.59	90.91	169.99	230.44	84.62	60.73
Fluorene	540	17.48	9.37	25.24	40.03	9.82	8.94
Naphthalene	2100	9.87	10.45	145.34	281.90	62.71	33.65
2-Methyl naphthalene	670	5.85	5.58	57.20	36.34	22.73	8.07
Total PAHs	44792	1511	1163	1947	3164	2342	1205
Total high molecular wt PAHs	9600	1255	961	1666	2632	2098	1052
Total low molecular wt PAHs	3160	256	202	281	532	244	153

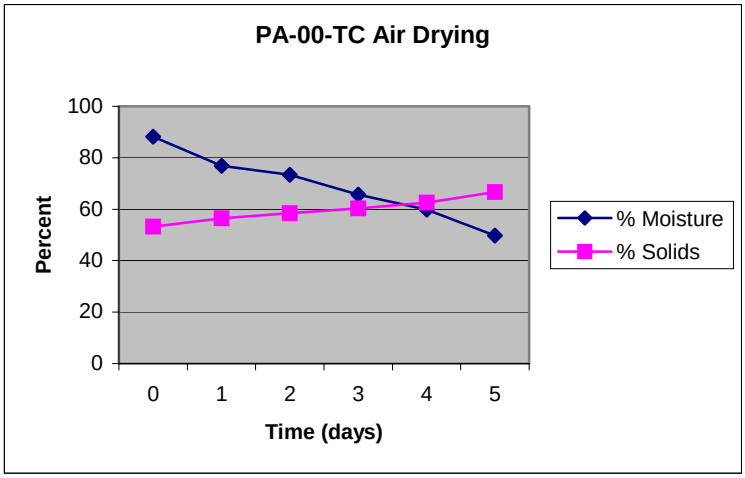
[1] RWQCB, 2000; these concentrations are ER-M values unless marked otherwise (Long et al., 1995)

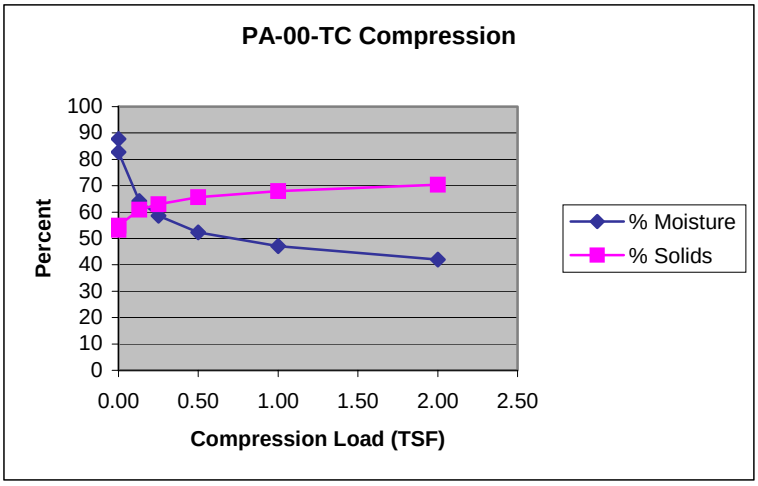
[2] PEL value (Florida Department of Environmental Protection, 1994)

Bolded values exceed guideline.

Table N-5. Sediment Physical Characteristics

Parameter	ASTM Method	PA-00-TC	SB-00-TC
Grain Size Distribution	D422		
% gravel		0.2	0.5
% sand		6.0	59.3
% silt		53.4	19.5
% clay		40.4	20.7
Organic content (%)	D2974	2.62	1.83
Moisture content (%)	D2216	84.95	47.13
Maximum dry density (pcf)	D698-91A	94	113
Plasticity (Atterberg Limits)	D4318		
Plasticity Index		25	13
Liquid limit		53	33
Plastic limit		28	20





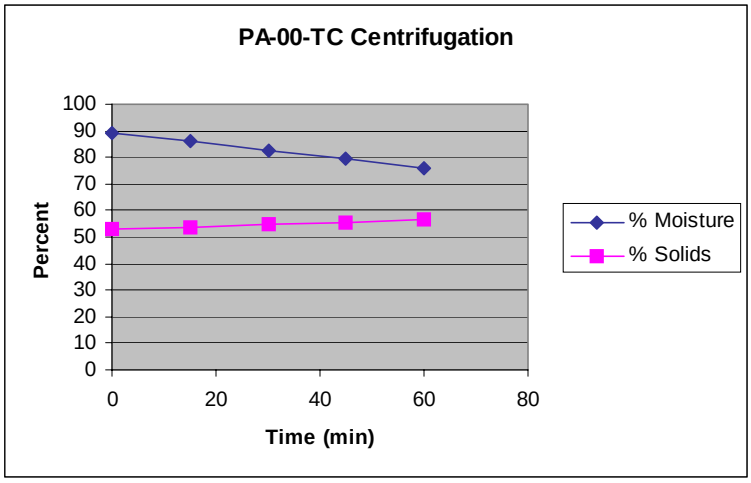
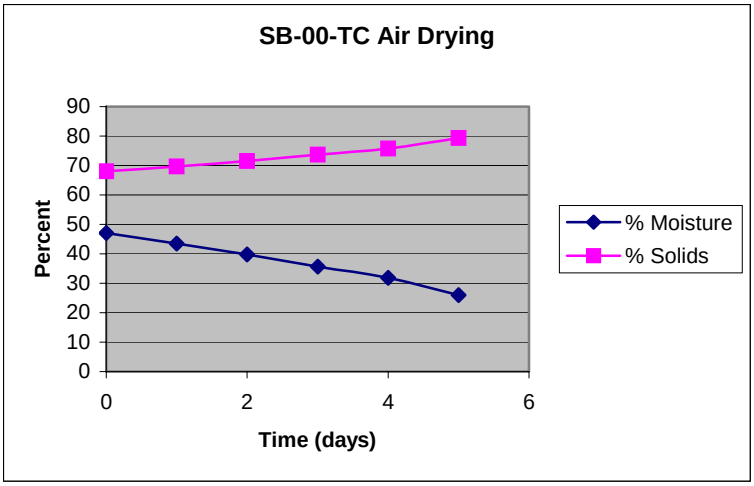
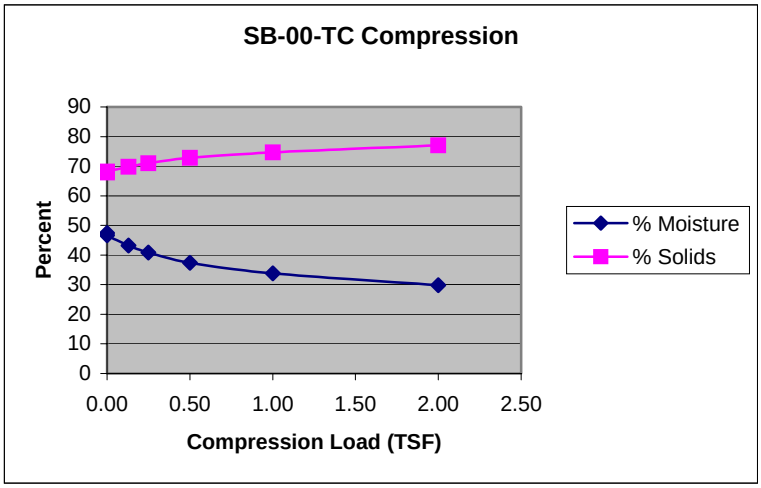


Figure N-1. Dewatering Test Results for PA-00-TC





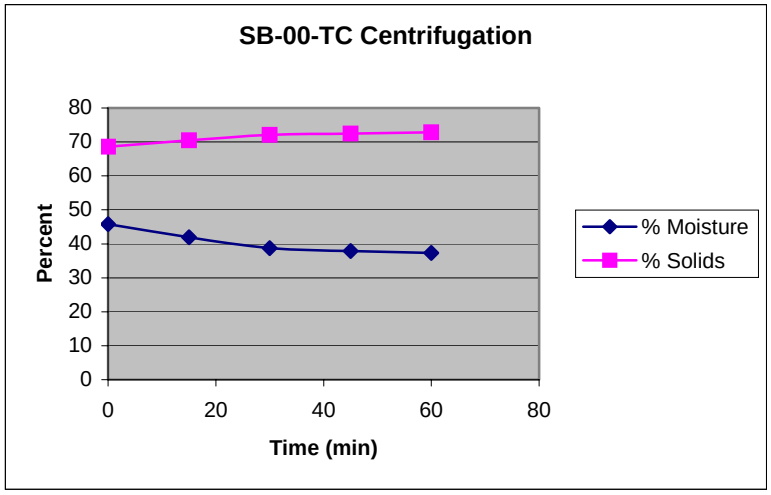


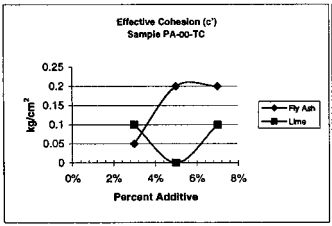
Figure N-2. Dewatering Test Results for SB-00-TC

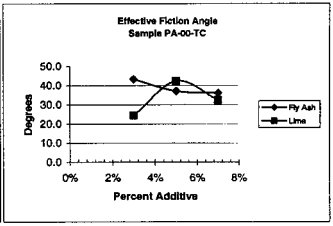
Attachment N-1

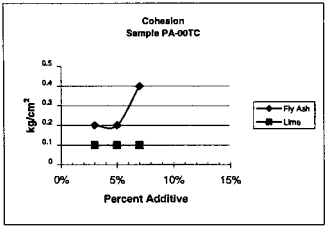
STS Consultants Ltd.
Consulting Engineers
Laboratory Services Group *750 Corporate Woods Parkway Vernon Hills, Illinois 60061* *Phone: (847) 279-2500 Fax: (847) 279-2550*

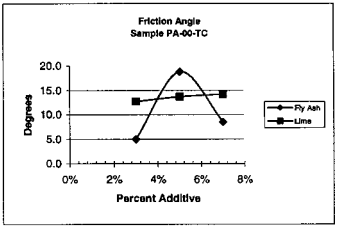
STS Project No. **32037**
Project Name: **HUNTERS POINT SHIPYARD**
Client Name: **BATTELLE**

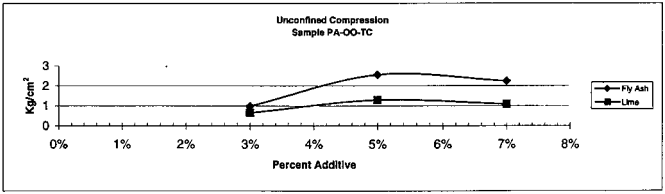
Summary of Sample PA-00-TC Strength Data











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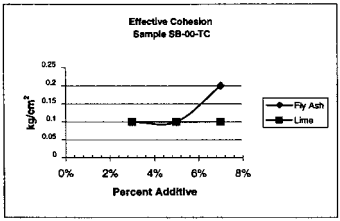
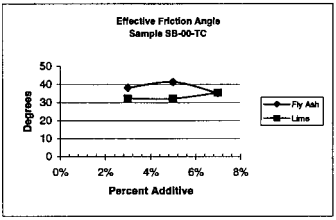
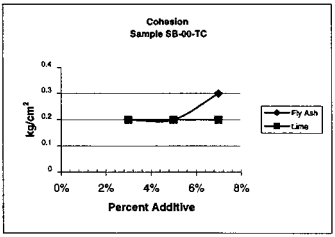
Laboratory Services Group *750 Corporate Woods Parkway Vernon Hills, Illinois 60061* *Phone: (847) 279-2500 Fax: (847) 279-2550*

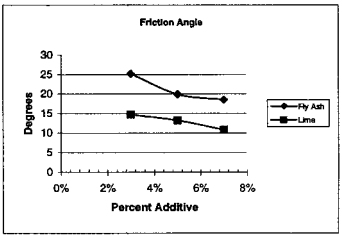
STS Project No. **32037**
Project Name: **HUNTERS POINT SHIPYARD**
Client Name: **BATTELLE**

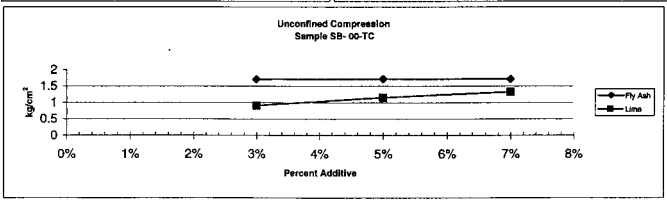
Summary of Sample SB-00-TC Strength Data











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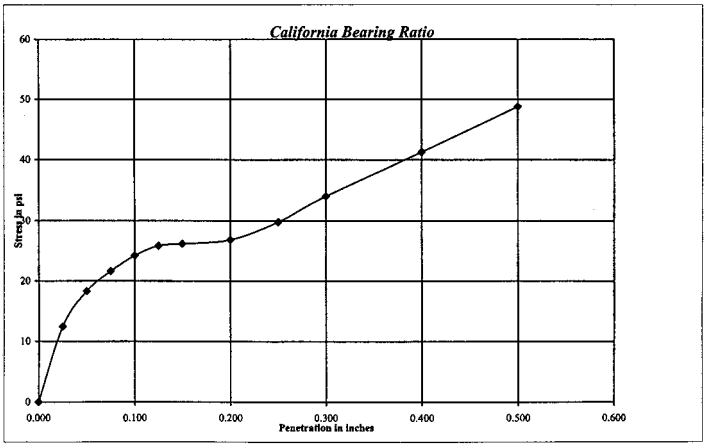
California Bearing Ratio

ASTM D-1883

STS Project No.	32037		10/30/2001
Project Name	HUNTERS POINT SHIPYARD		
Client Name	BATTELLE		
Boring/Source:		Max. Dry Density (pcf):	94.0
Sample No.:	PA-OO-TC (5% FLY ASH)	Optimum Moisture (%):	24.0
Depth (ft.):		Method of Compaction:	ASTM D 698
Description:	ORGANIC SILTY CLAY TRACE F-C SAND - DK.GRAY	Surcharge (lb):	10

% COMPACTION	95%	Percent Swell 95%
Initial Dry Density (pcf):	89.3	0.3
Initial Moisture (%):	26.7	

	95%	CBR Data 95%
Final Dry Density (pcf):	89.0	@ 0.1": 2.42
Final Moisture (%):	34.4	@ 0.2": 1.79



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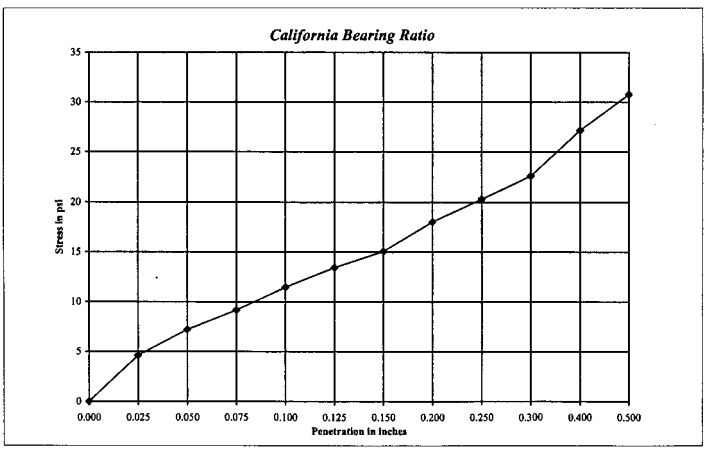
California Bearing Ratio

ASTM D-1883

STS Project No.	32037		10/30/2001
Project Name	HUNTERS POINT SHIPYARD		
Client Name	BATTELLE		
Boring/Source:		Max. Dry Density (pcf):	94.0
Sample No.:	PA-OO-TC (5%LIME)	Optimum Moisture (%):	24.0
Depth (ft.):		Method of Compaction:	ASTM D 698
Description:	ORGANIC SILTY CLAY TRACE F-C SAND - DK.GRAY	Surcharge (lb):	10

% COMPACTION	95%		Percent Swell 95%
Initial Dry Density (pcf):	89.0		0.5
Initial Moisture (%):	28.0		
			CBR Data 95%
Final Dry Density (pcf):	88.6	@ 0.1":	1.15
Final Moisture (%):	32.0	@ 0.2":	1.20



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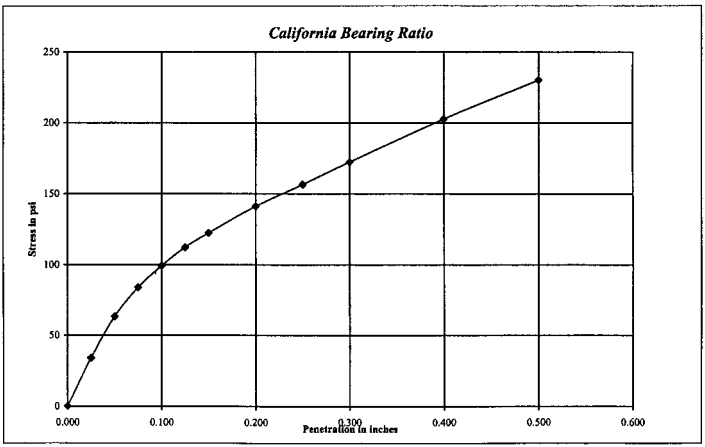
California Bearing Ratio

ASTM D-1883

STS Project No.	32037		10/30/2001
Project Name	HUNTERS POINT SHIPYARD		
Client Name	BATTELLE		
Boring/Source:		Max. Dry Density (pcf):	113.0
Sample No.:	SB-OO-TC (5% FLY ASH)	Optimum Moisture (%):	13.5
Depth (ft.):		Method of Compaction:	ASTM D 698
Description:	CLAYEY FINE TO COARSE SAND SOME SILT TRACE FINE GRAVEL - DK GRAY	Surcharge (lb):	10

% COMPACTION	95%	Percent Swell	95%
Initial Dry Density (pcf):	105.9		0.0
Initial Moisture (%):	14.7		

		CBR Data	95%
Final Dry Density (pcf):	105.9	@ 0.1":	9.92
Final Moisture (%):	19.6	@ 0.2":	9.41



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Laboratory Services Group *750 Corporate Woods Parkway Vernon Hills, Illinois 60061* *Phone: (847) 279-2500 Fax: (847) 279-2550*

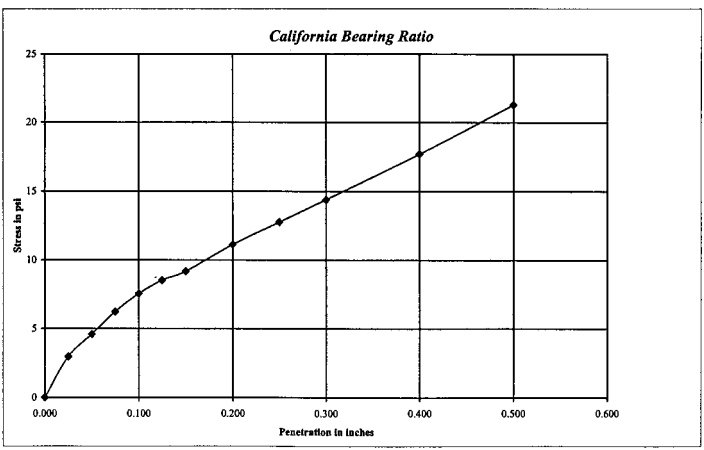
California Bearing Ratio

ASTM D-1883

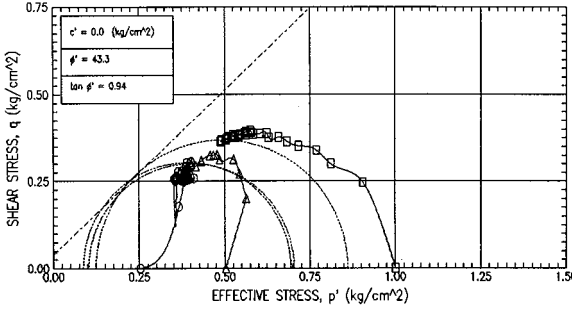
STS Project No.	32037		10/30/2001
Project Name	HUNTERS POINT SHIPYARD		
Client Name	BATTELLE		
Boring/Source:		Max. Dry Density (pcf):	113.0
Sample No.:	SB-OO-TC (5% LIME)	Optimum Moisture (%):	13.5
Depth (ft.):		Method of Compaction:	ASTM D 698
Description:	CLAYEY FINE TO COARSE SAND SOME SILT TRACE FINE GRAVEL - DK GRAY	Surcharge (lb):	10

% COMPACTION	95%	Percent Swell	95%
Initial Dry Density (pcf):	106.2		0.4
Initial Moisture (%):	14.3		

		CBR Data	95%
Final Dry Density (pcf):	105.7	@ 0.1":	0.75
Final Moisture (%):	21.7	@ 0.2":	0.74



CU TRIAXIAL COMPRESSION TEST ASTM D 4767

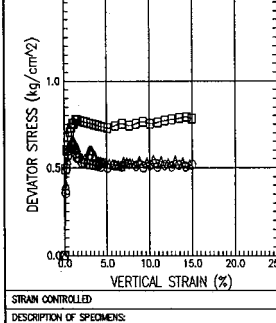


FAILURE SKETCHES

32037PF1

32037PF2

32037PF3



SYMBOL		○	△	□	
TEST NO.		32037PF1	32037PF2	32037PF3	
INITIAL	WATER CONTENT (%)	26.59	26.59	26.59	
	DRY DENSITY (gm/cm^3)	1.42	1.42	1.42	
	SATURATION (%)	79.56	79.32	79.83	
	VOID RATIO	0.902	0.905	0.899	
BEFORE SHEAR	WATER CONTENT (%)	34.03	34.26	33.06	
	DRY DENSITY (gm/cm^3)	1.40	1.39	1.41	
	SATURATION (%)	98.59	97.84	97.31	
	VOID RATIO	0.932	0.946	0.917	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		0.61	0.65	0.81	
TIME TO FAILURE (min)		8.00	10.00	170.00	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.80	4.80	4.79	
INITIAL HEIGHT (cm)		9.48	9.50	9.52	
B-VALUE		0.92	0.97	0.97	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS:

1) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 2) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 3) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY

LL 53.00	PL 28.00	PI 25.00	GS 2.70	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAXIMUM EFFECTIVE STRESS RATIO

2)

3)

PROJECT HUNTERS POINT SHIPYARD				
PROJECT NO.32037				
BORING NO.	SAMPLE NO.	PA-00-TC	PA-00-TC	PA-00-TC
TECH. LO	DEPTH/ELEV	3% FLY ASH	3% FLY ASH	3% FLY ASH
LABORATORY	DATE	9-16-01	9-17-01	9-16-01

TRIAXIAL COMPRESSION TEST REPORT

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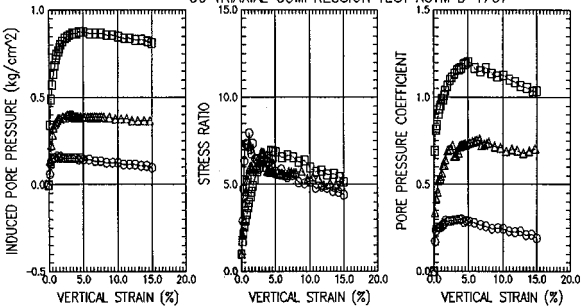
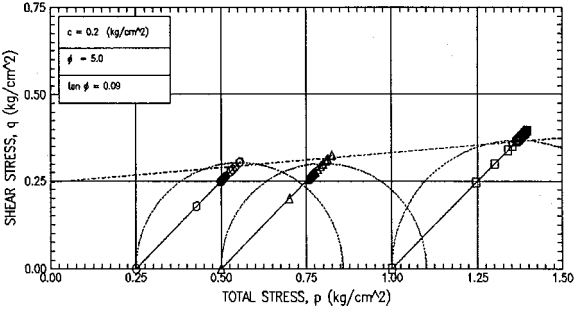
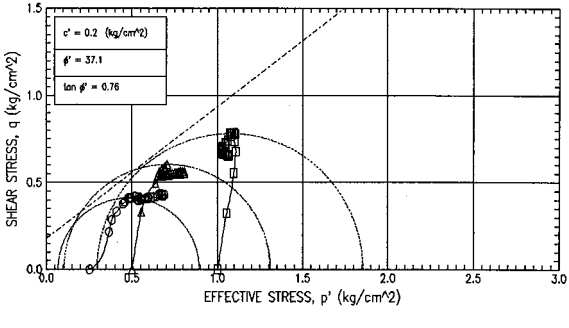




Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
PA-00-TC	3% FLY	ASH	32037PF1	32037PF1.DAT	○
PA-00-TC	3% FLY	ASH	32037PF2	32037PFF.DAT	△
PA-00-TC	3% FLY	ASH	32037PF3	32037PF3.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

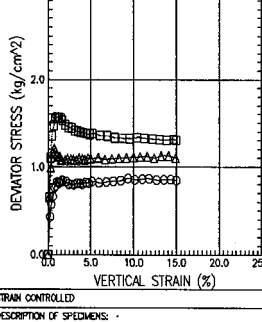


FAILURE SKETCHES

32037PF4

32037PF5

32037PF6



SYMBOL		○	△	□	
TEST NO.		32037PF4	32037PF5	32037PF6	
INITIAL	WATER CONTENT (%)	25.43	25.43	25.43	
	DRY DENSITY (gm/cm^3)	1.45	1.44	1.45	
	SATURATION (%)	79.19	78.23	79.89	
	VOID RATIO	0.867	0.878	0.859	
BEFORE SHEAR	WATER CONTENT (%)	31.75	31.94	30.95	
	DRY DENSITY (gm/cm^3)	1.47	1.46	1.46	
	SATURATION (%)	102.56	102.09	100.78	
	VOID RATIO	0.836	0.845	0.829	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		0.87	1.21	1.57	
TIME TO FAILURE (min)		110.00	8.00	11.98	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.79	4.80	4.78	
INITIAL HEIGHT (cm)		9.45	9.55	9.52	
B-VALUE		0.99	0.92	0.96	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS:

1) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 2) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 3) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY

LL 53.00	PL 28.00	PI 25.00	GS 2.70	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

2)

3)

PROJECT HUNTERS POINT SHIPYARD					
PROJECT NO.32037					
BORING NO.	SAMPLE NO.	PA-00-TC	PA-00-TC	PA-00-TC	
TECH. LO	DEPTH/ELEV	5% FLY ASH	5% FLY ASH	5% FLY ASH	
LABORATORY	DATE	9-19-01	9-19-01	9-19-01	

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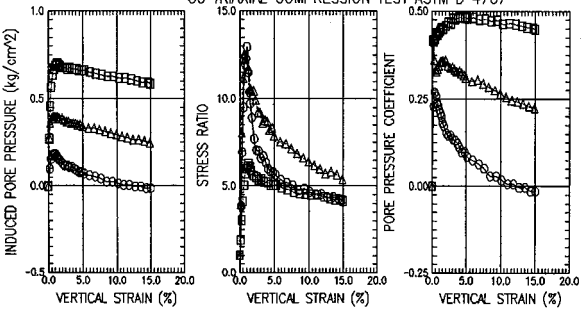
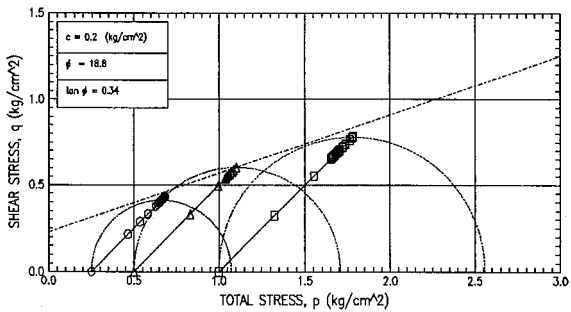
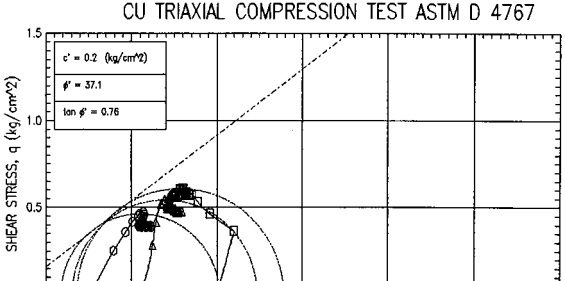




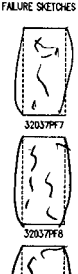
Project Name : HUNTERS POINT SHIPYARD

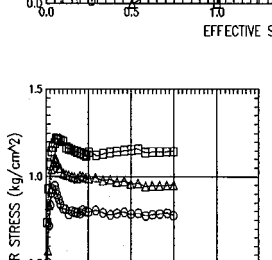
Boring No:	Sample No	Depth	Test No	Filename	Symbol
PA-00-TC	5% FLY ASH		32037PF4	32037PF4.DAT	○
PA-00-TC	5% FLY ASH		32037PF5	32037PF5.DAT	△
PA-00-TC	5% FLY ASH		32037PF6	32037PF6.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767



FAILURE SKETCHES





SYMBOL		○	△	□
TEST NO.		32037PF7	32037PF8	32037PF9
INITIAL	WATER CONTENT (%)	25.37	25.37	25.37
	DRY DENSITY (gm/cm^3)	1.44	1.44	1.44
	SATURATION (%)	78.38	78.60	78.81
	VOID RATIO	0.874	0.871	0.869
BEFORE SHEAR	WATER CONTENT (%)	33.17	32.14	32.26
	DRY DENSITY (gm/cm^3)	1.43	1.44	1.46
	SATURATION (%)	101.23	99.84	102.58
	VOID RATIO	0.885	0.869	0.849
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00
MAX. DEV. STRESS (kg/cm^2)		0.95	1.11	1.22
TIME TO FAILURE (min)		12.00	12.00	13.98
RATE OF STRAIN INCH (%/min)		0.08	0.08	0.08
INITIAL DIAMETER (cm)		4.78	4.80	4.78
INITIAL HEIGHT (cm)		9.50	9.51	9.51
B-VALUE		0.92	0.98	0.93

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS:

1) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 2) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 3) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY

LL 53.00	PL 28.00	PI 25.00	GS 2.70	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

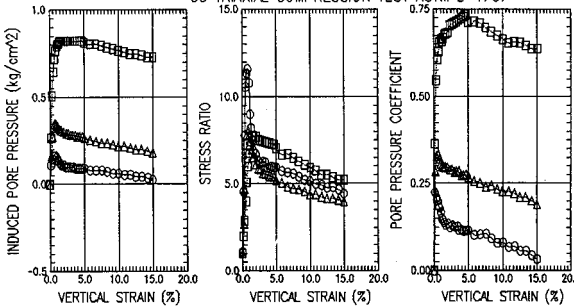
2)

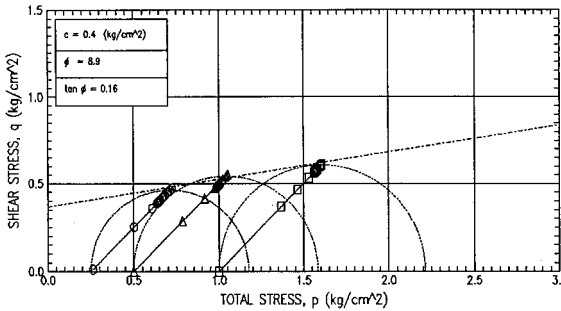
3)

PROJECT HUNTERS POINT SHIPYARD					
PROJECT NO.32037					
BORING NO.		SAMPLE NO.	PA-00-TC	PA-00-TC	PA-00-TC
TECH. LO		DEPTH/ELEV	7% FLY ASH	7% FLY ASH	7% FLY ASH
LABORATORY		DATE	9-24-01	9-24-01	9-24-01

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

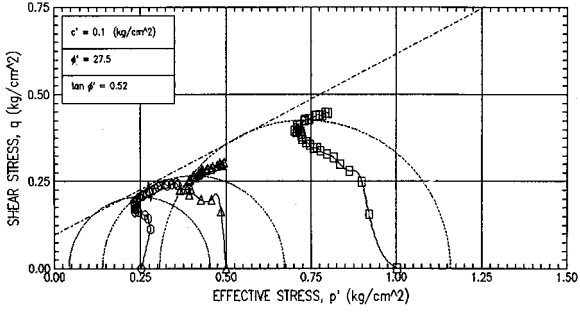




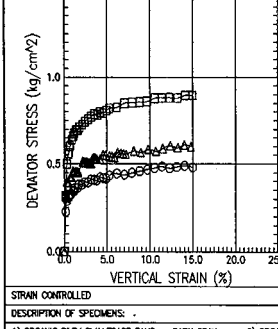
Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
PA-00-TC	7% FLY ASH	32037PF7		32037PF7.DAT	O
PA-00-TC	7% FLY ASH	32037PF8		32037PF8.DAT	Δ
PA-00-TC	7% FLY ASH	32037PF9		32037PF9.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767



FAILURE SKETCHES



SYMBOL		○	△	□
TEST NO.		32037PL1	32037PL2	32037PL3
INITIAL	WATER CONTENT (%)	26.93	27.08	27.08
	DRY DENSITY (gm/cm^3)	1.43	1.42	1.44
	SATURATION (%)	82.46	81.72	83.79
	VOID RATIO	0.882	0.895	0.873
BEFORE SHEAR	WATER CONTENT (%)	33.25	33.54	30.86
	DRY DENSITY (gm/cm^3)	1.42	1.40	1.47
	SATURATION (%)	99.22	98.05	99.99
	VOID RATIO	0.905	0.923	0.833
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00
MAX. DEV. STRESS (kg/cm^2)		0.49	0.61	0.94
TIME TO FAILURE (min)		160.00	0.00	159.98
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08
INITIAL DIAMETER (cm)		4.79	4.79	4.75
INITIAL HEIGHT (cm)		9.49	9.45	9.48
B-VALUE		1.00	0.99	0.94

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS: .

1) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 2) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 3) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY

LL 53.00	PL 28.00	PI 25.00	GS 2.70	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

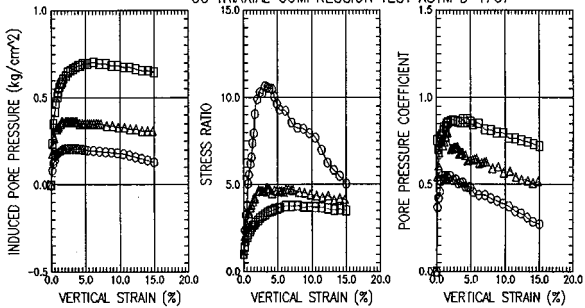
2)

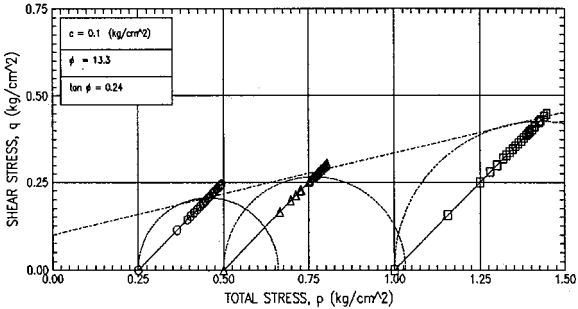
3)

PROJECT HUNTERS POINT SHIPYARD				
PROJECT NO.32037				
BORING NO.	SAMPLE NO.	PA-00-TC	PA-00-TC	PA-00-TC
TECH. LO	DEPTH/ELEV	3% LIME	3% LIME	3% LIME
LABORATORY	DATE	9-16-01	9-17-01	9-18-01

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

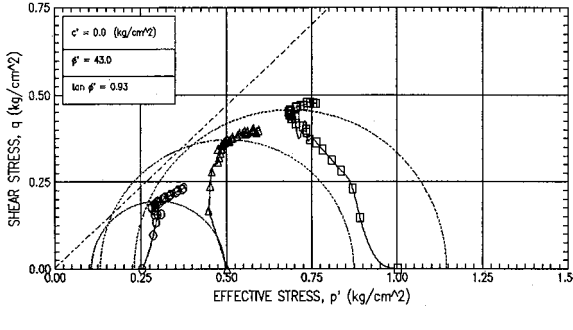




Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
PA-00-TC	3% LIME		32037PL1	32037PL1.DAT	○
PA-00-TC	3% LIME		32037PL2	32037PL2.DAT	△
PA-00-TC	3% LIME		32037PL3	32037PL3.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

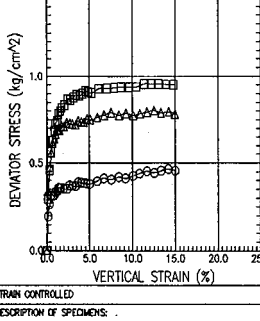


FAILURE SKETCHES

32037PL4

32037PL5

32037PL6



SYMBOL		○	△	□	
TEST NO.		32037PL4	32037PL5	32037PL6	
INITIAL	WATER CONTENT (%)	25.65	25.65	25.65	
	DRY DENSITY (gm/cm^3)	1.45	1.46	1.45	
	SATURATION (%)	80.42	81.97	80.58	
	VOID RATIO	0.861	0.845	0.859	
BEFORE SHEAR	WATER CONTENT (%)	32.56	31.14	30.78	
	DRY DENSITY (gm/cm^3)	1.45	1.48	1.51	
	SATURATION (%)	101.95	102.17	104.85	
	VOID RATIO	0.862	0.823	0.792	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		0.47	0.81	0.98	
TIME TO FAILURE (min)		170.00	150.00	130.00	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.75	4.74	4.76	
INITIAL HEIGHT (cm)		9.54	9.51	9.50	
B-VALUE		0.99	0.98	1.00	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS: .

1) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 2) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 3) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY

LL 53.00	PL 28.00	PI 25.00	GS 2.70	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

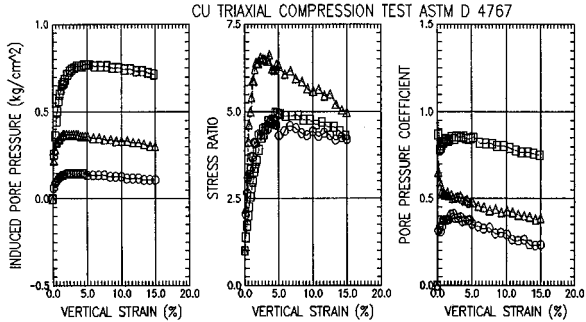
1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

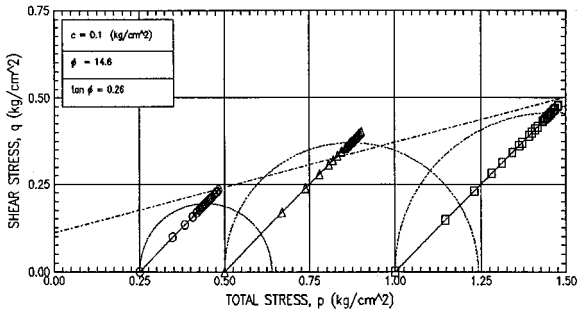
2)

3)

PROJECT HUNTERS POINT SHIPYARD				
PROJECT NO.32037				
BORING NO.	SAMPLE NO.	PA-00-TC	PA-00-TC	PA-00-TC
TECH. LO	DEPTH/ELEV	5% LIME	5% LIME	5% LIME
LABORATORY	DATE	9-20-01	9-20-01	9-20-01

TRIAXIAL COMPRESSION TEST REPORT

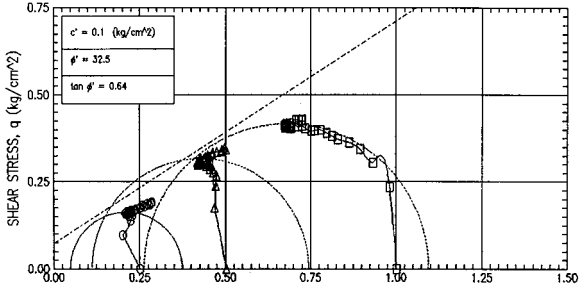




Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
	PA-00-TC	5% LIME	32037PL4	32037PL4.DAT	○
	PA-00-TC	5% LIME	32037PL5	32037PL5.DAT	△
	PA-00-TC	5% LIME	32037PL6	32037PL6.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

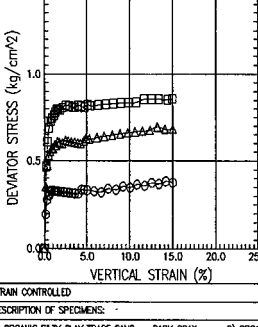


FAILURE SKETCHES

32037PL7

32037PL8

32037PL9



SYMBOL		○	△	□	
TEST NO.		32037PL7	32037PL8	32037PL9	
INITIAL	WATER CONTENT (%)	25.49	25.49	25.49	
	DRY DENSITY (gm/cm^3)	1.45	1.45	1.45	
	SATURATION (%)	79.89	79.68	80.12	
	VOID RATIO	0.862	0.864	0.859	
BEFORE SHEAR	WATER CONTENT (%)	31.79	30.73	29.27	
	DRY DENSITY (gm/cm^3)	1.45	1.45	1.51	
	SATURATION (%)	99.06	96.89	100.34	
	VOID RATIO	0.866	0.856	0.788	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		0.38	0.70	0.89	
TIME TO FAILURE (min)		170.00	150.00	169.98	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.78	4.78	4.77	
INITIAL HEIGHT (cm)		9.48	9.48	9.50	
B-VALUE		1.00	1.00	0.97	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS:

1) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 2) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY 3) ORGANIC SILTY CLAY TRACE SAND -- DARK GRAY

LL 53.00	PL 28.00	PI 25.00	GS 2.70	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

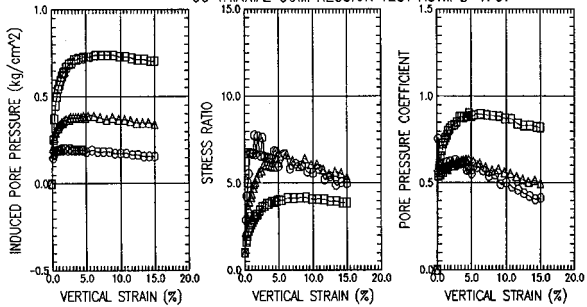
2)

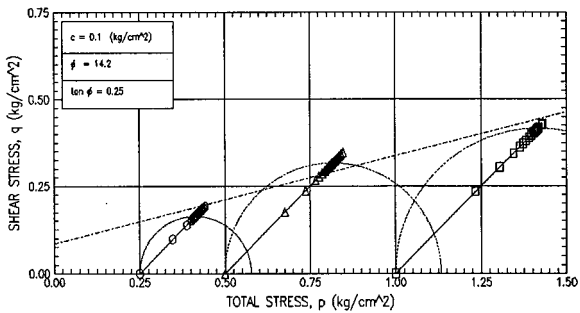
3)

PROJECT HUNTERS POINT SHIPYARD					
PROJECT NO.32037					
BORING NO.	SAMPLE NO.	PA-00-TC	PA-00-TC	PA-00-TC	
TECH. LO	DEPTH/ELEV	7% LIME	7% LIME	7% LIME	
LABORATORY	DATE	9-24-01	9-24-01	9-24-01	

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

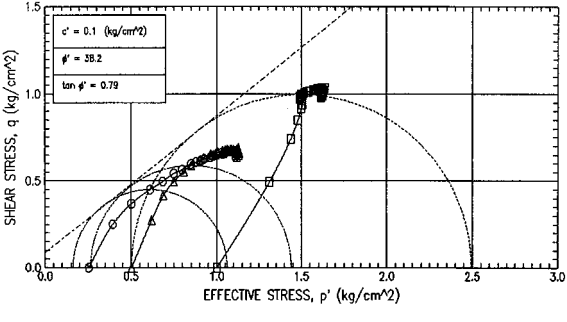




Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
	PA-00-TC	7% LIME	32037PL7	32037PL7.DAT	○
	PA-00-TC	7% LIME	32037PL8	32037PL8.DAT	△
	PA-00-TC	7% LIME	32037PL9	32037PL9.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

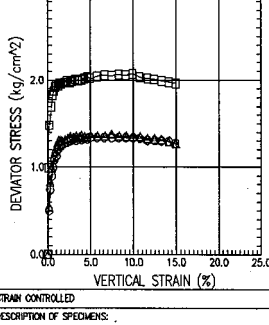


FAILURE SKETCHES

320375F1

320375F2

320375F3



	SYMBOL	○	△	□	
	TEST NO.	320375F1	320375F2	320375F3	
INITIAL	WATER CONTENT (%)	15.50	15.50	15.50	
	DRY DENSITY (gm/cm^3)	1.71	1.70	1.72	
	SATURATION (%)	73.23	71.86	74.30	
	VOID RATIO	0.569	0.580	0.561	
BEFORE SHEAR	WATER CONTENT (%)	20.89	20.89	20.05	
	DRY DENSITY (gm/cm^3)	1.72	1.71	1.74	
	SATURATION (%)	99.77	97.51	98.05	
	VOID RATIO	0.563	0.576	0.550	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
	MINOR PRIN. STRESS (kg/cm^2)	0.25	0.50	1.00	
	MAX. DEV. STRESS (kg/cm^2)	1.34	1.38	2.08	
	TIME TO FAILURE (min)	69.98	90.00	120.00	
	RATE OF STRAIN INCR (%/min)	0.08	0.08	0.08	
	INITIAL DIAMETER (cm)	4.80	4.81	4.80	
	INITIAL HEIGHT (cm)	9.51	9.52	9.52	
	B-VALUE	0.97	0.92	0.93	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS:

1) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 2) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 3) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

LL 33.00	PL 20.00	PI 13.00	GS 2.69	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

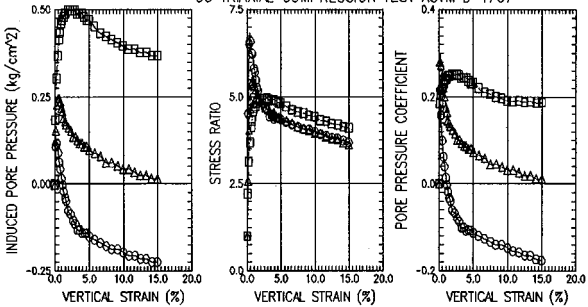
2)

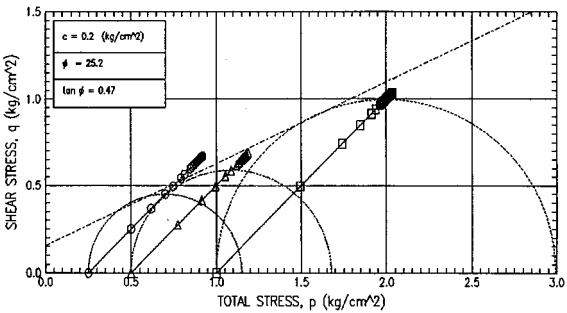
3)

PROJECT HUNTERS POINT SHIPYARD				
PROJECT NO.32037				
BORING NO.	SAMPLE NO.	SB-00-TC	SB-00-TC	SB-00-TC
TECH. LO	DEPTH/ELEV	3% FLY ASH	3% FLY ASH	3% FLY ASH
LABORATORY	DATE	9-26-01	9-26-01	9-26-01

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

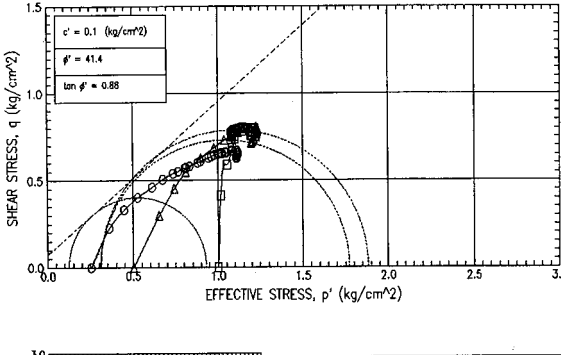




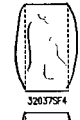
Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
SB-00-TC	3% FLY	ASH	32037SF1	32037SF1.DAT	○
SB-00-TC	3% FLY	ASH	32037SF2	32037SF2.DAT	△
SB-00-TC	3% FLY	ASH	32037SF3	32037SF3.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

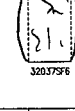


FAILURE SKETCHES

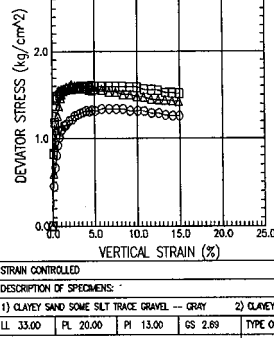


32037SF4

32037SF5



32037SF6



SYMBOL		○	△	□	
TEST NO.		32037SF4	32037SF5	32037SF6	
INITIAL	WATER CONTENT (%)	15.26	15.26	15.26	
	DRY DENSITY (gm/cm^3)	1.72	1.73	1.72	
	SATURATION (%)	72.92	73.66	72.74	
	VOID RATIO	0.563	0.557	0.564	
BEFORE SHEAR	WATER CONTENT (%)	21.16	20.72	20.90	
	DRY DENSITY (gm/cm^3)	1.72	1.72	1.73	
	SATURATION (%)	101.21	99.57	100.71	
	VOID RATIO	0.562	0.560	0.558	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		1.34	1.62	1.62	
TIME TO FAILURE (min)		79.98	28.00	55.98	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.80	4.80	4.80	
INITIAL HEIGHT (cm)		9.51	9.50	9.52	
B-VALUE		0.92	0.98	0.99	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS:

1) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 2) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 3) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

LL 33.00	PL 20.00	PI 13.00	GS 2.69

TYPE OF SPECIMEN REMOLDED TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

2)

3)

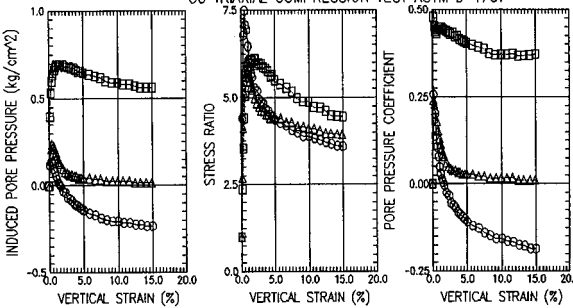
PROJECT HUNTERS POINT SHIPYARD

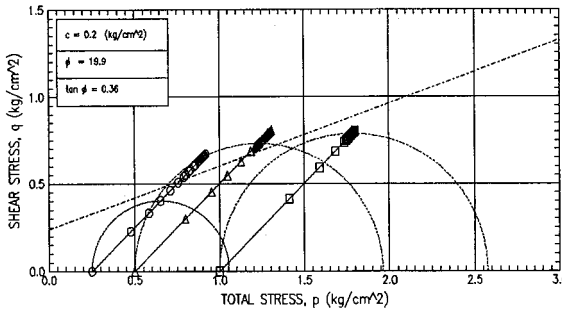
PROJECT NO.32037

BORING NO.	SAMPLE NO.	SB-00-TC	SB-00-TC	SB-00-TC
TECH. LO	DEPTH/ELEV	5% FLY ASH	5% FLY ASH	5% FLY ASH
LABORATORY	DATE	9-28-01	9-28-01	9-28-01

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

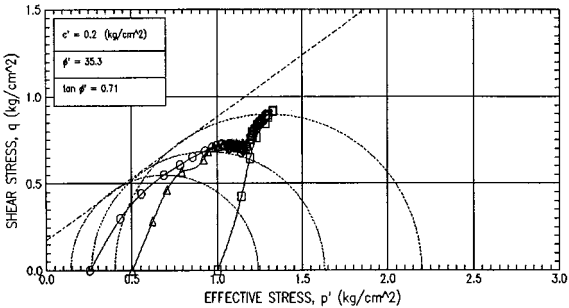




Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
SB-00-TC	5% FLY ASH	32037SF4	32037SF4.DAT	○
SB-00-TC	5% FLY ASH	32037SF5	32037SF5.DAT	△
SB-00-TC	5% FLY ASH	32037SF6	32037SF6.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

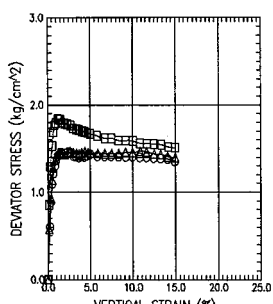


FAILURE SKETCHES

32037SF7

32037SF8

32037SF9



SYMBOL		○	△	□	
TEST NO.		32037SF7	32037SF8	32037SF9	
INITIAL	WATER CONTENT (%)	15.29	15.29	15.29	
	DRY DENSITY (gm/cm^3)	1.73	1.71	1.72	
	SATURATION (%)	73.80	72.29	72.49	
	VOID RATIO	0.557	0.569	0.567	
BEFORE SHEAR	WATER CONTENT (%)	21.01	21.06	21.15	
	DRY DENSITY (gm/cm^3)	1.73	1.72	1.72	
	SATURATION (%)	101.48	100.33	100.70	
	VOID RATIO	0.557	0.565	0.565	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		1.46	1.47	1.85	
TIME TO FAILURE (min)		26.00	130.00	14.00	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.79	4.81	4.81	
INITIAL HEIGHT (cm)		9.53	9.54	9.52	
B-VALUE		0.96	0.92	0.98	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS:

1) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 2) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 3) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

LL 33.00	PL 20.00	PI 13.00	GS 2.69	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

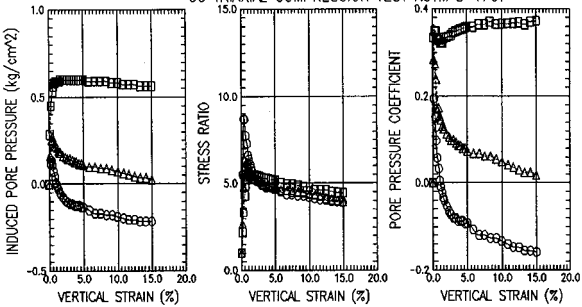
2)

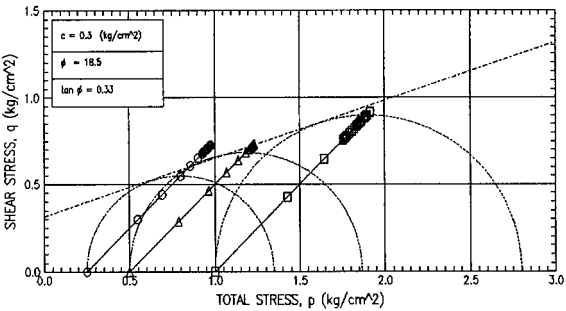
3)

PROJECT HUNTERS POINT SHIPYARD				
PROJECT NO.32037				
BORING NO.	SAMPLE NO.	SB-00-TC	SB-00-TC	SB-00-TC
TECH. LO	DEPTH/ELEV	7% FLY ASH	7% FLY ASH	7% FLY ASH
LABORATORY	DATE	10-01-01	10-01-01	10-01-01

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

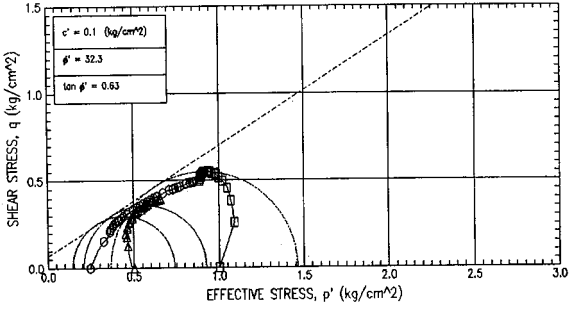




Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
SB-00-TC	7% FLY ASH		32037SF7	32037SF7.DAT	○
SB-00-TC	7% FLY ASH		32037SF8	32037SF8.DAT	△
SB-00-TC	7% FLY ASH		32037SF9	32037SF9.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

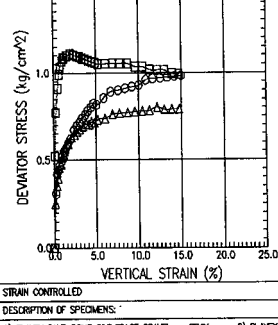


FAILURE SKETCHES

32037SL1

32037SL2

32037SL3



SYMBOL		○	△	□	
TEST NO.		32037SL1	32037SL2	32037SL3	
INITIAL	WATER CONTENT (%)	15.43	15.43	15.43	
	DRY DENSITY (gm/cm^3)	1.73	1.73	1.72	
	SATURATION (%)	74.41	74.58	74.00	
	VOID RATIO	0.556	0.557	0.561	
BEFORE SHEAR	WATER CONTENT (%)	19.85	20.00	19.72	
	DRY DENSITY (gm/cm^3)	1.78	1.73	1.75	
	SATURATION (%)	100.93	97.03	98.50	
	VOID RATIO	0.529	0.554	0.538	
	BACK PRESS. (kg/cm^2)	5.00	5.00	5.00	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		0.98	0.80	1.12	
TIME TO FAILURE (min)		179.98	140.00	23.98	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.78	4.78	4.79	
INITIAL HEIGHT (cm)		9.51	9.52	9.50	
B-VALUE		0.98	0.95	0.93	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS:

1) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 2) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 3) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

LL	PL	PI	GS
33.00	20.00	13.00	2.69

TYPE OF SPECIMEN REMOLDED

TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

2)

3)

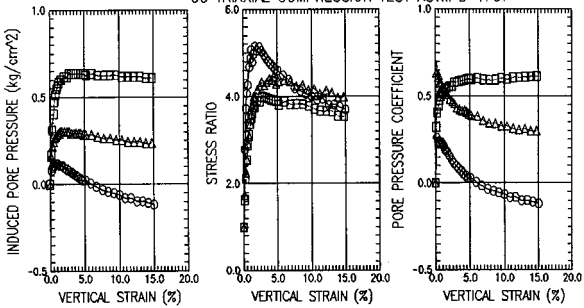
PROJECT HUNTERS POINT SHIPYARD

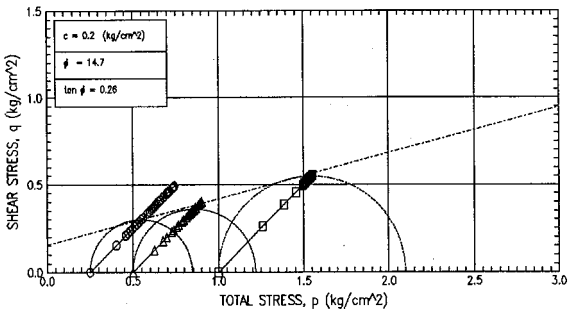
PROJECT NO.32037

BORING NO.	SAMPLE NO.	SB-00-TC	SB-00-TC	SB-00-TC
TECH. LO	DEPTH/ELEV	3% LIME	3% LIME	3% LIME
LABORATORY	DATE	9-26-01	9-26-01	9-26-01

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

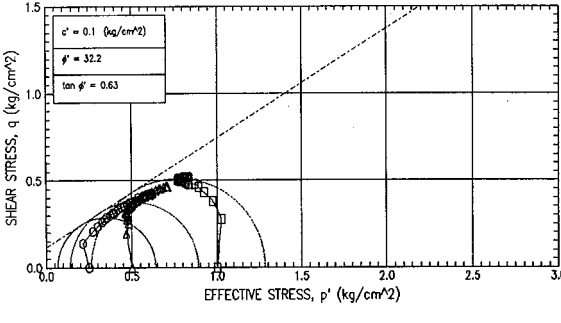




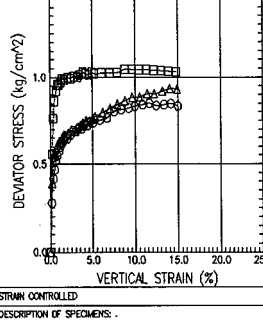
Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
	SB-00-TC	3% LIME	32037SL1	32037SL1.DAT	○
	SB-00-TC	3% LIME	32037SL2	32037SL2.DAT	△
	SB-00-TC	3% LIME	32037SL3	32037SL3.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767



FAILURE SKETCHES



SYMBOL		○	△	□	
TEST NO.		32037SL4	32037SL5	32037SL6	
INITIAL	WATER CONTENT (%)	15.38	15.38	15.38	
	DRY DENSITY (gm/cm^3)	1.74	1.73	1.72	
	SATURATION (%)	75.33	74.11	73.54	
	VOID RATIO	0.549	0.558	0.562	
BEFORE SHEAR	WATER CONTENT (%)	19.96	19.89	20.29	
	DRY DENSITY (gm/cm^3)	1.74	1.73	1.73	
	SATURATION (%)	98.13	96.49	98.33	
	VOID RATIO	0.547	0.554	0.555	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		0.86	0.94	1.05	
TIME TO FAILURE (min)		140.00	160.00	100.00	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.79	4.80	4.80	
INITIAL HEIGHT (cm)		9.50	9.50	9.50	
B-VALUE		0.99	0.95	0.97	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS: .

1) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 2) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 3) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

LL 33.00	PL 20.00	PI 13.00	GS 2.69	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

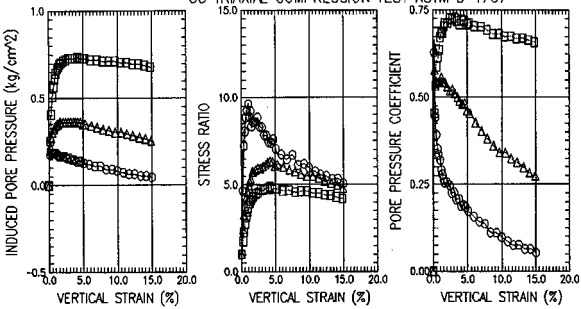
2)

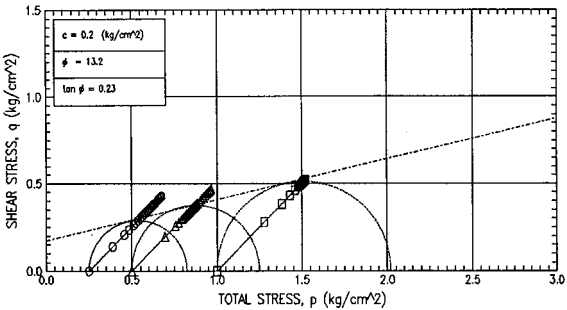
3)

PROJECT HUNTERS POINT SHIPYARD				
PROJECT NO.32037				
BORING NO.	SAMPLE NO.	SB-00-TC	SB-00-TC	SB-00-TC
TECH. LO	DEPTH/ELEV	5% LIME	5% LIME	5% LIME
LABORATORY	DATE	9-28-01	9-28-01	9-28-01

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

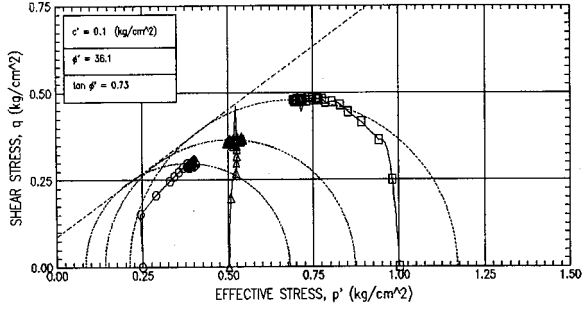




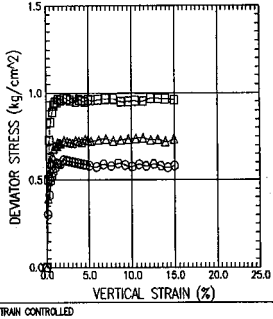
Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
	SB-00-TC	5% LIME	32037SL4	32037SL4.DAT	○
	SB-00-TC	5% LIME	32037SL5	32037SL5.DAT	△
	SB-00-TC	5% LIME	32037SL6	32037SL6.DAT	□

CU TRIAXIAL COMPRESSION TEST ASTM D 4767



FAILURE SKETCHES



SYMBOL		○	△	□	
TEST NO.		320375L7	320375L8	320375L9	
INITIAL	WATER CONTENT (%)	15.56	15.56	15.56	
	DRY DENSITY (gm/cm^3)	1.73	1.73	1.72	
	SATURATION (%)	75.02	75.15	74.78	
	VOID RATIO	0.556	0.556	0.560	
BEFORE SHEAR	WATER CONTENT (%)	20.49	20.19	19.62	
	DRY DENSITY (gm/cm^3)	1.72	1.72	1.74	
	SATURATION (%)	97.74	98.77	97.14	
	VOID RATIO	0.564	0.561	0.543	
	BACK PRESS. (kg/cm^2)	4.92	4.92	4.92	
MINOR PRIN. STRESS (kg/cm^2)		0.25	0.50	1.00	
MAX. DEV. STRESS (kg/cm^2)		0.61	0.74	0.97	
TIME TO FAILURE (min)		24.00	130.00	35.98	
RATE OF STRAIN INCR (%/min)		0.08	0.08	0.08	
INITIAL DIAMETER (cm)		4.80	4.80	4.80	
INITIAL HEIGHT (cm)		9.50	9.48	9.50	
B-VALUE		1.00	0.94	0.93	

STRAIN CONTROLLED

DESCRIPTION OF SPECIMENS: -

1) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 2) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 3) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

LL 33.00	PL 20.00	PI 13.00	GS 2.69	TYPE OF SPECIMEN REMOLDED	TYPE OF TEST CU (R)

REMARKS:

1) FAILURE CRITERIA = MAX. EFFECTIVE STRESS RATIO

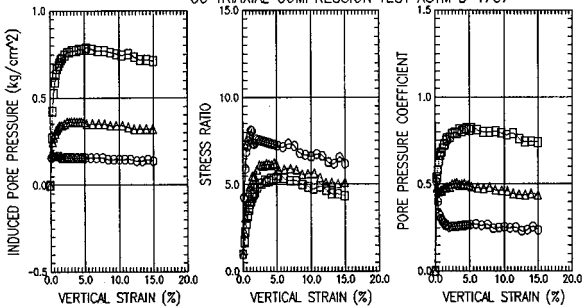
2)

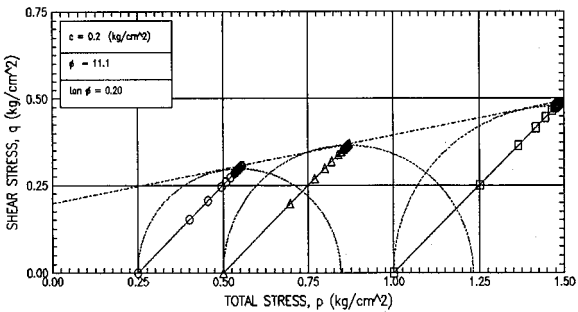
3)

PROJECT HUNTERS POINT SHIPYARD				
PROJECT NO.320375				
BORING NO.	SAMPLE NO.	SB-00-TC	SB-00-TC	SB-00-TC
TECH. LO	DEPTH/ELEV	7% LIME	7% LIME	7% LIME
LABORATORY	DATE	10-01-01	10-01-01	10-01-01

TRIAXIAL COMPRESSION TEST REPORT

CU TRIAXIAL COMPRESSION TEST ASTM D 4767

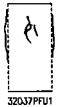




Project Name : HUNTERS POINT SHIPYARD

Boring No:	Sample No	Depth	Test No	Filename	Symbol
SB-00-TC	7% LIME		32037SL7	32037SL7.DAT	○
SB-00-TC	7% LIME		32037SL8	32037SL8.DAT	△
SB-00-TC	7% LIME		32037SL9	32037SL9.DAT	□

FAILURE SKETCHES



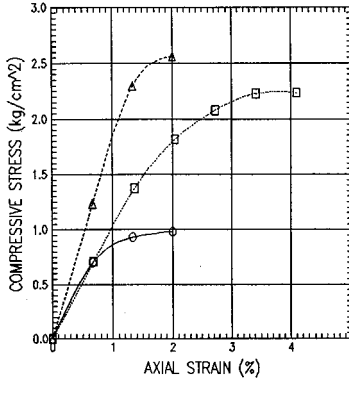
32037PFU1

32037PFU2

32037PFU3

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN



SYMBOL			○	△	□	
TEST NO.			32037PFU1	32037PFU2	32037PFU3	
TYPE OF SPECIMEN			REMOLDED	REMOLDED	REMOLDED	
INITIAL	WATER CONTENT %	w_o	26.59	25.70	25.91	
	VOID RATIO	e_o	0.544	0.532	0.517	
	SATURATION %	S_o	107.62	106.20	110.25	
	DRY DENSITY (gm/cm^3)	γ_d	1.43	1.44	1.45	
TIME TO FAILURE (min)		t_f				
UNCONFINED COMPRESSIVE STRENGTH (kg/cm^2)		q_u	0.98	2.56	2.24	
UNDRAINED SHEAR STRENGTH (kg/cm^2)		s_u	0.49	1.28	1.12	
RATE OF STRAIN (%/min)			.1	.1	.1	
INITIAL SPECIMEN DIAMETER (cm)		D_o	4.78	4.80	4.80	
INITIAL SPECIMEN HEIGHT (cm)		H_o	9.51	9.50	9.31	

DESCRIPTION OF SPECIMENS: 1) ORGANIC SILTY CLAY TRACE SAND -- DK GRAY 2) ORGANIC SILTY CLAY TRACE SAND -- DK GRAY 3) ORGANIC SILTY CLAY TRACE SAND -- DK GRAY

LL : 53.00 | PL : 28.00 | PI : 25.00 | GS : 2.20

REMARKS:	PROJECT	32037, HUNTERS POINT			
1) 3% FLY ASH ADDED					
2) 5% FLY ASH ADDED	BORING NO.	SAMPLE NO.	PA00TC+3%ASH	PA00TC+5%ASH	PA00TC+7%ASH
3) 7% FLY ASH ADDED	TECH. LO	DEPTH/ELEV			
	LABORATORY	DATE	09-14-01	09-17-01	09-23-01

UNCONFINED COMPRESSION TEST REPORT

FAILURE SKETCHES

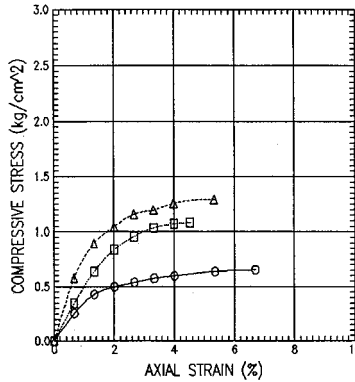
32037PLU1

32037PLU2

32037PLU3

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN



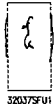
SYMBOL			○	△	□	
TEST NO.			32037PLU1	32037PLU2	32037PLU3	
TYPE OF SPECIMEN			REMOLDED	REMOLDED	REMOLDED	
INITIAL	WATER CONTENT %	w_o	26.25	25.82	25.49	
	VOID RATIO	e_o	0.525	0.525	0.521	
	SATURATION %	S_o	109.98	108.13	107.75	
	DRY DENSITY (gm/cm^3)	γ_d	1.44	1.44	1.45	
TIME TO FAILURE (min)		t_f				
UNCONFINED COMPRESSIVE STRENGTH (kg/cm^2)		q_u	0.65	1.29	1.08	
UNDRAINED SHEAR STRENGTH (kg/cm^2)		s_u	0.33	0.64	0.54	
RATE OF STRAIN (%/min)			.1	.1	.1	
INITIAL SPECIMEN DIAMETER (cm)		D_o	4.77	4.78	4.78	
INITIAL SPECIMEN HEIGHT (cm)		H_o	9.48	9.54	9.52	

DESCRIPTION OF SPECIMENS: 1) ORGANIC SILTY CLAY TRACE SAND -- DK GRAY 2) ORGANIC SILTY CLAY TRACE SAND -- DK GRAY 3) ORGANIC SILTY CLAY TRACE SAND -- DK GRAY

LL : 53.00 PL : 28.00 PI : 25.00 GS : 2.20

REMARKS:	PROJECT	32037, HUNTERS POINT			
1) 3% LIME ADDED					
2) 5% LIME ADDED	BORING NO.	SAMPLE NO.	PAOOTC+3%LIM	PAOOTC+5%LIM	PAOOTC+7%LIME
3) 7% LIME ADDED	TECH. LO	DEPTH/ELEV			
	LABORATORY	DATE	09-14-01	09-17-01	09-24-01
	UNCONFINED COMPRESSION TEST REPORT				

FAILURE SKETCHES



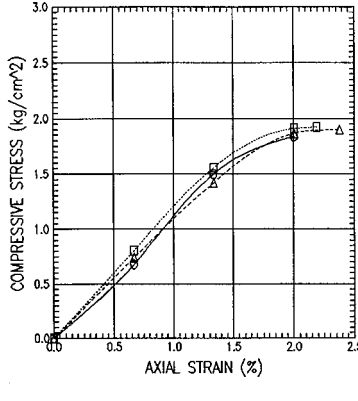
32037SFU1

32037SFU2

32037SFU3

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN



SYMBOL			○	△	□	
TEST NO.			32037SFU1	32037SFU2	32037SFU3	
TYPE OF SPECIMEN			REMOLDED	REMOLDED	REMOLDED	
INITIAL	WATER CONTENT %	w_o	15.43	15.26	15.29	
	VOID RATIO	e_o	0.572	0.561	0.566	
	SATURATION %	S_o	72.59	73.18	72.67	
	DRY DENSITY (gm/cm^3)	γ_d	1.71	1.72	1.72	
TIME TO FAILURE (min)		t_f				
UNCONFINED COMPRESSIVE STRENGTH (kg/cm^2)		q_u	1.84	1.90	1.92	
UNDRAINED SHEAR STRENGTH (kg/cm^2)		s_u	0.92	0.95	0.96	
RATE OF STRAIN (%/min)			.1	.1	.1	
INITIAL SPECIMEN DIAMETER (cm)		D_o	4.80	4.80	4.80	
INITIAL SPECIMEN HEIGHT (cm)		H_o	9.52	9.50	9.51	

DESCRIPTION OF SPECIMENS: 1) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 2) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY 3) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

LL : 33.00 PL : 20.00 PI : 13.00 GS : 2.69

REMARKS:

1) 3% FLY ASH ADDED

2) 5% FLY ASH ADDED

3) 7% FLY ASH ADDED

PROJECT	32037, HUNTERS POINT				
BORING NO.		SAMPLE NO.	SB00TC+3%ASH	SB00TC+5%ASH	SB00TC+7%ASH
TECH.	LO	DEPTH/ELEV			
LABORATORY		DATE	09-25-01	09-28-01	10-01-01

UNCONFINED COMPRESSION TEST REPORT

FAILURE SKETCHES

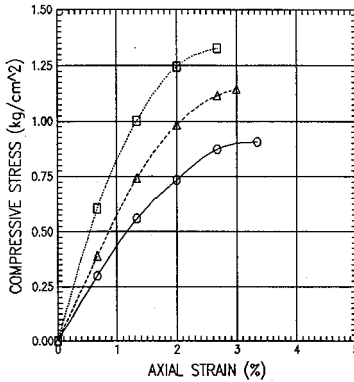
32037SLU1

32037SLU2

32037SLU3

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN



SYMBOL			○	△	□	
TEST NO.			32037SLU1	32037SLU2	32037SLU3	
TYPE OF SPECIMEN			REMOLDED	REMOLDED	REMOLDED	
INITIAL	WATER CONTENT %	w_o	15.58	15.36	15.43	
	VOID RATIO	e_o	0.558	0.556	0.559	
	SATURATION %	S_o	75.08	74.08	74.28	
	DRY DENSITY (gm/cm^3)	γ_d	1.73	1.73	1.73	
TIME TO FAILURE (min)		t_f				
UNCONFINED COMPRESSIVE STRENGTH (kg/cm^2)		q_u	0.91	1.15	1.33	
UNDRAINED SHEAR STRENGTH (kg/cm^2)		s_u	0.45	0.57	0.66	
RATE OF STRAIN (%/min)			.1	.1	.1	
INITIAL SPECIMEN DIAMETER (cm)		D_o	4.79	4.79	4.79	
INITIAL SPECIMEN HEIGHT (cm)		H_o	9.51	9.50	9.50	

DESCRIPTION OF SPECIMENS: 1) CLAYEY SAND SOME SILT TRACE GRAVEL --- GRAY 2) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

3) CLAYEY SAND SOME SILT TRACE GRAVEL -- GRAY

LL : 33.00	PL : 20.00	PI : 13.00	GS : 2.69

REMARKS:	PROJECT	32037, HUNTERS POINT			
1) 3% LIME ADDED					
2) 5% LIME ADDED	BORING NO.	SAMPLE NO.	SB00TC+3%LIM	SB00TC+5%LIM	SB00TC+7%LIM
3) 7% LIME ADDED	TECH. LO	DEPTH/ELEV			
	LABORATORY	DATE	09-25-01	09-28-01	10-01-01

UNCONFINED COMPRESSION TEST REPORT

APPENDIX O

Responses to Agency Comments on Draft Field Summary Report and Winter 2001 Sediment Dynamics Study Draft Technical Memorandum

HUNTERS POINT SHIPYARD PARCEL F
VALIDATION STUDY AND HUMAN HEALTH EVALUATION
FIELD SUMMARY REPORT
RESPONSE TO COMMENTS

California Department of Toxic Substances Control
Responses to October 18, 2001 Comments

Specific Comments

1. **There is no indication that the Navy intended or intends to collect molluscs during the investigation of Parcel F sediments (Section 1.2, page 2) for the Human Health Risk Assessment (HHRA). This omission appears to contradict the statements made regarding collection of clam tissue (Section 4.1, page 32). HERD has indicated in previous memoranda that it is not necessary that there be 'shellfish beds of sufficient size' for this to be a significant exposure pathway for sensitive subpopulations (*Draft Final Hunters Point Shipyard (Parcel F) Human Health Evaluation Work Plan, San Francisco Bay, California* Appendix B, page B-13).**

   Response: The risk assessment approach adopted in the Human Health Evaluation Work Plan (HHE Work Plan) relied upon laboratory bioaccumulation test data rather than field-collected clam tissue data to evaluate the shellfish consumption pathway so that the results could be used directly to support validation of the low-volume footprint on a station-by-station basis. The field-collected clam tissue described on page 32 of the Field Summary Report was collected as part of the Validation Study to evaluate the validity of using laboratory-exposed *M. nasuta* tissue data for the upper trophic level assessment. As described in Section 7.2.2 of the Draft Validation Study Report, chemical concentrations in field-collected clam tissue were similar to those in laboratory-exposed clams from adjacent sampling stations. Therefore, the results of a human health risk assessment using field-collected clam tissue data would be similar to those reported in Section 9.0 of the Draft Validation Study Report.

2. **The Navy should respond regarding the areas outlined in previous HERD memoranda wherein HERD recommended that some areas in Parcel F would best be evaluated separately. Standard sediment investigation techniques are not applicable in these areas due to access or sampling problems. For example, the large area of concrete and riprap in Area III and the location in Area VIII, where the metal debris has fused, apparently due to corrosion, has many sample locations which were relocated (Table 3-2, page 12).**

   Response: As noted in the Validation Study Work Plan (Page 1), the target of the investigation was soft, subtidal sediments. Although a small amount of soft sediment may be found in pockets between riprap and debris, the size of the area and volume of potentially affected sediment are small compared with the rest of the study area. By sampling the soft sediments as close to the debris as possible, it could be determined whether the debris in Areas III and VIII is likely to be a source of contamination to offshore sediments. Additionally, the onshore portion of the debris will be evaluated further as part of the Parcels B and E shoreline investigations.

3. **The toxicity test results from Area IX locations OR-24, OR-26 and OR-29 should be carefully evaluated. Few worms were found in the sediment samples (Table 3-3, page 17) and many species of polychaete worms are know to be tolerant of high chemical sediment concentrations. Sample location OR24 and OR26 are the closest to the shore in Area IX (Figure 3-5, page 24). No response is required for this comment.**

Response: This comment is acknowledged. It should be noted that the observations recorded in Table 3-3 of the Field Summary Report were qualitative only, and polychates were not classified to determine if they were pollution-tolerant species.

4. **Some comparison of the physical, chemical and biological data must be provided for the reference station results as the sediment samples for the Sediment Water Interface (SWI) samples at two 'reference" stations (Red Rock and Alcatraz Environs) were collected differently from the other three 'reference' stations (Section 3.2, page 29).**

   Response: The results of the SWI test for HPS samples were compared with an ambient threshold value developed for San Francisco Bay as part of the Bay Protection and Toxic Hot Spot Program (BPTCP), and not to reference site results. Therefore, the fact that the SWI cores were collected differently at the coarse-grained reference sites has no impact on the interpretation of SWI test results for the Validation Study. The reference sites were included in the SWI test to help assess test performance.

5. **To our knowledge there was no mention of treatability testing (Section 3.3, page 30) in the work plan. Please confirm that this was included in the work plan provided for HERD review. In any event, the treatability test results should be reviewed by a DTSC geologists and/or DTSC engineer familiar with remedial actions for subtidal sediments.**

   Response: Treatability testing was discussed on Pages 22-23 of the Final Validation Study Work Plan. Data quality objectives for treatability testing were provided in Table 3-8 of the Work Plan.

6. **Please explain in the text why fish species for the Human Health Evaluation (HHE) were only collected at four San Francisco Bay reference sites (Section 5.0, page 46), when five reference sites were sampled for sediment.**

   Response: The reference sites sampled for the Validation Study were Paradise Cove, Alameda Buoy, Alcatraz Environs, Bay Farm and Red Rock. These sites were selected based upon the criteria outlined in Section 3.1.1 of the Final Validation Study Work Plan. The sites sampled for the risk communication portion of the Human Health Evaluation were selected to ensure that fish tissue data were comparable to previous data collected for the Regional Monitoring Program and focused on areas that are known to be popular fishing locations for recreational anglers. It is important to note that these locations were not intended to be 'reference' sites, but rather to provide an estimate of ambient tissue concentrations in fish from throughout the Bay. The locations sampled included San Francisco Pier 7, Berkeley Pier, San Mateo Bridge, and Bay Farm.

HUNTERS POINT SHIPYARD PARCEL F
WINTER 2001 SEDIMENT DYNAMICS STUDY
DRAFT TECHNICAL MEMORANDUM
RESPONSE TO COMMENTS

U.S. Environmental Protection Agency
Responses to November 20, 2001 Comments

General Comments

1. **Throughout the report, several generalized qualitative statements were provided regarding data interpretation and significance, with no citations or other (more quantitative) validation. While it is recognized that the document is intended to present interim results, a greater effort to elucidate data and model limitations and uncertainties should have been included in the discussion. Please provide citations and more quantitative validation in future documents, and in this document if it is revised.**

   Response: This comment is acknowledged. Additional citations have been provided in the Draft Validation Study Report, including additional support for the specific conclusions regarding the sediments around HPS.

2. **In several areas throughout the report, various uncertainties were mentioned, but were not listed in the conclusions as data limitations. Although the level of uncertainty associated with a data set is not clearly quantified, it should be listed as a potential limitation to the application of the data. Please include a bulleted list of limitations in the Validation Study Report and in this document if it is revised.**

   Response: A discussion regarding the uncertainties associated with this study and limitations on data use has been provided in Appendix L of the Draft Validation Study Report.

3. **In Appendix F-1, Page F-1, Paragraph 5, the text states "model performs well for sandy to silty noncohesive beds." The Hunters Point (S1, S2) sediment environment falls within a much more narrow grain size (silt-clay) range. This particular variable might impact the precision of the model. Please clearly describe this limitation and the associated uncertiantly in model precision in future documents.**

   Response: The major difference of interest in this study between cohesive and non-cohesive sediments is in the determination of critical shear stress values. Cohesive sediment critical shear stresses cannot be determined from standard methods (i.e., Shields Curve); therefore, values from the field must be used. Because field tests were not conducted to determine these values, they were taken from other studies completed in the South San Francisco Bay. With the appropriate critical shear stresses used in the models, the models are valid for evaluating the resuspension potential for the HPS area.

4. **In Appendix F.2.2, Page F-5, Paragraph 1, the text states "Unfortunately, modeling of cohesive sediment transport is not well understood and developed as for non-cohesive sediment environments. Determination of appropriate input parameters such as T_c and other model factors for cohesive beds is still problematic and under general study." This point is highly significant, as it speaks directly to the "limited" utility of the study results and 1D model, since cohesive sediments predominate at the South Stations. This significant uncertainty should be**

clearly evaluated in the presentation of the results of this effort as well as carefully considered during remedial decision making. Please discuss this uncertainty in future documents.

Response: The models and input parameters have been updated in the Draft Validation Study Report to significantly increase the accuracy of the results for cohesive sediment beds. This includes a more accurate determination of the critical shear stress as described in the response to General Comment 3.

Specific Comments

1. **Section 1.0, Introduction, Page 1, Paragraph 2: The text states "Processes that may affect the mobilization and transport of sediments at HPS include tides, wind, waves, bottom currents, surface water runoff and benthic biologic activity.' The scope of this report attempts to quantify each of these processes, with the exception of biological activity. In order to best represent all possible contributions to sediment mobilization in the area, the biotic component (sediment dwelling detritus and filter-feeding marine invertebrates) should be quantified rather than discounted with qualitative opinion. Please discuss the contribution of biota to sediment mobilization in future documents.**

   Response: Biological processes are typically not quantified in sediment transport models, and bioturbation has not been shown to be a significant sediment transport forcing mechanism compared with waves and tidal currents. The greatest effect of bioturbation is expected to be on the cohesiveness of the sediment bed. This factor has been taken into account in the models by using an empirical value for critical shear stress determined in previous San Francisco Bay studies.

2. **Section 2. 1, Sediment Transport Measurement System, Page 3, lines 5 and 6: It is stated "Each system was designed to collect time-series measurements of all parameters in an area of unobstructed flow near the seafloor for a one-month period." Please provide specific information regarding system quality assurance and/or validation protocols.**

   Response: The oceanographic instruments that were deployed were calibrated at the factory and routinely checked in the laboratory prior to deployment. Simple performance checks were included in the setup procedures provided in manufacturer control and acquisition software. The new generation of acoustic current and wave meters report a range of ancillary engineering data with basic hydrodynamic data, including backscatter intensities, beam correlation, percent good data, and range to boundary. The wave/current meter underwent a series of system self checks that it must pass prior to deployment. Detailed QA/QC steps were not provided in the Draft Validation Study Report, although the instrument specification sheets were included.

3. **Section 2.1.2, Suspended Sediment Measurements, Page 3, Paragraph 2: It is indicated that "these types of effects have been discussed in previous studies, and add an undetermined uncertainty to the quantitative estimates of suspended sediment concentrations." Because the level of uncertainty is "undetermined," it seems highly inappropriate to use data that have no 'boundary of limitation.' Please provide some measure or estimate from recognized experts or the peer-reviewed literature of the degree of advection from upstream sources.**

   Response: While there remains some level of uncertainty as to the quantitative effect of advected suspended matter on the OBS data, the qualitative effects are generally recognizable and were described in Section 3.6 of the technical memorandum. The uncertainty associated with the measurement of suspended sediment concentrations is discussed further in the General Response on Page O-10.

4. **Section 2.2, Field Operations Program, Page 4, Paragraph 3: The text states that "data appeared acceptable." Please present the information supporting this conclusion. Also, please present quality control and quality assurance measures used to evaluate the data.**

   Response: Mid-deployment instrument recovery and data download served two primary functions: to check for biofouling of optical sensor windows, and data recovery. Optical windows were cleaned to minimize the effects by algal slime and detritus of suspended sediment data. Data were downloaded at mid-deployment to provide backup for the first half of the deployment period. This backup ensured usable data in the event of subsequent sensor or system failure due to natural events, fishing operations, or random component failure. Due to the cost of vessel-supported field operations, these data downloads were performed on board and at sea. Cursory system and data checks were performed to ensure that the basic systems are still performing within nominal parameters. Data were field collected just prior to recovery to determine the current performance of the hardware. In the case of the wave/current meters, basic acoustic functioning of the current probes were checked, including power availability and current drain, backscatter intensities and beam correlations, all indicators of overall system performance. These are simple system checks that were performed using manufacturer software and system diagnostics. In general data were deemed acceptable if there were no anomalously high or missing data and all system functions appear to be normal.

5. **Section 4.1.2, Stations South I and South 2, Page 9, Paragraph 1: It is stated "Because the current velocities were generally low at the South Basin stations and the data were only collected over a relatively short time period (i.e., about one month), the estimates of flux have a lower degree of statistical confidence than the flux estimates calculated for North 1 and therefore must be regarded with a moderate degree of uncertainty." Please reiterate the lower degree of statistical confidence and other uncertainties associated with the South Basin stations as a study limitation in the report conclusions. This verbiage is subjective without quantitative information. Please make a greater effort to provide quantitative information regarding the degree of uncertainty (i.e., order of magnitude, etc) and statistical confidence in the data and model.**

   Response: As noted above, the uncertainties associated with the sediment dynamics field measurements and flux calculations are discussed in Appendix L of the Draft Validation Study. These uncertainties have been quantified where possible.

6. **Section 4.2, One-Dimensional Sediment Resuspension Modeling, Page 10, Paragraph 3: It is stated "Because direct information about the cohesive and physical properties of the bottom sediment was not available (e.g., yield strength, bulk density, etc.), critical stress estimates were used to represent the initial mobilization criteria." Cohesive and physical properties of site sediments can be derived employing relatively rudimentary testing methods (e.g., yield strength using a ploughmeter, bulk density using gamma ray attenuation). This information would have been useful in order to validate the 1D model. Further, this would have reduced uncertainty to some extent, with little additional effort. Because this part of the 1D model was not based on site-specific sediment properties, please state this limitation in the report conclusions.**

   Response: Although site specific data on sediment properties were not collected for this study, values of critical shear stresses for the soft, surficial sediments in the South Basin were obtained from other studies of muddy estuarine sediments. These estimates were compared in the Draft Validation Study Report with those used by other researchers in San Francisco Bay.

7. **Section 4.2, One-Dimensional Sediment Resuspension Modeling, Page 11, Paragraph 2, last line. It is indicated that based on the model employed, "little transport of the resuspended materials occurred at Stations South 1 and 2." It should be noted however that there are other variables, not considered by the model, that contribute to the constant flux within the sediment milieu, particularly with sediments containing high proportions of silt, clay, and organic matter. Even in a standard hydrometer test, where the sediment/water column remains static after mixing, most of the silt and clay can remain suspended in the water column at the conclusion of the test for several hours. One would assume then that even intermittent or minor physical influences in the South 1 and 2 locales would keep the silt and clay in the (fluid) water column, making these fine sediments amenable to the constant fluid mechanics flux of the water itself. Hence, to state that sediment disturbance sometimes occurs via tidal, current, or wave influences, but that transport of these disturbed sediments is not occurring, seems contradictory. Please state why sediment biota were not considered in this study, and cite the data that provides technical support for the conclusion that (intermittently) suspended sediments would not be transported by physical forces of the overlying water.**

   Response: The STMS data from winter 2001 showed that suspended sediment concentrations in South Basin increased during episodic winter storms and decreased rapidly after the storm event, indicating that sediments did not remain suspended in the water column. In estuarine environments, the suspended particles flocculate and settle out of the water column more rapidly than they would in a standard hydrometer test, where the sediment particles are vigorously shaken and disaggregated as part of the test.

   The sediment dynamics study did not conclude that no sediment transport was occurring in South Basin. Section 4.1 of the technical memorandum concluded that the measured cumulative residual flux during the winter deployment was small compared with the flux at Station North 1, where it was two orders of magnitude greater. While resuspended sediment is transported by advection in South Basin, the sediment is not likely to be carried far because of the weak circulation. As noted in the response to Specific Comment 1, biological activity has not been shown to be a major forcing mechanism for sediment resuspension.

8. **Section 5.2, Two-Dimensional Regional Sediment Transport Modeling, Page 13, Paragraph 2: It is stated, "the currents are dominated by tidal forcing. Therefore, for the winter simulations, wave-induced currents were not included in the regional sediment transport modeling. During storm/extreme conditions, the wave-induced currents will comprise a more significant portion of the total bottom boundary current, and will play a larger role in initiating sediment movement. In future simulations for storm/extreme cases, wave-induced currents will be included in the sediment transport modeling." This passage identifies other potentially significant limitations to this study. Please include these limitations in a list of data-related limitations. It would be useful to include the site-specific data employed to support the decision to use tidal forcing while omitting any contribution from currents. Lastly, the fact that storm events were not considered in this study is another source of uncertainty. Assuming the South sites are true depositional areas, such events, given higher sediment disturbance potential from wave-induced currents, seem potentially significant with respect to sediment transport issues. Please discuss the limitations that result when storm events are not considered in the study.**

   Response: As previously noted, the limitations and uncertainties associated with the study are discussed in the Draft Validation Study Report. The only measurable sediment transport in South Basin occurred during winter storm events. This transport was essentially caused by wave-induced resuspension and small residual advective flux. In contrast, stronger tidal currents dominated

transport at Station North 1. The 2D regional modeling presented in the Draft Validation Study Report includes two modes of regional transport: tidally-driven sediment transport conditions at all three stations during winter and summer, and the analysis of the combined effects of wave and tidal currents during extreme storm events. These scenarios provide a good representation of the sediment transport patterns at HPS.

9. **Section 5.2, Two-Dimensional Regional Sediment Transport Modeling, Page 15, last two sentences: The document states "It is likely that a majority of the sediment movement within these basins occurs during storm events. Future simulations will include the impact of storms on the region and present an overall picture of sediment movement, erosion, and deposition at HPS.' Please specify the document where these simulations will be presented.**

   Response: The extreme event analysis is provided in Appendix L of the Draft Validation Study Report. The El Nino event of 1997-1998 was used to evaluate the potential effects of an extreme storm. During the 1997-98 El Nino, higher than normal tides and storms created conditions that approximated a 100-yr event. In the past one hundred years of sea-level records in the San Francisco Bay, no single event has exceeded the sea-level rise of storms during the 1997-98 El Nino.

10. **Section 6.1, Summary, Page 16, Paragraph 6: It is stated "cumulative flux over the deployment period was minor and insignificant." The use of the term "insignificant" is not clear. Please clarify whether the significance was demonstrated statistically and the type of treatments that were used for this demonstration. In addition, please provide references to support this conclusion.**

    Response: Please refer to the response to Specific Comment 7. The significance of the cumulative flux in South Basin was not determined statistically; rather, it was qualitatively compared with cumulative flux at Station North 1.

11. **Section 6.2, Conclusions, Page 17, Paragraph 2: The document states that "Bottom stresses estimated from the 1D model were generally weak, although increased wave currents associated with infrequent and moderate winter storms combined with periods of spring tidal flow indicated that resuspension of the bottom sediment and local transport would occur at both sites ... These results suggest that although bottom sediment was infrequently mobilized by increased wave and current stresses, the sediment was not transported out of the South Basin during the period of study." Earlier in the report, the contribution of wave currents were discounted in the model, though in this passage it is stated that *"increased wave currents* ... (contribute to) *resuspension of the bottom sediment.* Though the data does show that sediments were not transported out (via erosion) of the South Basin, the study should also qualify the data limitations (i.e., the study took place over a 1 month period, a "snapshot" with only 1 of 4 seasons of approximately 30 of 365 possible monitoring days). The utility or application of this study should be identified as being limited. Sediment transport depends on a number of abiotic and biotic variables. No biotic contribution were considered. In order to accurately characterize site-specific sediment transport mechanics, each of these variables must be quantified through a more inclusive "longitudinal" approach to data collection. Lastly, several study limitations were identified in the report, though no discussion pertaining to how these uncertainties should restrict the application of the report conclusions, were provided. Much of the data herein is useful, however, please clearly state that this study only considers a partial and in some cases entirely qualitative picture based entirely on physical/mechanical influences within the broader field of sediment transport and fate.**

Response: As previously noted, uncertainties and data limitations are discussed more fully in Appendix L of the Draft Validation Study Report, including the representativeness of the data and potential effects of biota. The overall study design is addressed more fully in the General Response on Page O-10.

12. **Table F-2: The "excess bed shear stress" (T_c) variable is missing from the table. Please include the missing variable in the next iteration of the report.**

    Response: The missing variable is included in the Draft Validation Study Report.

13. **Table G-1, Page G-6: Citation(s) should be provided to support all variables (i.e., velocity, density, critical bed stress). If these estimates are only "best professional judgments" then please state this in Appendix G as a limitation.**

    The references for the variables have been provided in Appendix L of the Draft Validation Study Report.

HUNTERS POINT SHIPYARD PARCEL F
SEDIMENT DYNAMICS STUDY
SUMMER 2001 FIELD SUMMARY REPORT
RESPONSE TO COMMENTS

U.S. Environmental Protection Agency
Responses to November 20, 2001 Comments

General Response to Overall Evaluation

The reviewer expressed concern about "unidentified and unqualified" limitations of the HPS Sediment Dynamics Study. Because of the complexity and variability associated with sediment dynamics in estuarine systems, it is not feasible to quantify all parameters and eliminate all uncertainty in a cost effective manner. The approach adopted for the HPS Sediment Dynamics Study was to develop a program that represented the critical seasonal variations, tidal variations, and areas of greatest interest at HPS (i.e., Point Avisadero and South Basin). Site-specific data for the most important forcing mechanisms were collected. For important parameters that were not directly measured (i.e., critical shear stress of the sediment bed), empirical values that best represented site conditions were used. While the results of this study cannot definitively answer all questions, it provides valuable site-specific information for characterizing the fate and transport of sediment-bound contaminants. This information can be used with other lines of evidence (e.g. horizontal and vertical distribution of contamination and radioisotope profile data) to develop a reliable conceptual site model that can be used to support site management decisions. Specific uncertainties are discussed more fully in the Validation Study Report.

The instruments that were used in the study were state-of-the-science, and employ sensors that are used in industry and research sectors. The reviewer notes the "lack of a standard method" for the Sediment Transport Measurement Systems (STMS). As with any field study of physical and geological processes, confidence in field measurements and results derived from measured data are in part dependent on data accuracy and sensor calibrations. All of the instruments employed in this study were off-the-shelf commercial sensors and systems, and have been utilized in other investigations of sediment transport by the project scientists as well as other investigators (e.g., Cacchione and Drake, 1990; Wright, 1995). Instrument specifications are provided in the Draft Validation Study Report.

The Acoustic Doppler Velocimeter (ADV) probes have accuracies exceeding +0.25 cm/s, and were quite capable of detecting reliably the low flow speeds in South Basin. The primary uncertainty associated with the estimates of sediment flux were associated with the difficulties in calibration of the optical sensors for suspended sediment concentrations. The OBS (Optical Backscattering Sensor) is widely used to make time-series measurements of suspended sediment concentrations because of its small size (low flow interference), low power requirements, and ease of integration into multi-sensing systems like STMS. However, the OBS is difficult to calibrate accurately because of the inherent dependence of output on particle size and shape. OBS calibrations have been described by many other investigators, and the conversion of OBS detection outputs to SSC typically have large error intervals (the estimate of error for the HPS study is ~25% of the estimated SSC value).

The limitations and unquantifiable errors of the measurements and modeling do not invalidate the conclusions of the study. The hydrodynamic variations measured by instruments are real phenomena as evidenced not only by direct observation, but by extensive previous research. Also, the trends shown in the model are based on the solution of well-understood physical equations driven by measured boundary conditions. Many of the conclusions are based on these measured and modeled trends; therefore, the conclusions are not invalidated by a small error in the magnitude of a measured or modeled quantity.

Furthermore, the typical magnitudes of values measured and modeled (velocities, sediment concentrations, shear stress, etc.) are well known for the region, and the quantifications presented in this report are consistent with the results of previous investigations in the region, although a comprehensive literature review and comparison of HPS results with previous studies was beyond the scope of the current study. The conclusions presented in the Draft Validation Study Report are a valuable resource for current evaluation of the site and as a guide for further work.

General Comments

1. **Throughout the report, several generalized, qualitative statements were provided regarding data interpretation and significance, with no citations or other (more quantitative) validation. While it is recognized that the document is intended to present interim results, a greater effort to elucidate data and model limitations and uncertainties should have been included in the discussion. Please provide citations and more quantitative validation in future documents, and in this document if it is revised.**

   Response: The objective of the Field Summary Report was to disseminate preliminary results from the summer 2001 field deployment. A more comprehensive evaluation and interpretation of the data is provided in the Draft Validation Study Report.

2. **The issue of contaminant transport via pore water should be addressed within the larger realm of sediment dynamics and transport. However, neither the Validation Study Work Plan (May 15, 2000) nor the two Sediment Dynamics Reports attempt to address this issue. Please address the issue of contaminant transport via pore water in future documents.**

   Response: The potential biological effects of contaminant transport via porewater diffusion into the overlying water column were evaluated in the Validation Study using a sediment-water interface bioassay. If water column effects are found to be causing an unacceptable ecological risk, then additional studies to characterize this pathway will be considered.

3. **The Introduction indicates that there are four objectives of this study including: 1. *Identify areas of sediment deposition and erosion; 2. characterize fate and transport of sediment-bound contaminants; 3. estimate rates of sediment accumulation; and 4. predict the likelihood of subsurface sediment remobilization under various weather conditions, including extreme events.* While these objectives are in agreement with those specified in the Work Plan, the limitations associated with each were not adequately accounted for or discussed. Because these limitations speak directly to the certainty of the study conclusions, it is impossible to know how reliable the results of the study are. Also, item #4 has not yet been addressed to any practical extent in either the Winter and Summer Reports. Please discuss the limitations associated with each objective and the impact of these limitations on the study conclusions in future documents.**

   Response: All of the objectives of the sediment dynamics study are addressed in the Draft Validation Study Report, including a discussion of the limitations of the results.

4. **The report does not specify the "area of influence" the model can be used to predict. Even if the sample station locales are representative of sediment in areas that are known to be most contaminated, it is possible that the model may not represent the larger sediment milieu near Hunter's Point. Please clarify the area the model represents and discuss how well the model does or does not represent the sediment milieu near Hunters Point in the future evaluations and presentations of this study.**

Response: The "area of influence" that the model can be used to predict should be separated into two types of predictions: hydrodynamics and sediment transport. The hydrodynamic predictions from the 2D modeling efforts are valid throughout the entire model domain and were validated using available NOAA data. The sediment transport predictions are based upon a resuspension model that was successfully calibrated for this region of the San Francisco Bay. Although the model does not represent smaller scale variations of the sediment distribution, it does provide a calibrated method to obtain average values of resuspension flux throughout the domain.

5. **Surface sediment chemistry data available from previous investigations at Hunter's Point, should be correlated with the model presentation in order to strengthen the validation of the model assumptions. Please include this correlation in future documents.**

   Response: The results of the sediment dynamics study will be integrated with data for other lines of evidence (e.g. the distribution of chemical concentrations in surface and subsurface sediment, radioisotope data) in the Feasibility Study as part of the development of remedial alternatives for sediment.

Specific Comments

6. **Field Operations, Page 1, Paragraph 1: The text states that "one system was deployed on the northern side of HPS and two were deployed in South Basin (Figure 1)." During previous sediment and benthic invertebrate sampling events conducted by the Navy, "sampling areas" were identified (designated as areas I - X). The North locale is in Area 1, and the South stations are in Areas IX and X. Neither the Work Plan nor this report provide specific rationale for the selected sediment study sampling locations. Please list the specific criteria considered when determining the best location(s) for the tripods (i.e., tripods were placed in areas with confirmed sediment contamination, in areas within an unbiased and randomized grid pattern, or according to best professional judgment).**

   Response: The rationale for selection of the HPS stations is provided in the Draft Validation Study Report as well as previous documents. Briefly, two of the three STMS stations (North 1 and South 1) were located in Parcel F areas that were determined to be the most likely to require sediment management (i.e., in Areas III and X, respectively). The third station (South 2) was positioned in the center of a channel in South Basin to provide the best data for modeling hydrodynamics and sediment transport in South Basin.

7. **Station South 1, Page 5, Paragraph 2: It is indicated that the average water salinity was approximately 26 parts per thousand (ppt). The units used to report salinity (ppt) are not consistent with the "psu" salinity units in the Winter 2001 report. For consistency, please use consistent salinity units in all Parcel F documents.**

   Response: Salinity is presented in the Draft Validation Study Report in psu units of measure. The relationship of psu to ppt is 1:1, and thus the units are equivalent.

8. **Hydrodynamic Data, Pages 3 - 6. There are several quality control and/or quality assurance (QA/QC) shortcomings associated with the hydrodynamic data set. Based on the sheer number of field problems, the integrity of this data is in question, Please discuss the integrity and usefulness of the hydrodynamic data in light of the problems listed below:**

Response: Data deemed useful after careful QA/QC were considered reliable, and used for the data analysis and modeling efforts. Identification and removal of data that were deemed unusable are described in the Draft Validation Study Report. It should be noted that given the nature of this field investigation and sediment transport studies in general, some loss of data is not unusual and in some cases is unavoidable. For example, the interference of a mat of vegetation with the tripod cannot always be prevented. Any measures taken to protect the tripod may also interfere with the measurements themselves.

As previously noted, the oceanographic instrumentation deployed are calibrated at the factory and routinely checked in the lab prior to deployment. Simple performance checks are built into the setup procedures provided in manufacturer control and acquisition software. All of the instruments undergo a series of system self checks that they must pass prior to deployment.

Page 3, Paragraph 1: QC checks indicate "that the OBS data for Station North I were lost due to an instrument malfunction."

Response: The OBS system for Station North 1 was thoroughly checked out before deployment, and the failure occurred in the electronics while in situ. All possible measures were taken to prevent this type of occurrence; however, the instruments are not infallible and are subject to random failure.

Page 3, Paragraph 2: "Altimeter (bottom elevation data) for Stations South I and South 2 were highly variable and considered to be unreliable."

Response: Measurement of bottom elevation was not included in the original study design because the data were not needed to accomplish the study objectives. The sensor was added to the system to provide additional information about system performance. The unreliability of the data had no effect on the data evaluation and interpretation or achievement of study objectives.

Station South 1, Page 4, Paragraph 3: "The gradual increases in SSC from about July 22 to August 3 were apparently caused by biofouling of the sensor port. Biofouling appears to have affected the background trend of the SSC data again starting on August 6. "

Response: Biofouling is a common occurrence during the summer months in the San Francisco Bay estuary, and has an inevitable effect on optical instruments. Some of the HPS field data were corrected (i.e., detrended) to statistically remove the effects of biofouling and improve the reliability and useability of the data.

Station South 2, Page 5, Paragraph 1: "Apparent biofouling of the STMS instruments affected current, SSC, and salinity data.... SSC signals were large and erratic from July 21-26 and after August 12 (Figure 6c). Diagnostic data from the ADV were analyzed and found to be characteristic of a large mat of vegetation lodged within the tripod structure of attached to the ADV Ocean sensor. The conductivity sensor at this station was also fouled with organic material after recovery.

Response: As previously noted, there is always a risk that vegetation or other undesirable occurrences (e.g., fishing nets, boat activity) will interfere with the collection of reliable hydrodynamic data . All reasonable measures were taken to minimize the chance of such interferences.

Station North 1, Page 5, Paragraph 1: "No SSC data were recorded at this station because of instrument malfunction... The system was relocated a short distance west of the original site in

shallower water." Data from these two locales should not be combined, but recorded as two distinct data sets based on their different locations and 2 meter depth differential. Lastly, rather than *"The system was relocated a short distance west. . ,* " it would be useful to know measured distance difference between stations. Please specify the distance between the original and relocated stations and clearly state that no data from the original station was used in the study.

Response: The location of Station North 1 was moved approximately 35 m to the west. This shift and the use of data from Station North 1 are described in the Draft Validation Study Report.

9. **Summary and Conclusions, Page 6, Paragraph 1: The data set is too limited and there are too many associated uncertainties (i.e., hydrodynamic field data) to support anything more than "general" conclusions. Without a more rigorous study, results from this investigation will not help site managers make informed technical decisions for Parcel F. Please clearly discuss these limitations and uncertainties in the Validation Study.**

   Response: This comment is addressed further in the General Response on Page O-10. The results of the sediment dynamics study combined with other lines of evidence collected in the Validation Study support development of a reliable and useful conceptual site model that can be used to make informed decisions about the site.

10. **Summary and Conclusions, Page 6, 4" bullet: It is stated "Small increases in SSC at Station South 1 were associated with peak spring tides." If true, this conclusion would only be based on a single day of data. The spring tide duration was from July 21 - 24, while biofouling of the sensor port was reported on approximately July 22. Therefore, July 21 would have been the only day available to measure spring tides without sensor port problems. Please clarify whether this conclusion is based on data collected on a single day or explain how data from other days is reliable enough to have been used to draw conclusions.**

    Response: The calculation of suspended sediment concentrations was performed after detrending of the biofouled data. The interference from biofouling was removed statistically, and the corrected data were used to calculated suspended sediment concentrations during this time.

11. **Summary and Conclusions, Page 6, last bullet: It is indicated that "temperature and salinity were higher in South Basin compared with Station North 1, reflecting its more restricted circulation " A source of fresh water recharge (via surface or ground water) or discharge from the sanitary treatment plan into the South Basin might be other possible explanations for lower temperature and salinity at the North 1 location. Please discuss other possible explanations for the lower temperature and salinity at the North 1 location.**

    Response: During the dry summer months, freshwater discharge from surface flow is minimal to non-existent, and the influence of groundwater discharge on overall temperature and salinity in South Basin is expected to be minimal. The City's combined sewer overflow in Yosemite Creek is only permitted to discharge once per year under storm conditions. Therefore, the proposed explanation for the higher temperature and salinity in South Basin is believed to be the most reasonable.

APPENDIX P

Toxicity Identification Evaluation (SAIC/EFANE)

DEPARTMENT OF THE NAVY
ENGINEERING FIELD ACTIVITY, NORTHEAST
NAVAL FACILITIES ENGINEERING COMMAND
10 INDUSTRIAL HIGHWAY
MAIL STOP, #82
LESTER, PA 19113-2090

IN REPLY REFER TO
5090
Code EV22/JS
April 16, 2002

Mr. Michael Pound
Deputy Chief Environmental Engineer for Restoration
Southwest Division NAVFACENGCOM
1220 Pacific Highway
San Diego, CA 92132-5190

Dear Mr. Pound:

SUBJECT: DRAFT REPORT FOR SEDIMENT TOXICITY IDENTIFICATION EVALUATION DEMONSTRATION: HUNTER'S POINT NAVAL SHIPYARD, PARCEL F, SAN FRANCISCO, CA

Enclosed, please find the Draft Report for Sediment Toxicity Identification Evaluation (TIE) Demonstration for Hunter's Point Shipyard, Parcel F. The TIE demonstration for Hunter's Point was funded through the Navy's YO817 Program, which is a program set up by the Navy to develop and validate new technologies within the environmental field. The TIE study, as described in the Hunters Point Shipyard Parcel F Validation Study Work Plan, (Battelle, 2000) was completed to provide SWDIV and its contractors with ancillary data to assist with the determination of whether any observed toxicity is due to the presence of confounding factors (e.g., ammonia or sulfides), constituents of potential ecological concern (COPECs), or a combination of both at selected stations.

Comments on the report from the Hunter's Point BCT should be submitted directly to SWDIV, and subsequently forwarded to EFANE. EFANE will coordinate responses to any comments on the Draft report with SWDIV.

If additional information is required please contact Mr. Jason Speicher at (610) 595-0567 x-188 or Mr. David Barclift at x-183.

Sincerely,

DEBRA L. FELTON, P.E.
Head, Restoration Technical Branch
By direction of the
Commanding Officer

Copy to:
Ms. Ruth Owens (NFESC)
Dr. Gregory Tracey (SAIC)
Mr. Jason Speicher (EFANE)
Mr. David Barclift (EFANE)

SITE REPORT FOR:

SEDIMENT TOXICITY IDENTIFICATION EVALUATION DEMONSTRATION:

HUNTER'S POINT SHIPYARD
PARCEL F

SUBMITTED TO:

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING SERVICE CENTER
NCBC CODE 27162 BUILDING 41
1000 23RD Avenue
Port Hueneme, CA 93043-4410

SUBMITTED BY:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
221 THIRD STREET
NEWPORT, RI 02840

IN RESPONSE TO:

NAVY BAA N47408-97-D-0410

April 2002

Final

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EXECUTIVE SUMMARY

A Toxicity Identification Evaluation (TIE) demonstration was conducted using sediment pore waters from the Hunter's Point Shipyard in San Francisco Bay, California. The study was part of a demonstration project for Naval Facilities (NAVFAC) (technically managed by U.S. Navy Engineering Field Activity Northeast (EFANE)) designed to illustrate the applicability of TIEs in resolving the sources of toxicity and hence assist with management of contaminated sediments. The TIE was conducted with the same sediments that were characterized as part of an ongoing Validation Study supported by the Installation Restoration support team at EFD Southwest (SWDIV). Results of the TIE test exposures confirmed previous findings that ammonia is a major source of toxicity in Hunter's Point sediments, but it was also found that an additional source of toxicity attributable to metals is present in selective site samples. However, a similar correlation was also observed at the reference station, indicating that metals-related toxicity might not be site-specific.

Of the five areas within Hunter's Point Shipyard Parcel F sampled for SWDIV during the final two weeks of May, 2001, four were selected for TIE testing. Sediment samples tested in SAIC's TIE study were distributed as follows: two (co-located surface and subsurface samples) from Point Avisadero, one each from the Eastern Wetland and the Oil Reclamation Area, six from the South Basin (including a co-located surface and subsurface collection), and one from the reference site (Paradise Cove). The sample locations were chosen to represent a variety of contaminant types and/or ammonia in toxic concentrations. The samples were also selected to address issues concerning spatial variability.

The TIE consisted of a sequential series of toxicity tests consisting of exposures to serial dilutions of pore waters using the sensitive embryo-larval stages of the purple sea urchin (*Strongylocentrotus purpuratus*) and the Atlantic silverside fish *(Menidia menidia)*. Test organisms were exposed to untreated sediment pore waters and then to a series of treated pore waters. The first five treatments were conducted sequentially, while the final two manipulations were independent of each other. Each step was conducted to identify a unique class of contaminants, as follows:

Untreated: Establishes baseline toxicity.
Sodium thiosulfate (STS): Added to reduce oxidants such as chlorine, halogenated amines and several cationic metals including Cd^{2+}, Cu^{2+}, Ag^{1+} and Hg^{2+} (with low reduction of Ni^{2+}, Zn^{2+}, and Pb^{2+}) in pore water samples (U.S. EPA 1991).
Ethylenediamine Tetraacetic Acid (EDTA): Added to chelate divalent cationic metals (i.e., Al^{2+}, Ba^{2+}, Fe^{2+}, Mn^{2+}, Sr^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+}, Co^{2+} and Zn^{2+}) by replacing dissolved metals with less bioavailable forms.
Filtration: Required to remove excess particulates to improve efficiency of the solid phase extraction treatment.
Oasis® solid phase extraction (SPE): Removes non-polar organic contaminants such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).
Ulva lactuca: Plant that removes ammonia, and potentially other residual sources of toxicity (e.g., non-ionic contaminants, metals)

Following the Oasis® extraction, a pH adjustment was performed to provide additional evidence for the role of confounding factors (e.g., ammonia):
Increase pH: Change the equilibrium of ammonia to favor the more toxic un-ionized form; change the equilibrium of sulfides to favor less toxic forms.

A follow-on TIE test series was conducted using the embryo-larval sand dollar (*Dendraster excentricus)* test (a replacement echinoderm for the original urchin test species, due to seasonal availability). In these tests, an additional, modified sequence was employed, placing *Ulva* additions first to remove the potentially masking effects of ammonia toxicity prior to the assessment of toxicity reduction due to other treatments. The modified design was applied to a three-station subset of the original test stations.

Results from all tests are summarized in Table ES-1, which is accompanied by interpretive text in Section 4 of this report.

General conclusions can be summarized as follows:

- Levels of toxicity observed in the pore water exposures were substantially higher than in bulk sediment and Sediment Water Interface toxicity tests, where minimal toxicity occurred. Known differences between the tolerance limits of the species tested as well as differences in exposure concentrations account for these differences. For the TIE study sediment pore water was used as the test media, thus representing a potential worse-case scenario for exposure. Results of the TIE study should contribute as ancillary data in identifying potential sources of toxicity within the overall weight of evidence process utilized for the Hunters Point Validation Study.

- Toxicity did not differ substantially with depth in the two stations where surface and subsurface sediments were represented.

- Very high oxygen demand in the pore water samples offers clues to the biogeochemical properties governing the bioavailability of the toxicants. Ammonia has a relatively high oxygen demand (consumes oxygen through transformation to nitrite and nitrate), but it is likely that the formation of metal oxides and sulfides, as well as biotic factors (i.e., bacteria) contributed to the oxygen depletion in the samples.

- Toxicity reductions due to STS reduction and EDTA chelation observed in all species were correlated with elevated pore water concentrations of metals, especially aluminum, copper, manganese and zinc. A similar correlation was also observed at the reference station, indicating that metals-related toxicity may not be site-specific.

- Ammonia toxicity was the predominant source of toxicity removed by TIE procedures for urchins, sand dollars and fish, but other contributors to effects were observed, particularly with the purple urchin. Follow-on testing with sand dollars confirmed that factor(s) other than ammonia contributed to toxicity.

1. INTRODUCTION

The Hunter's Point Shipyard in San Francisco Bay, California, a location with tidal salt, potentially contaminant-impacted aquatic habitats, was chosen as the second site to be evaluated as part of the Sediment Toxicity Identification Evaluation (TIE) demonstration project for NAVFAC. The project was developed to evaluate the effectiveness of TIEs conducted with sediment pore waters to resolve ecological risk concerns. The Technical Proposal for the Demonstration Project was submitted and approved in March 2001 (SAIC, 2001a), and a final addendum to the proposal was submitted in May 2001 (SAIC 2001b). The Hunter's Point site conforms to the principal site-selection criteria developed for the demonstration project:

- An identified need exists for information that may clarify the source of apparent toxicity. One objective of the on-going Validation Study (VS) for the site is to determine the chemical characteristics that will guide remedial decisions to treat, depose or investigate reuse options for the contaminated sediments. Thus, results from the TIE should help to resolve regulatory uncertainties and assist site management decisions.

- The site presents a unique case study relative to environmental and contaminant characteristics at the Indian Head Naval Surface Warfare Center (NSWC), the first site chosen for the demonstration project. Hunter's Point is a saltwater site incorporating numerous habitat types and sources of Contaminants of Potential Concern (CoPCs), while Indian Head is a freshwater riverine site with more defined sources of contamination. Thus, the TIE program should demonstrate applicability in diverse habitat conditions, and serve to address uncertainties with regard to the principal toxic agents that may be found across a wide variety of Navy sites.

The Team involved in the TIE demonstration study at Hunters Point includes the primary technical team (SAIC), the Navy Engineering Field Activity Northeast (EFANE) oversight/liaison team, the Installation Restoration support team at Navy Southwest Division (SWDIV IR staff and contractors), and Regulatory Team (Hunter's Point Base Closure Team). The Team is committed to a close collaboration with the TIE effort to assure successful and efficient study designs and sampling efforts.

1.1. BACKGROUND

Navy Southwest Division (SWDIV) Naval Facilities (NAVFAC) Engineering Command is currently performing a Validation Study within Parcel F at the Hunter's Point site. The purpose of the study is to confirm the location and extent of contamination identified as the "Low-Volume Footprint" delineated in the Parcel F Feasibility Study Draft Report (Tetra Tech EM, Inc., and Levine-Fricke-Recon, Inc., 1998). A site description and history, as well as a review of the findings from previous studies, is presented in the Validation Study Work Plan (Battelle *et al*., 2000a). Fifty-nine surface sediment samples were collected for the Validation Study. Through coordination with SWDIV, extra volumes were collected for eleven of the sediments, including the reference station, to provide split samples for the TIE demonstration.

Accordingly, the TIE demonstration reflects the shared interest of all parties involved to efficiently coordinate a plan that is mutually beneficial.

A recent report summarizing existing sediment chemistry and bioassay data for Parcel F, (Battelle *et al.*, 1999) found exceedences of sediment screening levels for copper, chromium, lead, zinc and polychlorinated biphenyls (PCBs). Nevertheless, toxicity was most strongly correlated to total ammonia. In this and other historical and recent surveys conducted at Hunter's Point, sediment constituents were measured to varying degrees, and considerable uncertainty remained with regard to the potential for toxicity of CoPCs and confounding factors. Only a limited number of samples were fully evaluated to characterize factors that mediate toxicity (e.g., organic carbon and ammonia), and there had been no analyses to determine the relative presence of Acid Volatile Sulfides (AVS) and Simultaneously Extracted Metals (SEM) that affect bioavailability and consequently toxicity in metal contaminated sediments (Hansen *et al.*, 1996). Still, the available data indicate that locations generally characterized by lower Total Organic Carbon (TOC) and or alternatively, high ammonia (NH_4^+), had the greatest potential for toxicity (Battelle *et al.*, 1999; SAIC, 2001a).

1.2. OBJECTIVES

The objectives of this Phase 1 TIE study are to provide data to identify sources and magnitude of toxicity associated with contaminants at the site as well as to characterize the extent to which confounding factors (e.g., ammonia) are potentially involved in the toxic response. The sampling design developed to meet these objectives is presented in Section 2 as well as a review of the technical approaches and methodologies used for field and laboratory analysis. Results and conclusions are presented in Sections 3 and 4, respectively, with references provided in Section 5.

2. TECHNICAL APPROACH

The following Sections discuss the technical approaches used in the selection of TIE stations (Section 2.1), the interpretation of chemistry data (Section 2.2), and the TIE data (Section 2.3). Field and laboratory methodologies (Section 2.4) used in the collection and analysis of toxicity data (Section 2.5) are also presented.

2.1. STATION SELECTION STRATEGY

The choice of sampling locations within the Hunter's Point study area is shown in Figure 2.1-1. Sediment sampling locations chosen from the total of fifty-nine Validation Study stations emphasize sites with CoPCs measured during previous studies that exceed NOAA Effects Range Median (ERM) benchmark concentrations. Stations were chosen to represent the higher concentrations of the range of CoPCs, as well as a broad range of ammonia concentrations. For purposes of the TIE Demonstration, stations were also chosen to cover various source inputs. The stations were selected with regard for each of the following criteria:

- Bulk sediment concentrations exceed benchmarks for potential/probable effects;
- Mediating factors (e.g., TOC, AVS) that may affect chemical bioavailability;
- Confounding factors (e.g., NH_4^+) that directly contribute to toxicity;
- Contaminants other than cationic metal CoPCs (e.g., tributyltin (TBT)) that might contribute to toxicity, based on benchmark Hazard Quotients (HQs); and
- Spatial distribution that reflects unique contaminant sources and different environmental conditions or CoPC distributions that represent gradients in chemical availability.

In order to satisfy the data needs, samples were obtained from eight locations sampled during the Validation Study (Battelle *et al*., 2000a; Figure 2.1-1). Two additional samples were collected from the 5-10 cm stratum as secondary collections following surface sampling (0-5 cm) at the same station. The stations were chosen not only to maximize opportunities to observe and characterize potential toxicity from CoPC and confounding factors, but also to provide a representation of the varying contaminant signatures and sediment characteristics that occur across the Low-Volume Footprint areas. The stations for the TIE were selected from the following areas:

- Point Avisadero (PA); HP-1 and HP-2
- Eastern Wetlands (EW); HP-3
- Oil Reclamation Area (OR); HP-4
- South Basin (SB); HP-5 through HP-10
- Paradise Cove (reference site); HP-REF

In the PA area, stations were chosen to represent the sites where copper, zinc and lead all exceeded ERL values. Stations HP-1 and HP-2 were selected for TIE testing on pore waters from subsurface sediments because of the known elevations in CoPCs, as well as expected differences in sediment characteristics with depth (Battelle *et al.*, 2000a).

One station was selected from both the EW and OR areas in order to represent the potential differences in toxic signatures at the two sites. The EW station represents a single hot spot in the area with four target CoPCs exceeding ERM levels. The OR station is characterized by copper, zinc and lead that were above Effects-Range Low (ERL) values.

In the South Basin Area, six stations on the eastern bank were selected to represent toxic sediment with a mixture of contaminants that exceed ERL values but with consistent Effects Range-Median (ERM) exceedences for zinc. Finally, a subsurface sample (HP-6), co-located with HP-5, was taken because of its proximity to a landfill (Battelle *et al.*, 2000a).

2.2. CHEMICAL EVALUATION

The toxicology of identified chemicals at the Hunter's Point site with respect to the observed toxicity in TIE treatments is a key factor in elucidating the sediment constituents responsible for toxicity. For purposes of the TIE Demonstration, the chemistry data from each of the selected stations were assessed for toxicity potential based on one or more of the following

characteristics: Bulk sediment concentrations that exceed benchmarks for potential/probable effects (Section 2.1.1);

- Divalent metal concentrations (simultaneously extracted metal (SEM)) that enhance potential for divalent metal (Cu, Cd, Pb, Ni, Zn) and silver (Ag) toxicity (Section 2.1.2);
- Pore water benchmark exceedences that reflect location-specific sediment characteristics (e.g., low TOC or low AVS increasing the potential for chemical bioavailability (Section 2.1.3);
- Non-CoPC sources (e.g., NH_4^+) that confound the elucidation of CoPC contributions to toxicity (Section 2.1.4);
- Contaminants other than the identified CoPCs (e.g., pesticides) that could contribute to toxicity (Section 2.1.5); and
- Spatial variation that might reflect novel environmental conditions or CoPC distributions that may represent gradients in chemical availability (Section 2.1.6).

2.2.1. Sediment Benchmark Exceedences.

Results of the bulk sediment analyses were compared to selected sediment benchmarks to reflect the potential for toxicity of the sample. The sediment-based benchmarks used to evaluate the exposure conditions of concern at the Hunter's Point site are from U.S. EPA (1997) and NOAA (1999) and are summarized in Table 2.2-1. Most values are NOAA Effects Range-Median (ERMs) and Aquatic Effects Threshold-High (AET-H) concentrations. When such values were not available, most commonly alternate Aquatic Effects Threshold-Low (AET-L) and Probable Effects Levels (PELs) were used.

It is noted that the above sediment contaminant benchmarks are derived from field measurements of adverse effects expressed in a variety of ways (e.g., toxicity, decreased benthic diversity) and hence frequently reflect the cumulative response to the co-occurrence of multiple contaminants. Often these co-contaminants are at very elevated levels, and most of the data has originated from highly contaminated sites. Accordingly, the resulting chemical-specific benchmarks can be overly conservative. With these uncertainties in mind, it is important to evaluate other measures of potential toxicity, as discussed in the following sections.

2.2.2. Divalent Metals Bioavailability

Simultaneously Extractable Metal:Acid Volatile Sulfide (SEM:AVS) measurements are conducted on sediments to assess the bioavailability and hence toxicity of divalent metals. In this method, the amount of metal liberated form the sample during extraction is measured, and at the same time, the quantity of sulfide released from the sediment is also measured. Sulfides are a common constituent of organic-rich sediments that will bind divalent metals in direct proportion to their respective molar concentrations (Hansen *et al.*, 1996). SEM metals bind to AVS and when concentrations of toxic metals occur in excess of the available AVS concentration (on a molar basis), toxicity can be expected. Hence, for Hunter's Point, SEM:AVS data was used to evaluate the potential for divalent metal toxicity.

The difference approach (SEM-AVS) for quantifying SEM:AVS data was used in the present evaluation as it most accurately represents available SEM concentrations; the more traditional ratio approach (SEM/AVS) commonly used tends to misrepresent available concentrations of SEM at low AVS concentrations. The EPA National Sediment Quality Inventory has adopted the difference approach; an SEM-AVS value of 5 µM/g dry wt is recommended as a screening value for identification of bedded sediments of concern with regard to potential divalent metal effects on aquatic biota (U.S. EPA, 1997).

In planning the Hunter's Point TIE study, estimated as well as measured SEM:AVS data were used to identify locations of potential metal toxicity for the purposes of station selection for the TIE demonstration (SAIC 2001a). Until recently SEM:AVS analyses were not typically included in sediment chemistry measurements, hence the evaluation of historical sediment data for potential divalent metals toxicity is problematic. Here, the concentration of SEM was roughly estimated to be equal to the corresponding bulk sediment concentration due to similarity in the chemical extraction methods for SEM and typical bulk sediment metals analysis (both are weak acid digestion methods). Also, in the absence of AVS data, iron concentration in bulk sediment was used as an indicator of AVS binding capacity. This is because the principal form of AVS is iron monosulfide (FeS), although the more stable pyrite form (FeS_2) might also be present. While this approach was used in the station selection process, direct measurements of SEM:AVS were employed in the TIE investigation.

2.2.3. Pore Water Benchmark Exceedences

Similar to the bulk sediment benchmark comparisons, pore water chemistry data are used for comparison with water quality benchmarks to assess the potential for toxicity of the sample. For chemical contaminants measured in the current study, the appropriate pore water benchmarks are the USEPA Water Quality Criteria - Saltwater Acute (WQC-SA) values (Table 2.2-2), or lacking those, Water Quality Criteria – Freshwater Acute (WQC-FA) values. In the absence of a water-derived benchmark, pore water benchmarks for organics were derived from sediment benchmarks using the Equilibrium Partitioning (EqP) model approach of DiToro *et al.* (1992) as follows:

$$1) \qquad C_p = C_s/(f_{oc} * K_{oc})$$

In the above equation, organic chemical pore water concentrations (C_p, µg/L) are calculated from the corresponding sediment concentration (C_s; µg/kg) based on the fraction of organic carbon (f_{OC}) in the site sediment (f_{oc} = %TOC/100) and the organic carbon/water partitioning coefficient (K_{OC}) for the CoPC. Values for K_{oc} are determined from the relationship developed by the USEPA (Karickhoff *et al.*, 1989):

$$2) \qquad \log_{10}K_{oc} = 0.00028 + 0.983*\log_{10}K_{ow}$$

where K_{ow} = the octanol/water partition coefficient. In this process, it is assumed that the resultant value provides a level of protection equivalent to other water quality based benchmarks. For purposes of completing the benchmark table for organics (Table 2.2-2), the sediment

benchmark values were transformed into water-equivalent benchmarks using the EqP model by assuming a default value of 1% sediment TOC concentration. However, when the sediment-based benchmarks were applied to the site sediment, the benchmark was adjusted based on the measured TOC in each sample. It is noted that these estimated benchmarks tend to be overly conservative, as in many cases they are several orders of magnitude lower than published WQC benchmarks (based on lowest observed effect level) when both are available for comparison.

In the present TIE study, concentrations of chemicals measured directly in pore water (i.e. metals) or predicted using the EqP model described above (i.e. organics), were subsequently divided by the pore water benchmarks to calculate Hazard Quotients (HQs). These HQs were used to assess the potential for pore water chemicals to cause toxicity.

2.2.4. Non-CoPC Toxicity Sources.

In the historical and recent surveys conducted at the Hunter's Point site, ammonia concentrations were positively correlated with toxicity to both the urchin embryos in elutriate preparations and the west coast amphipod, *Eohaustorius estuarius,* in bulk sediment tests (Battelle, 2001). In order to evaluate the relative contributions of ammonia the hazard quotient approach has been applied using both total and un-ionized concentrations. As with pore water contaminants, the U.S. EPA Water Quality Criteria - Saltwater Acute (WQC-SA) values (un-ionized ammonia) have been presented as benchmarks in Table 2.2-2, and corresponding HQs were calculated.

Hydrogen sulfide is another potential contributor to toxicity in pore waters that is often overlooked. In a review focusing on sediment toxicity, Wang and Chapman (1999) provide a comprehensive summary of the available data concerning sulfide toxicity to benthic invertebrates and report 96 hr acute LC_{50} values ranging from 0.02-1.1 mg/L total sulfides. Specific data for the organisms used in the present study were not provided. Hence, these values were qualitatively used to assess potential sulfide toxicity in the present study.

2.2.5. Species-specific benchmark exceedences

Whenever possible, it is desirable to use species-specific benchmarks to derive chemistry HQs that are directly applicable to the species used in a TIE test. For many CoPCs and ammonia, these values are often available in the literature. Table 2.2-3 summarizes species-specific acute effect data, as available, for the three species used in the current TIE study. Data for embryo-larval tests with bivalves are provided for some CoPCs as potential surrogates for the purple urchin or the sand dollar when no data for these species were available.

2.2.6. Spatial Heterogeneity in Sample Toxicity.

Characterizations of existing data for the Validation Study areas have demonstrated a range of contaminant loads, with variability between and within areas (Battelle *et al.,* 1999; Battelle, 2001). Some sources of contamination may be shared between areas while others represent more spatially limited area and/or 'hot spot' concerns, based on sediment benchmark HQs. Ammonia was also variable across sites and areas, with the highest concentrations in the

South Basin. The distribution of contaminants with depth is also addressed though the inclusion of subsurface sampling (5 cm – 10 cm) at two stations, in addition to the surface sediments (0 cm – 5 cm) that were collected for all TIE stations. Generally, the TIE stations represented locations with the greatest potential for toxicity but within this group, factors governing toxicity (e.g., low percentage TOC and fines in the Eastern Wetland, moderate levels of both in the Point Avisadero area, and higher levels of both in the south basin) were evaluated.

2.3. TIE TECHNICAL APPROACH

In a TIE investigation, the physical/chemical properties of sediment pore water samples are manipulated in order to alter or render biologically unavailable generic classes of chemicals (U.S. EPA, 1991). Toxicity tests with aquatic organisms provide responses to each type of manipulation and thus reflect the nature of the sources of toxicity within each sample. Depending upon the responses, the toxic contaminants can be tentatively categorized as having chemical characteristics of non-polar organics, cationic metals or confounding factors such as ammonia (U.S. EPA, 1996).

The basis for conducting the specific TIE steps in the present study was developed by U.S. EPA (1996) where specific methodologies and QA/QC are described. SAIC has modified the order of the EPA approach by performing sequential testing of fractions. This permits documentation of cumulative toxicity removal up to and including the production of completely non-toxic samples (Figure 2.3-1). This approach is preferred because absence of residual toxicity provides a clearer demonstration that all the relevant chemical exposures in a sample can be adequately accounted for. At Naval Submarine Base New London, CT, for example, prior remedial investigation and risk assessment studies for Goss Cove suggested actionable risk although considerable uncertainty previously existed as to the contaminants responsible for risk (Navy RPM News 1999; SAIC 1999). The application of the improved TIE process revealed that ammonia (a ubiquitous non-CoPC sediment constituent) and not the suspected sediment contaminants (e.g., PAHs, metals) was responsible for the toxicity.

The first test species selected for the Hunters Point TIE demonstration was the purple urchin (*Strongylocentrotus purpuratus*), chosen through coordination with toxicity testing conducted by Battelle under the Validation Study. Urchins were obtained from the same source (Steven LePage, MREP) for both studies. The second test organism, the Atlantic silverside (*Menidia menidia*) in the embryo/larval stages, was chosen to represent a fish species with sensitivity to a variety of contaminants. A third, limited series of tests were conducted with the sand dollar, *Dendraster excentricus,* to further resolve the role of CoPCs vs. confounding factors in pore water toxicity.

TIE Manipulations. The Phase I TIE characterization consists of the following characterization steps or tiers: (1) Baseline Toxicity Test, (2) Sodium thiosulfate (STS), (3) Ethylenediamine tetra-acetic acid (EDTA), (4) Filtered Sample Toxicity, (5) Oasis® solid phase extraction (SPE) column, and (6) *Ulva lactuca* incubation The original work plan called for a zeolite treatment to remove ammonia, but preliminary tests conducted by SAIC with a commercial zeolite that had been successfully applied in freshwater tests resulted in poor seawater control responses. Recent

work with *Ulva* for TIE purposes (Ho et al.;1999 and Lapoda and Grovhoug (2001) confirm that this treatment may result in uptake of CoPCs. Hence, as with zeolite, the *Ulva* treatment placement at the end of the TIE treatment is the only way to clearly segregate the effects of ammonia removal. Supplemental tests were conducted with sand dollars, with *Ulva* treatments conducted both first and last. One purpose of these tests was to test for masking effects that can occur when ammonia concentrations are sufficient to result in complete mortality in all treatments, notwithstanding the removal of toxic CoPCs. With the *Ulva*-first treatment, reduction in toxicity resulting from subsequent TIE treatments may underestimate CoPC effects to some degree, but the effects are not masked by ammonia. Each of the pore waters were manipulated according to the sequential extraction scheme shown in Figure 2.3-1. A high pH treatment followed the Oasis® column extraction, independent but in parallel with the *Ulva* treatment. This sequential scheme for pore water manipulations is a revision of the SAIC TIE sequence used in previous studies. Because filtration may remove metals and organics, the placement of the filtration step after the treatments for metals (STS and EDTA) reduces ambiguity of interpretations associated with filtration effects. Filtration has not been found to affect the concentrations of confounding factors.

Guidelines for TIE data interpretation are presented in U.S. EPA (1991) and are summarized below:

1. **Untreated pore water toxicity**. Baseline toxicity tests are conducted to assess toxicity prior to TIE treatment. If no toxicity is observed, TIE manipulations are not performed.

2. **STS**: STS ($Na_2S_2O_3$) is used to reduce oxidants such as chlorine, ozone, chlorine dioxide, mono and dichloramines, bromine, iodine, manganous ions, and some electrophilic organic chemicals and to remove cationic metals including Cd^{2+}, Cu^{2+}, Ag^{1+} and Hg^{2+} (with low reduction of Ni^{2+}, Zn^{2+} and Pb^{2+}) in pore water samples (U.S. EPA 1991). Reduced toxicity indicates oxidants or cationic metals as contributors to overall toxicity of the sample.

3. **EDTA chelation**: Samples are treated with EDTA to chelate divalent cationic metals (i.e., Al^{2+}, Ba^{2+}, Fe^{2+}, Mn^{2+}, Sr^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+}, Co^{2+}, and Zn^{2+}) (Schubauer-Berigan *et al*., 1993a; U.S. EPA, 1991) and render them biologically unavailable for uptake into cell tissues. Reduction in toxicity of the sample after EDTA treatment indicates the above metals are present in toxic concentrations. A fully or partially toxic response indicates that something other than divalent cationic metallic compounds is a contributor to sediment toxicity.

4. **Filtration**: The pore water is filtered with 0.45 μm filter paper to remove particulates. Toxicity tests conducted on the post-filtered fraction indicate potential toxicity associated with large colloids or particulates in the pore water.

5. **Oasis® SPE**: Pore water samples are eluted through an SPE column (Waters, Oasis® short-body type cartridge) to remove polar and non-polar organic compounds (Waters, 2001). According to Waters' procedures, the pore water is eluted through the column at a

rate of 10 ml/min. For each pore water sample, the column is exchanged after 500 ml is eluted. A reduction in toxicity response to the extraction treatment indicates the potential role of organic compounds as a contributor to the toxicity of pore waters.

6. ***Ulva* treatment**: The green seaweed (*Ulva lactuca*) is generally collected on the day prior to test treatments and held in aerated seawater at 15°C. *Ulva* is added to each of the pore water samples (1g/15 ml) and incubated for 5 hours at 15°C (Ho *et al.*, 1997). A reduction in toxicity response following the *Ulva* treatment indicates ammonia as a source of toxicity.

7. **Graduated pH**: Sample pH is manipulated to discriminate between ammonia and hydrogen sulfide as a source for the observed toxicity (Schubauer-Berigan *et al.*, 1993a; Schubauer-Berigan *et al.*, 1993b; U.S. EPA, 1991). If sample toxicity increases with increased pH (8.8 to 9.1), ammonia is suspected. Conversely, if sample toxicity increases with decreased sample pH (7.2 to 7.8), hydrogen sulfide is suspected.

    A. **Low pH**. Not used in this study because pre-test pore water pHs generally ranged from 7.2-7.6 and further reduction could compromise the tolerance levels of the test organism.

    B. **High pH**. The high pH treatment is produced by adding 1N sodium hydroxide to 100% pore water. The dilution samples generally decrease in pH with increasing dilution (generally 0.1-0.2 per dilution) due to the water dilution.

Spiked samples. In addition to the pore water samples from the site, a "spiked" sample consisting of a clean seawater sample amended with fluoranthene and copper at a concentration sufficient to be toxic was prepared and subjected to the TIE treatments. This sample serves as a positive control for assessment of the capacity of the TIE treatments to selectively remove toxicity and is treated in the same manner as the pore water samples. Details about the spiked sample as well as the field sampling, chemical analyses and toxicity testing procedures are provided in Section 2.3, below.

***Reverse-phase Tests*.** A follow-on TIE test series was conducted using the embryo-larval-larval sand dollar test (*Dendraster* was a replacement echinoderm for the original urchin test species, due to seasonal availability). In these tests an additional, modified sequence was employed, placing *Ulva* additions first to remove the potentially masking effects of ammonia toxicity prior to the assessment of toxicity reduction due to other treatments. The modified design was applied to a three-station subset of the original test stations.

Screening Tests. Prior to TIE testing, pore water screening tests were conducted on samples from the ten stations chosen for the TIE. Screening tests were conducted using the same urchin embryo-larval development test (U.S. EPA, 1995) planned for the full TIE. The urchin larval development test was performed on 100%, untreated pore water, with three replicates per sample. The intent of the screening tests is to eliminates the potential to conduct a full TIE on pore waters that are unexpectedly non-toxic; it also provides the opportunity to limit

the dilution series in cases where more dilute samples would be non-toxic. If the screening test resulted in ≥ 50% reduction in normal development relative to the control response, a four dilution series (10%, 25%, 50% and 100%) TIE would be conducted. If less than a 50% effect was observed, only the 50% and 100% pore water samples would be tested in the TIE manipulation series. Water for control exposures and dilution water was clean saltwater, filtered to 10 µm, in all TIE tests. Reference treatments for TIE tests consisted of pore water extracted from the Paradise Cove reference sediment.

2.4. FIELD SAMPLING, CHEMICAL ANALYSIS AND TOXICITY TESTING PROCEDURES

The Hunter's Point TIE Demonstration was an integrated effort involving sediment sampling, bulk toxicity testing, pore water TIE testing and chemical analyses of sediment and pore water. The following sections provide an overview of these tasks; statistical methods to facilitate interpretation of the data are discussed in Section 2.4. Complete details are provided in the Project Work Plan (Appendix C).

2.4.1. Field Sampling and Pore Water Extraction.

As introduced in Section 2.1, field sampling to collect sediment samples was conducted in conjunction with the SWDIV-NAVFAC Hunter's Point 'Low Volume Footprint' Validation Study (Battelle *et al.*, 2000a). Battelle collected the samples and prepared the splits of the homogenized bulk sediments during the second to fourth weeks of May 2001. TIE samples were shipped from Battelle to the toxicity-testing laboratory (Aquatec Biological Sciences, Williston, VT) on May 30th 2001 and arrived the following day.

For toxicity screening tests (as described in Section 2.3), 60 ml of pore water was extracted from homogenized sediments using the syringe extraction method (Winger and Lassier, 1991). Personnel re-homogenized the sediments and inserted a 50 ml syringe to extract pore water from each sediment bucket. Individual syringes were filled full in as little as 2 hrs or as long as 10 hours generally depending on the sediment grain size. This method served as an efficient means to collect the small volume required for the screening test. Subsequently, pore waters for TIE testing were extracted on June 4th - 5th by centrifuging the samples at 7500 rpm for 15 minutes. A total of 1800-2000 ml were collected from each sediment sample to provide sufficient water for the TIE and analytical measurements. The resulting pore water samples were shipped to SAIC for TIE manipulation.

Various pore water extraction methods are known to produce differing results in TIE studies, with syringe extraction generally resulting in lower levels of toxicity than high speed centrifugation (U.S. EPA, 1991). In a recent workshop convened to assess the state of the science of pore water testing, several advantages of centrifugation for laboratory extractions were noted, including low potential for changes in chemical equilibrium (for both metals and organics), and efficient extraction of both hydrophilic and hydrophobic compounds. Principal disadvantages cited would have toxicity-reducing effects, included sample oxidation, and cell lysis that could contribute DOC(Adams et al, 2001). Also, centrifugation is ineffective in sandy sediments.

2.4.2. Toxicity Testing Methods.

Sediment/Interface toxicity characterization. Sediment toxicity tests (10-day bulk sediment survival of adult amphipods) and Sediment Water Interface (SWI) tests (with larval stages of purple urchins, *Stronglyocentrotus purpuratus*) were conducted by Battelle as part of the Validation Study (Battelle *et al.,* 2000a). These data were used to augment findings from the screening and TIE tests discussed below. Findings from the TIE contribute another line of evidence regarding aquatic risks at the site, and will be evaluated in the context of the various aspects of environmental relevance associated with each set of test results.

Test organisms. Phase I TIE methods (U.S. EPA, 1996) are designed for acutely toxic samples and are based on the use of larval test organisms; all exposures were conducted in 20 ml Fisher Brand HDPE vials in a volume of 10 ml. Larval urchins and sand dollars were obtained from MREP in San Diego, CA (who also supplied organisms used for the Validation Study toxicity test). Fish embryos were obtained by SAIC using in-field techniques to strip gametes and fertilize eggs (U.S. EPA, 1987). The fish were collected from Bissel Cove in North Kingstown, RI, using a seine net. Collection temperatures were 17 $\pm$ 2°C, and collections occurred on three separate days. Embryos were cultured in filtered seawater with aeration at temperatures between 18 and 24 °C with temperature conditions varied by batch to insure that hatching occurred either immediately prior to test initiation, or during the anticipated 48-hour exposure period.

Experimental Design. Test procedures generally followed the reduced-volume methodology developed by the EPA for TIEs (U. S. EPA, 1996) and are outlined in Table 2.4-1. Dilutions of the pore water were prepared to generate a series of test concentrations: 10%, 25%, 50% and 100% for the purple urchin test; 50% and 100% for the fish test; and 1%, 10%, 50% and 100% for the sand dollar test. One control treatment was run in parallel with each TIE manipulation. The above experimental design resulted in a total of 264 (11 samples x 4 dilutions x 6 treatments) toxicity tests with the purple urchin, 154 tests (11 samples x 2 dilutions x 7 treatments) with the fish and 160 tests (4 samples x 4 dilutions x 10 treatments) with the sand dollar, plus controls for each treatment and species. Each test was performed in triplicate, and included an additional water-only chamber to monitor water quality.

Spike sample testing. A positive control "spiked" sample was prepared by chemically amending a dilution water sample to produce a measured copper concentration in the untreated sample of 315 µg/L and a nominal fluoranthene concentration of 200 µg/L. The copper was expected to be toxic to the urchin in all dilutions based on the reported EC_{50} value of 24 µg/L for the larval development test (Bay *et al.*, 1993). Toxicity to the fish was expected in the 50% and 100% spiked samples, based on the LC_{50} value (136 µg/L) reported in EPA Aquatic Life Criteria Document for Copper (U.S. EPA, 1985a). Fluoranthene was not expected to be toxic to either species, but was added to the test matrix to track the effectiveness of TIE treatments for copper in the presence of a common organic contaminant.

Water quality. Water quality measurements (temperature, dissolved oxygen and pH) were recorded for each sample prior to distribution into the dilution series. Temperature was

monitored daily in all treatments. Upon test termination, pH and dissolved oxygen were measured in one animal exposure replicate and in a separate water quality replicate.

2.4.3. Analytical Chemistry Methods.

Sub-sampling for Chemical Analyses. As an integral part of the Validation Study, the sediments were also analyzed for priority contaminants, including all CoPCs. The resulting data, as well as other measurements that are critical in the evaluation of sediment characteristics associated with toxicity, including total organic carbon (TOC), grain size and percent moisture, were provided to SAIC by Battelle (Battelle, 2001).

In addition to the Validation Study sediment analyses, laboratory analyses of pore water metals and sediment SEM and AVS were conducted on the eleven TIE samples. On 5 June 2001 re-homogenized sediment were sub-sampled into clean glass bottles for chemical and physical analyses and airfreighted on ice for overnight delivery to the subcontract laboratory (Severn-Trent Services, Baltimore, MD). At the same time, sub-sample of each of the pore waters selected for TIE testing were preserved with 10% nitric acid in clean polyethylene containers and shipped for metals analyses.

Laboratory analyses of SEM:AVS as well as metals in pore water were conducted according to methods outlined in the NOAA Status and Trends Program (NOAA, 1998). These multi-elemental techniques provide sensitive results with a high degree of accuracy and precision (NOAA, 1998). Details regarding sample measurements and QA/QC are provided in the report to SAIC from its contractor, Severn/Trent Laboratories.

Individual analytes are listed with Method Detection Limits (MDL) in Table 2.4-2. MDLs were established for each analyte before analyses were conducted. Laboratory analysis of metals and organic contaminants in bulk sediments were conducted as part of the Validation Study (Battelle *et al.*, 2000a). Sediment evaluations also included TOC and grain size distributions for each sample. Battelle provided SAIC with results from sediment and initial pore water analyses (salinity, pH, ammonia and sulfides), including QA/QC erratum for all analyses (Battelle *et al.*, 2001).

2.5. Analysis of Toxicity Data

In the present study, the interpretation of the toxicity data relied upon three lines of evidence (in decreasing order of importance: 1) results of individual dilutions (10%, 25%, 50% and 100% pore water concentration) compared among treatments, 2) reductions in toxicity relative to performance controls, and 3) cumulative toxicity reductions in the treatment compared to previous treatments. Also calculated was the concentration of pore water required to cause 20% and 50% adverse effects in exposed animals (LC_{20} and LC_{50}) in the fish and effects concentration (EC_{20} and EC_{50}) in the urchin and sand dollar. These values were calculated by linear interpolation of the survival results from each of the TIE treatments (4 dilutions x 3 replicates). ToxCalc software (version 4.0.8, Tide Pool Scientific Software, 2000) was used to generate test statistics including a test for normality of the distribution of the data (Shapiro-Wilkes test) and

confidence intervals by the bootstrapping technique. These results also contained statistical comparisons of each dilution with the performance control (evaluated by ANOVA followed by Dunnett's test to detect statistical differences from controls, alpha = 0.05).

It should be noted that in the qualitative evaluation of the toxicity data, the potential for observing residual toxicity (i.e., sources of toxicity that are not explained by any of the TIE treatments) is greatest at the highest dilutions. Here, exposure concentrations are most likely to exceed removal capacity of the treatment for the particular chemical (Hockett and Mount, 1996). The relevance of the undiluted exposures must also be considered in light of actual exposure concentrations in the field, in that neither the sea urchin embryos nor the fish larvae are likely exposed to full strength pore water for extended durations.

3. RESULTS

3.1. CHEMICAL CHARACTERIZATION OF SEDIMENTS AND PORE WATERS

As discussed in Section 2.1, HQs were calculated by normalizing sediment and pore water concentrations of chemicals to appropriate benchmarks. Results from laboratory analyses of sediments (Appendix A-1-1, A-1-2) and pore water metals (Appendix A-1-3) as well as predicted pore water concentrations for organics (Appendix A-1-4) have been converted into HQs (Appendices A-2-1 and A-2-2, respectively) through normalization to the respective sediment and pore water benchmarks as discussed in Section 2.1. A brief summary of the HQ results is presented here; a more detailed discussion is incorporated into the toxicity results addressed in Sections 3.2 and 3.3.

Interpretive summaries for sediment and pore water HQs can be found in Table 3.1-1 and Table 3.1-2, respectively. Results were categorized in a manner deemed useful for prediction of acute toxicity responses in the TIE treatments: A concentration above the acute threshold (HQ>1) suggests a possible toxicity ("+"), while elevations that are three-fold and ten-fold above the benchmark indicate likely ("++") and probable ("+++") toxicity, respectively.

The sediment HQ calculations show that all ten of the TIE stations and the reference station had at least two analytes above sediment benchmarks (Table 3.1-1) and that up to seven benchmark exceedences were observed, albeit at only one station (HP-8). Analytes showing the most common exceedences were cobalt, manganese and nickel, which exceeded benchmarks at all stations (including the reference station), and Total PCBs, exceeding benchmarks at seven stations. Less frequent exceedences were observed for mercury (five stations), copper (four stations) and chromium (one station). Of the metals, only nickel was present in concentrations greater than three times the benchmark, and at only two stations (HP-4 and HP-8). Values for SEM-AVS were negative except in samples HP-1, HP-8 and HP-REF, where SEM exceeded AVS by 1.2, 1.3 and 0.4 μmole g^{-1} respectively. For Total PCB exceedences, all but one were three-fold above unity. Two pesticide exceedences were observed (4, 4'-DDD, HP- 8 and dieldrin, HP-6); no PAH exceedences were observed.

The HQs derived from pore water concentrations indicated that manganese exhibited elevations above the acute benchmark at all stations including the reference station (Table 3.1-2). The highest manganese exceedence, greater than ten-fold above the benchmark, was observed at the reference station. Copper also frequently exceeded the benchmark (at nine stations and the reference station), with the highest exceedence (greater that ten-fold unity) observed at HP-7. Other notable exceedences were for aluminum (three stations and the reference station) and arsenic (one station), while a minor zinc exceedence was observed at HP-7. Neither PAHs nor PCBs exceeded benchmark based on pore water estimates made from sediment concentrations using the equilibrium-partitioning model.

The HQs derived for un-ionized ammonia exceeded unity for every station other than HP-6 (Table 3.1-2). Station HP-3 had a concentration that exceeded the benchmark by greater than a factor of ten. Most other stations (HP-4, HP-5, HP-8, HP-9 and HP-10) exceeded the benchmark by greater than three-fold. The remaining stations (HP-1, HP-2 and HP-7) exceeded the benchmark to lesser degrees.

A species-specific HQ table (Table 3.1-3) was prepared to represent pore water risks to the test species. For urchins, copper HQs were above reference (HQ=1.5) at Stations HP-7 (HQ=16), HP-8 (HQ=5.8) and HP-10 (HQ=2.2). The urchin benchmark for zinc was also higher than reference (HQ=1.4) at Stations HP-2 (HQ=2.1), HP-7 (HQ=11), HP-8 (HQ=7.8) and HP-10 (HQ=2.4). Finally, the urchin benchmark for aluminum was exceeded at all stations but was above reference (HQ=8.5) only at Stations HP-7 (HQ=61) and HP-8 (HQ=23). Other than the exceptions noted above, the HQs for copper, zinc and aluminum across the HP stations were low (0.7 to 2.4) and below reference.

The species-specific pore water HQs for larval fish and sand dollar were lower than those observed for the urchin. For copper, only one station approached concentrations representing potential acute toxicity to fish (HP-7; HQ=0.95). Manganese HQs for fish at the HP stations included five values ranging from 1.0 to 2.3 (Stations HP-4, HP-1, HP-5, HP-9 and HP-8, in order of increasing HQs). The reference station was also elevated (HQ=3.9). Finally for the sand dollar, two stations (HP-7 and HP-8) were above acute toxicity thresholds for copper, with HQs of 6.5 and 2.3, respectively.

For ammonia, the species-specific HQs were much higher for the urchin than for the fish owing to the greater sensitivity of urchins to ammonia. Because the measured ammonia concentrations represent pore water used to test both species, the fish follow the same relative potency pattern as the urchin. Un-ionized ammonia HQs for the urchin (derived from un-ionized ammonia concentrations calculated from Total Ammonia; Appendix A-3), were greater than ten for six stations (HP-5, HP-8, HP-4, HP-9, HP-10 and HP-3, in order of increasing values). Three of the remaining stations (HP-1, HP-2 and HP-7) had HQs between 3 and 10 while Station HP-6 had an HQ of 1.1, below the reference station value (HQ=2.1). For the fish, un-ionized ammonia HQs were in the acute effects range (i.e. HQ>1) at Stations HP-3, HP-9 and HP-10, and an order of magnitude above reference (HQ=0.1).

3.2. TOXICITY RESULTS IN SEDIMENT AND WATER MATRICES

Results of bulk sediment survival with the amphipod were evaluated in conjunction with chemistry results discussed above to select the pore waters to be used for the TIE investigation. Survival of the amphipod in bulk sediment samples ranged from 72% to 102%, when normalized to the control survival of 97% (Table 3.2-1). Survival in both sediments from Point Avisadero (HP-1 and HP-2, surface and subsurface samples, respectively) was 75%. Survival results in the Eastern Wetland sediment (HP-3) and in the Oil Reclamation Area (HP-4) were both equivalent to control responses. Generally, toxicity was not observed in the South Basin sediments, but survival in two of the six representative sediments (HP-6, a subsurface sample) and HP-9) were 72% and 76%, respectively. Results from the current bulk sediment test are consistent with those reported in the Parcel F Data Summary report (Battelle *et al.*, 1999). Grain size analyses results compiled into three size fractions, gravel, sand and fines (silt + clay), are presented in Appendix A-4. The majority of the stations contain greater than 50% fines except for several stations (HP-3, 7, 8 and 10) that contain a considerable (>70%) sand component. Moisture content of the samples was fairly consistent, ranging from 25-57%. These parameters are within acceptable ranges to the amphipod.

For the present round of amphipod bulk sediment tests, the pore water ammonia concentrations are similar to ammonia measured in pore waters collected for the TIE study (Table 3.2-2). Values were variable, ranging from 4.4 mg/L to 34.9 mg/L, and did not correlate well with the marginal toxicity observed. In this range of concentrations, ammonia toxicity is not expected, as amphipods are reported to tolerate total ammonia concentrations < 60 mg/L (U.S. EPA, 1994). The TOC concentrations in the sediment and in pore water samples are also presented in Table 3.2-2. Concentrations were generally low, ranging from 0.34 to 1.7% across all sediment samples used for the TIE.

Table 3.2-1 presents a summary of toxicity observed in pore water TIE tests with the urchin and fish relative to the toxicity test results from bulk sediment tests with the amphipod. The effects observed in the SWI tests with urchins are also presented. The total absence of normal development in the urchin exposed to 100% pore water contrasts dramatically with the minimal effects on survival of the amphipod in bulk sediment exposures. Almost as dramatic and more difficult to explain are the differences between the rate of normal development of the urchin in 10% pore water compared with development of the same species in SWI exposures, where the dilution was only 1:5 rather than 1:10. Survival of the fish in exposures to 100% pore water in the TIE test represent yet another unique pattern of toxicity across the set of ten stations. While differences in results from bulk sediment, elutriate and pore water tests are common in sediment toxicity assessments, the degree of differences observed here is unusual, and provides opportunities to discern the qualities of the samples that resulted in this broad range of response. Principal attributes of the bulk sediment test, one or more of which would account for the relatively low adverse response rate, include: 1) a mode of exposure characterized by limited uptake of pore water; 2) retention of contaminants by particulates and chemical complexes with lower availability in interstitial pore water than in extracted pore water, and 3) lower sensitivity of the amphipod relative to the urchin and fish. The latter is the most probable explanation when ammonia toxicity is likely.

In the SWI test, the urchin exhibited minimal adverse effects relative to the same species in pore water exposures. A partial explanation for this could be that while the SWI test preparation has a dilution component similar to the lowest dilution in the pore water test (5 vs. 10), potential contributors to toxicity, including ammonia and contaminants were only made bioavailable by the process of centrifugation. Another procedural factor that was unique to the pore water collection and handling was the need to oxygenate most of the samples prior to test initiation. Several of the pore waters had very high oxygen demand, with dissolved oxygen measurements falling to concentrations as low as 0.2 mg/L in samples prepared for TIE testing. An oxygenation process was required to provide the best potential to meet acceptable water quality conditions for the toxicity tests, and associated changes in potential sources of toxicity resulting from this pre-TIE manipulation are possible. However, this seems an unlikely cause for increased toxicity because metal toxicity is usually ameliorated by oxidation reactions (O'Day *et al.*, 2000). Also, the different responses of the fish and urchins exposed to pore waters are consistent with differences in tolerance of the two species (Table 2.2-3).

One of the simplest effects of oxygenation is elevation in pH corresponding to the displacement of CO_2. While all sample pHs increased over the course of the TIE test exposures, the oxygenated samples tended to increase 0.2-0.4 pH units more than non-oxygenated treatments (e.g., 7.4 to 8.4 vs. 7.4 to 8.2). Thus oxygenation through pH changes could potentially have facilitated the oxidation of ammonia to free atmospheric nitrogen but it is more likely that the process, resulted in some shift in the relative concentrations of ammonia, nitrite and nitrate, which are also toxic to varying degrees. Also, the pH shift increased the proportion of the more toxic un-ionized ammonia form. Oxidation of Fe^{+2}, Mn^{+2}, hydrogen sulfide and dissolved organic carbon (DOC) as well as the elimination or oxidation of volatiles are also potential outcomes resulting from oxidation (Adams et al., 2001), and especially from oxygenation .

3.3. TIE RESULTS

The interpretation of TIE toxicity responses is based on both the observed magnitude of the toxicity in the treated sample and the relative change in toxicity from the previous samples in the TIE sequence. It is also useful to evaluate changes as they occur across the sample dilutions. Some toxicants may only exhibit effects in less dilute samples while others may be evident across multiple dilutions. Changes in toxicity of a potent toxicant may only be seen in dilute samples, when additional toxic constituents mask the removal of a single class of toxicants. The individual dilutions responses are presented with highlighting to illustrate changes in toxicity with each TIE treatment (Tables 3.3-1 to 3.3-3; laboratory report presented in Appendix B-1). Responses that are statistically different from performance control responses are presented in boldface. In addition, the relative magnitudes of changes associated with each TIE manipulation for each sample are synthesized in Tables 3.3-4 to 3.3-6. Supporting lines of evidence are obtained with assistance from plots of mean survival responses versus pore water concentration (Appendix B-3), and also from calculation of statistical endpoints that estimate dilutions (pore water percentage) that would result in specific levels of mortality ('LC' values; Appendix B-4 to

B-6; interpretive summary presented in Appendix B-7 to B-9), including corresponding 95% confidence limits for each treatment calculated with Toxcalc software (Appendix B-2).

In the sections below, results of QA/QC procedures are presented first to assess the efficiency of the treatment procedures (Section 3.3.1). Next, an interpretive summary of the TIE responses is presented to provide the reader with an overview of the study findings (Section 3.3.2), as well as a discussion of the patterns of response that may vary spatially across the study area. Section 4 presents a synthesis of treatment responses evaluated in conjunction with the associated chemistry, whereby specific chemicals or confounding factors are attributed as likely toxicity sources. Uncertainty generated through the data synthesis process is also reviewed.

3.3.1. Quality Assurance Results for TIE Tests

Completeness. The urchin screening test exposures were conducted as described in the Work Plan (Appendix C). For the TIE tests with the urchin, the low pH treatment was excluded from the final test design because pore water pHs in the range of 7.2-7.6 approached acceptable limits for testing, and further reductions were not warranted. The fish were available in limited supply and for this reason, only the 100% and 50% dilutions were tested. In addition, because partial hatching occurred prior to test initiation, embryos were generally distributed to the 50% dilutions and newly hatched larvae were used in the 100% pore waters. In some of the 50% dilutions there were only sufficient animals for two replicates rather than three. Because no effects were observed in the fish exposed to 50% dilutions, the shortage of animals did not compromise interpretation of results. There was a shortage of pore water from HP-7, resulting in the omission of the filtrated pore water test with the urchin, and all of the 100% samples for the fish. The shortage was due to a centrifuge explosion that occurred during the pore water extraction of HP-7 sediment.

Performance standards. In the screening test conducted with urchins, all test criteria were met and performance controls were highly successful, with a mean of 92% normal development. The reference toxicant test with copper also performed within control standards. In the TIE tests, normal development in each of the control treatments was sub-optimal, ranging from 59 to 78% normal development. This was attributed to the additional sensitivity of the test organisms, which were collected very late in the spawning season (only a few out of several dozen animals could be spawned). The high pH treatment was omitted from analyses because the performance control response (53% normal development) was lower than the performance control results for the other treatments, and because pHs at the end of the exposure were not different from the treatments without pH adjustment. Given the normally strong buffering capacity of seawater, the large number of test chambers (~ 1000, in this case), and small volumes it was difficult to maintain constant pH exposure conditions. In the tests with the sand dollar, control treatments produced high rates of normal development, ranging from 90% to 96% in all treatments with the exception of the *Ulva*-last treatment where normal development was anomalously low (60%). The reference toxicant test conducted with sand dollars exposed to copper performed within control standards.

Most of the pore waters received for TIE exposures also had very low DO values (<1 mg/L), with the exception of HP-1. Stations HP-2 and HP-4 and the reference site (HP-REF) were also marginally hypoxic (3-5 mg/L); the control and spiked samples and HP-1 were not hypoxic. All hypoxic samples were bubbled with pure, medical grade oxygen, to reach an initial concentration of > 20 mg/L. This step was required in order to provide sufficient DO to prevent mortality in the fish (LC_{50}= 2.5 mg/L; U.S. EPA, 2000). Even with oxygenation, HP-3, HP-8 and HP-10 still had DO < 1.0 mg/L on Day 1 and complete mortality of fish larvae occurred in the untreated pore waters of these samples. Because DO less than 1.0 mg/L is known to be lethal to larval fish (U.S. EPA, 2000), the TIE tests with this species were not considered useful in assessing other potential sources of toxicity. However, all three of these samples did have complete survival following the *Ulva* treatment, where DO levels were acceptable. In this case, the *Ulva* not only removed sufficient ammonia to allow survival, but photosynthesis also provided supplemental oxygen to restore D.O. to acceptable levels for the larval fish. For urchin exposures, low DO concentrations (< 1.0 mg/L), were occasionally observed (Appendix B-10), but not to an extent that TIE responses should be masked by DO effects. Embryo-larval tests with bivalves have indicated that DO concentrations between 0.5 mg/L and 1.0 mg/L are not lethal in exposures up to 24 hrs (Morrison, 1971; Huntington and Miller, 1989). It appears that sea urchins and sand dollars in this stage may have similar or greater tolerance.

Finally, spurious pHs were recorded in the performance control (PC) water, (seawater collected from Narragansett Bay at the U.S. EPA Laboratory during the week of the TIE, filtered with 1µm glass fiber filters) and in the spiked sample generated using control water. Low pHs (6.9, 6.8) occurred in the EDTA treatment PC and spike while high pHs (9.2, 9.3) resulted from *Ulva*-treated PC and Spike samples. This indicates an abnormal ionic matrix with low buffering capacity in the control water. This effect was not observed in any other samples, or in any other TIE treatments involving control water.

Spiked sample results. A spiked sample containing 315 µg/L (measured) copper, 200 µg/L (nominal) fluoranthene, and 25 mg/L (measured) ammonia was used in TIE toxicity tests with urchins and fish in order to demonstrate the effectiveness of the TIE manipulations. For the urchin, the initial untreated, undiluted sample was toxic to 100% of exposed organisms at all dilution levels (Table 3.3-1). Following all TIE treatments, approximately 79% of the originally observed toxicity was removed. Of this, STS contributed little to toxicity reduction, but the EDTA treatment removed 46% and *Ulva* removed the remainder. It is most common for STS to remove copper toxicity, but higher removal capacity with EDTA has also been reported (Hockett and Mount, 1996; Schubauer-Berrigan *et al.*, 1993a). TIE treatments should not be expected to totally remove toxicity in all case, particularly when the spike represents a very high level of toxicity (e.g., the copper species-specific HQ was 39; 6.7 times the highest level measured in TIE pore water samples). The efficiency of toxicity reduction reported here is similar to the illustration provided in the EPA TIE saltwater guidance document (U.S. EPA, 1996), where separate treatments of STS and EDTA reduced toxicity in sea urchins exposed to copper-spiked samples from 5 to 2.2 and <2.0 but >1.0 toxic units, respectively.
For the fish, following TIE treatments of the spiked sample, 100% of the toxicity was removed indicating the general success of the TIE process for a matrix that was moderately toxic to this species. Here, the initial response to 100% untreated pore water was 7% survival and survival

increased with successive treatments (STS, 47%; EDTA, 53%; filtration, 80% and *Ulva*, 100%). Filtration and Oasis® SPE steps both resulted in moderate increases in toxicity in the 10% and 25% dilutions. The cause of this response is unclear but it is possible that a toxic constituent of the SPE column eluted into the sample. This effect was noted in evaluating the general pattern of residual toxicity observed in the TIE series (Section 4). Trends towards increasing toxicity in larval fish toxicity occurred following the Oasis® SPE treatment in several spiked samples, as with the urchin tests. It is notable that the apparent reduction in toxicity following the STS treatment of the spiked sample differs from the urchin test where the reduction to fish occurred with EDTA. This suggests different modes of toxic action for these two species since the exposure water was the same in both cases.

3.3.2. Summary of TIE Results by Treatment and Location

Tables 3.3-1 to 3.3-3 summarize the individual dilution results from toxicity testing with the urchin, fish, and sand dollar, respectively, while Tables 3.3-4 to 3.3-6 present a quantitative toxicity reduction analysis of the TIE data for these species. For the dilution results, the data are shaded to indicate a reduction in toxicity relative to the preceding TIE treatment(s), and values are bolded when results are different from the performance controls. As discussed previously, lower dilutions (e.g., 10%) represent less concentrated samples. Where toxicity occurs in the more dilute sample, TIE treatments may be more effective in revealing the most potent sources of toxicity because the additional stresses of other less toxic factors no longer mask the effects of the more potent constituents. For the toxicity reduction data, the sum of toxicity across all dilutions was calculated and compared to the prior treatment result to obtain the percent reduction in toxicity achieved by the treatment.

Purple urchin TIE results. From the synthesis presented for sea urchin tests (Table 3.3-1), it is clear that ammonia was evident as a source of toxicity in most samples and in most dilutions. The next most prevalent signal for reduction in toxicity was from STS, and in some samples the metal toxicity signal was split between STS and EDTA. Evidence of potent contributors to toxicity are represented by embryo-development impairment that occurred in the baseline, pre-TIE 10% pore water concentrations; all pore waters except HP-5 experienced <22% normal development at the 10% concentration (Table 3.3-1). After STS additions, five of these samples (HP-1, HP-4, HP-5, HP-6 and HP-9) yielded >46% normal development, while the reference station (HP-REF) also improved substantially (>44% normal development). Results from the 10% dilution indicate that in samples listed above, metals were the most potent contributor to toxicity. Overall, including all dilutions of these samples, STS accounted for 20% to 62% of the total toxicity removed by TIE treatments (Table 3.3-4). The greatest reduction in total toxicity from the STS treatment occurred in sample HP-6, including reduced toxicity in the 50%, 25% and 10% dilutions. Total and calculated un-ionized ammonia were the lowest in this sample. In other samples, the concentrations of ammonia present until the final TIE treatment were sufficient to limit the degree of metal toxicity that could be detected by the TIE. For HP-2, STS had limited effect, while toxicity was largely removed by EDTA at the 10% concentration.
Of the four samples where toxicity did not change with STS (HP-2, HP-3, HP-8 and HP-10) in the10% dilution, HP-3, HP-8 and HP-10 had un-ionized ammonia HQs that were still above the acute effects range (i.e., HQ>1 for 10% of values in Table 3.1-3). Hence, for these three

samples, it was presumed that ammonia toxicity was still sufficient to mask other potential sources of adverse effects addressed by the TIE treatments. As noted previously for the spiked sample, the Oasis® SPE treatment resulted in moderate increases in toxicity.

Fish TIE results. For the fish larvae, which are more tolerant of ammonia than embryo-larval stages of the urchin (LC_{50} =37 mg/L vs. 2 mg/L total ammonia), toxicity was only observed in the 100% pore water samples (Table 3.3-2). No toxicity occurred in HP-2, HP-6, or HP-Ref; these samples had the lowest ammonia concentrations (HQs < 0.2; Table 3.1-3). Of those samples with complete mortality in 100% pore water (HP-3, HP-8, HP-9, HP-10) all had pore water un-ionized ammonia HQs $\geq$ 2. In contrast, only partial mortality was observed when HQ $\leq$ 2. However, in HP-3, HP-8 and HP-10, DO values < 1.0 mg/L were observed, which by itself could cause complete mortality in all treatments prior to the *Ulva* treatment. Therefore, the test was not effective in elucidating other potential toxicants effects in these samples. The *Ulva* treatment restored DO photosynthetically while removing ammonia, restoring conditions necessary for full survival, indicating that there were no residual toxic effects. As with the sea urchin, reduction in toxicity due to toxic constituents other than ammonia (e.g., manganese) might have been masked even if low DO had not been a confounding factor. In one case (HP-9), filtration accounted for a 34% reduction in the total reduction in toxicity (Table 3.3-5). Moderate reductions (53%) in toxicity were also observed following the STS treatment of HP-4. Finally, the high pH treatment did little to alter toxicity because the non-adjusted pHs drifted upward during the course of the test, approaching the 'High pH' treatment values.

Sand dollar results. A follow-on test was conducted with the sand dollar, *D. excentricus*, using fresh pore water re-extracted from stored sediments. Samples chosen for additional testing included HP-4 from the Oil Reclamation Area, and HP-5 and HP-9 from the South Basin. These samples were chosen because they were among the samples that had caused mortality during the fish test that was not fully attributable to ammonia. In this procedure, the original sequence of TIE treatments was repeated, but was accompanied by a reverse sequence where the *Ulva* treatment was applied first to remove ammonia prior to the other treatments.

Dilution results for the sand dollar are presented in Table 3.3-3. Similar patterns to the original urchin exposures were observed, but were somewhat less pronounced than those previously manifested. HP-4, from the Oil Reclamation Area, exhibited lower overall toxicity than in the original test, with no toxicity in the 10% concentration. Interestingly, in the 100% concentration, a large reduction in toxicity occurred only in the *Ulva* treatment when it was the final treatment, but in the *Ulva*-1st treatment, gradual increases in normal development occurred with *Ulva*, STS and EDTA applications. This is similar to the original test, where 29% of the total toxicity was removed by STS. In HP-5 at the 10% concentration, the EDTA-1st and *Ulva* last treatments reduced toxicity by 27% and 24%, respectively (Table 3.3-6). Conversely, when *Ulva* was the first treatment, all of the toxicity was removed. A similar effect was observed for HP-REF at the 50 and 100% dilutions. In HP-9 (10%), small reductions in toxicity occurred through each of the first three treatments (STS, EDTA and filtrations), yielding 54% normal development in the post-filtered sample, and an additional gain of 24% following *Ulva* treatment. Like HP-4, the *Ulva*-1st treatment removed all toxicity in all but the 100% concentration. In the undiluted sample, the combined STS and EDTA treatments reduced effects by 20%.

This follow-on test suggests that the *Ulva* treatment from HP-5 (10% dilution), HP-4 (50% dilution), HP-9 (50% dilution) and HP-REF (100% dilution) removed toxicity. This would indicate that there was no constituent more toxic than ammonia, although it is also possible that the toxicant(s) present in the original samples had diminished relative to ammonia. If this were the case, the results from the urchin test either reflected ultra-sensitivity to certain components of the pore water matrix, possibly due to compromised condition of the animals, or to a greater natural sensitivity in the urchin than in the sand dollar due to factors other than ammonia.

Spatial trends. Regarding TIE responses for each of the four Hunter's Point areas targeted for the study, the Point Avisadero exposures (HP-1 and HP-2), were the least influenced by ammonia, and STS effects and/or EDTA responses occurred. Conversely, the Eastern Wetland (HP-3) was largely affected by ammonia. The Oil Reclamation Area (HP-4), South Basin and Paradise Cove (HP-REF) samples had intermediate ammonia effects. The latter samples also tended to exhibit STS effects (HP-4, HP-5, HP-6, HP-7, HP-9 and HP-REF).

The surface and subsurface samples from Point Avisadero exhibited nearly identical responses to STS, EDTA and *Ulva*, and were non-toxic or minimally toxic to the fish. In South Basin, HP-5 and HP-6 also represented co-located surface and subsurface samples, with substantially lower ammonia concentrations (0.3 vs. 1.3 un-ionized ammonia HQs in the 10% samples). The subsurface sample with lower ammonia exhibited the greater STS signal in the urchin, but was non-toxic to the fish. This indicates that other samples with higher ammonia could also have constituents that would be highly toxic to the urchin larval development, in the absence of ammonia.

4. SYNTHESIS, CONCLUSIONS AND UNCERTAINTY

The most notable finding from the tests with Hunter's Point sediment pore waters was the principal TIE signal revealing the role of ammonia as a source of toxicity. With regard to the potential role of CoPCs, the pattern of reduced toxicity resulting from STS treatments was exhibited principally in the 10% and 25% dilutions. STS is expected to reduce many cationic metals (U.S. EPA 1991, 1996). In fresh water it has been demonstrated to be a most effective TIE treatment for copper, silver and mercury, but it also acts on lead, cadmium and manganese, in more restrictive proportions (Hockett and Mount, 1996). The ability of both STS and EDTA to remove toxicity is dependent on the relationship between the concentrations of the metals that are causing toxicity and the maximum concentrations of STS and EDTA that can be used to complex the metals without themselves causing toxicity. Where metals with high benchmarks such as aluminum and manganese are present at toxic concentrations, the amount of STS and/or EDTA that is used in the test (e.g., quantities tolerable to the test organisms) may be insufficient to react with all of the available metal (Hockett and Mount, 1996).

Measured pore water concentrations of copper, zinc and aluminum in the TIE samples were near or above species-specific benchmarks, and thus could explain changes in toxicity that were observed, particularly in the more dilute STS-treated urchin test exposures (Table 3.1-3). Among

these metals, aluminum appears to present the greatest potential for acute toxicity. The species-specific HQs for aluminum derived using bivalve response data are higher than the water quality criteria HQs, indicating extra-sensitivity in bivalve larval development (and presumably in urchins and sand dollars). Problematically, the effect concentrations may be near the limits of efficient treatment using acceptable doses of STS and EDTA. Aluminum is not frequently associated with toxicity (U.S. EPA, 1997) and EPA TIE guidance documents (U.S. EPA, 1991 and 1996) provide no specific reference to the effectiveness of STS for removing aluminum toxicity; it is listed only as a metal that is chelated by EDTA. Additively, the HQs for copper, zinc and aluminum present the most cogent case for non-ammonia toxicity in urchins. In the fish, where non-ammonia and low DO effect observations were limited to stations HP-1, HP-5 and HP-9, species-specific HQs for copper and zinc were much lower than for the urchin. These values, and the absence of suitable surrogate species data for aluminum effects, preclude the association of this metal group with toxicity in the fish.

Another potential association with the STS/EDTA treatment response in the more dilute samples is the reduced toxicity associated with manganese. Toxicity of manganese to the early life stages of rainbow trout has been reported at concentrations near those measured in the 100% samples. In fact, in all three samples where the larval fish appeared to respond to STS and/or EDTA, manganese species-specific HQs were greater than unity. Assuming the reported bivalve embryo-larval effect concentration is an adequate surrogate for the urchin and sand dollar effects, it appears that sensitivity to manganese was less than observed in the fish. Still, manganese should not be ruled out as a contributor to toxicity in both species. Also, manganese (along with copper) was one of the few analytes that produced HQs greater than unity in both sediment and pore water evaluations using standard benchmarks.

CoPCs aside, variances from optimal ionic concentrations of natural constituents (e.g. salts) can contribute to toxic effects. Bay *et al.* (1993) reviewed some of these factors that may mediate toxicity in echinoderm early life stages, and reported tolerable limits for salinity (>29 ppt) and pHs (< 8.3) for the purple urchin. However, the endpoints cited, such as fertilization and larval pigmentation, are not directly comparable to those used in the current TIE. On the other hand, Fairey *et al.* (1998) report high rates of larval development in the purple urchin with salinities below 28 ppt; this illustrates that the susceptibility of this species may vary from study to study. Ionic imbalance problems have been suggested as contributors to toxicity in both effluent and sediment TIEs (Ho and Caudle, 1997; Adams et al., 2001). In a recent TIE with marine sediments from the Calcasieu River in Louisiana, SAIC found that a high concentration of calcium was the most likely source of toxicity in at least one pore water sample (SAIC, 2002). Because specific TIE treatments have not been developed to address problems of ion imbalance (it is difficult to selectively remove major ions such as calcium) this problem is normally only considered when the traditional TIE treatments fail to remove toxicity. In the current study, residual toxicity appears to have occurred in some samples (most notably HP-4 and HP-10), where measurement of the major ions in these sediments would serve as one first step towards resolving this uncertainty.

Sediment and water quality characteristics that were evaluated to discern potential factors that might influence toxicity (e.g., TOC, SEM:AVS, % fines) do not appear to be major determinants

in affects observed during the TIE exposures. Total Organic Carbon values were all relatively low, as were SEM-AVS values. One possible explanation for the demonstrated deviation from the general rule that AVS controls divalent metal bioavailability is that two of the metals contributing to elevated HQs (Al^{2+}, Mn^{2+}) were not (and typically are not) measured as SEM metals. A recent study presented by O'Day *et al.* (2000) conducted to determine the effectiveness of SEM:AVS in predicting metal toxicity in pore waters from Seaplane Lagoon in San Francisco Bay found that sand dollar embryo larval toxicity was poorly correlated with SEM:AVS. The study reported that the SEM:AVS toxicity model could be applicable for cadmium, and only partially valid for zinc, while the bioavailability of other metals is mostly controlled by factors other than AVS. O'Day and colleagues surmised that pore water variables such as oxidation potential, pH and ionic strength, along with consideration for clay-binding properties, carbonates, oxyhydroxides and sulfur oxidation and reduction reactions in the sediments will ultimately lead to better methods to predict metal toxicity.

While the current TIE has provided valuable insight with regard to the relative contributions of metals vs. ammonia, there were no signals that suggested acute toxicity associated with the sparse benchmark exceedences of CoPC organic contaminants. This was expected, as the larger exceedences were for PCBs, and PCBs are not generally contributors to acute effects. The potential for some toxicity associated with the Oasis column elutions requires further investigation. Because this effect was not observed in a previous spiking trial with fish larvae conducted antecedent to this study, it is likely that the characteristics of individual pore water matrices mediated the response. It is possible that some residual toxicity (remaining after the *Ulva* treatment) may have been due to effects associated with the Oasis column. Optimizing an SPE column to effectively remove more organic contaminants than the current standard C_{18} column would serve as a significant advance in TIE technology.

Another objective of the TIE study was to evaluate the effect of sediment sampling depth on potential sources of toxicity. In the samples from Point Avisadero (HP-1 and HP-2), surface and subsurface toxicity did not differ with depth. TIE responses and HQs were nearly identical for both samples. In contrast, toxicity to the fish in the South Basin samples did vary with vertical distribution (HP-5 and H-6). Additionally, TIE responses were different. The deeper sample produced a greater reduction in toxicity following STS treatment than did the shallower sample. The surface sample demonstrated a stronger *Ulva* signal. These differences are consistent with the much higher ammonia HQs derived for the surface sample. While metal HQs are similar between samples, it is likely that the lower ammonia concentration in the deeper station (the only station with a total ammonia HQ <1) allowed for expression of metal toxicity that was masked in the surface sediment sample.

Ultimately, the results of TIE studies must be interpreted within a risk assessment framework, as supporting ancillary data to the overall weight-of evidence process that broadly encompasses all that is known regarding effects on aquatic receptors at the site. All laboratory exposures employed for toxicity testing purposes are limited representations of potential field conditions. Bulk sediment tests reflect the bioavailability of contaminants relative to response thresholds for the species tested. SWI tests represent exposure conditions likely to be experienced by early life stages of benthic organisms, such as the sea urchin. Pore water tests represent exposure

conditions that infaunal organisms might experience, and application of a sensitive bioassay such as the sea urchin larval development test serves as a surrogate for infaunal species that could potentially have a similar level of sensitivity. As noted by Allan et al. (2001), pore water tests frequently result in an order of magnitude, greater toxicity than bulk sediment tests, but these responses prompt the need to evaluate underlying causes, particularly when they are correlated with observed complex changes in the benthic community structure in field studies (Adams et al., 2000). The greatest advantage of the TIE results with sea urchins is that the sensitive responses they provide allow observations of toxicity reduction for multiple potential classes of toxicants that may be present in varying degrees of potency.

An interpretive summary of the Hunter's Point TIE is provided in Table 4.1-1. Results from test with each species are tabulated, carried forward principally from Tables 3.3-4 to 3.3-6. These TIE responses, were paired with species specific HQs. Pore water HQs and sediment HQs that provide additional information regarding potential sources of toxicity are noted in the final column as they provide less specific correlation with the pore water tests that were conducted. General conclusions can be summarized as follows:

- Levels of toxicity observed in the pore water exposures were substantially higher than in bulk sediment and Sediment Water Interface toxicity tests, where minimal toxicity occurred. Known differences between the tolerance limits of the species tested as well as differences in exposure concentrations account for these differences. For the TIE study sediment pore water was used as the test media, thus representing a potential worse-case scenario for exposure. Results of the TIE study should contribute as ancillary data in identifying potential sources of toxicity within the overall weight of evidence process utilized for Hunters Point Validation Study.

- Toxicity did not differ substantially with depth in the two stations where surface and subsurface sediments were represented.

- Very high oxygen demand in the pore water samples offers clues to the biogeochemical properties governing the bioavailability of the toxicants. Ammonia has a relatively high oxygen demand (consumes oxygen through transformation to nitrite and nitrate), but it is likely that the formation of metal oxides and sulfides, as well as biotic factors (i.e., bacteria) contributed to the oxygen depletion in the samples.

- Toxicity reductions due to STS reduction and EDTA chelation observed in all species were correlated with elevated pore water concentrations of metals, especially aluminum, copper, manganese and zinc. A similar correlation was also observed at the reference station, indicating that metals-related toxicity may not be site-specific.

- Ammonia toxicity was the predominant source of toxicity removed by TIE procedures for urchins, sand dollars and fish, but other contributors to effects were observed, particularly with the purple urchin. Follow-on testing with sand dollars confirmed that factor(s) other than ammonia contributed to toxicity.

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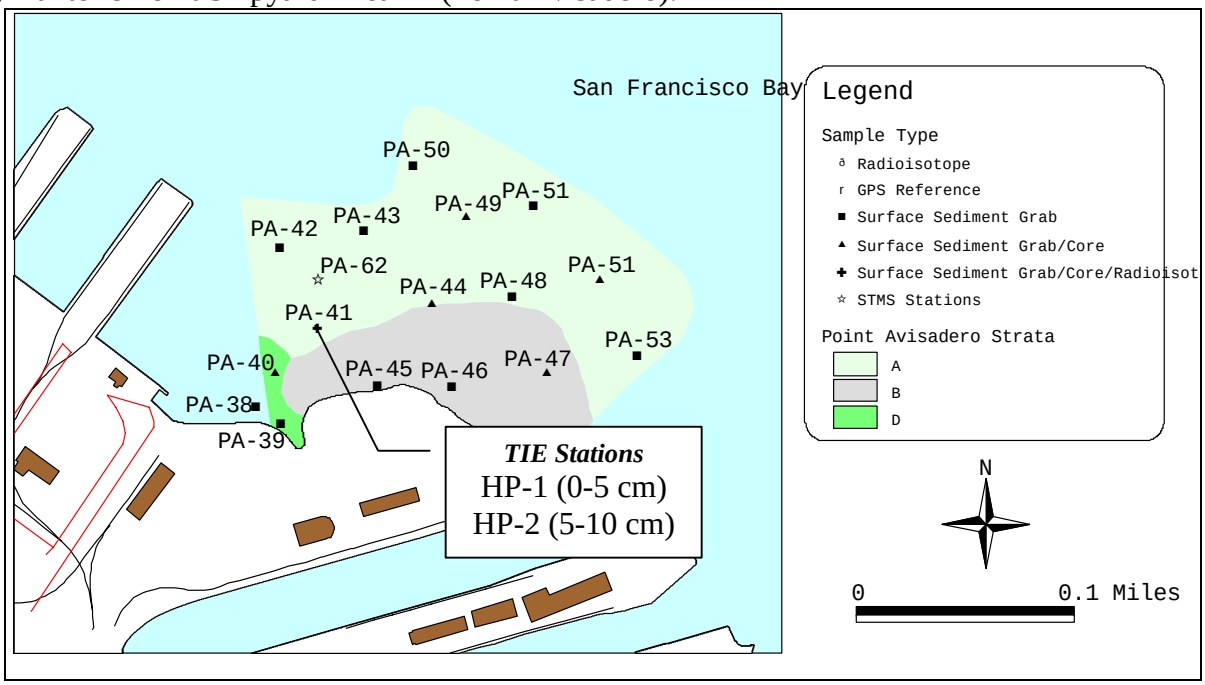
Figure 2.1-1. Location of Hunter's Point Validation Study sampling locations selected for the Hunter's Point TIE investigation[1].

a) Hunter's Point Shipyard Area III (Point Avisadero).



1 – Locations from the Hunter's Point Validation Study Work Plan, Draft Final (Battelle *et al.*, 2000a)

b) Hunter's Point Shipyard Area VIII (Eastern Wetland).

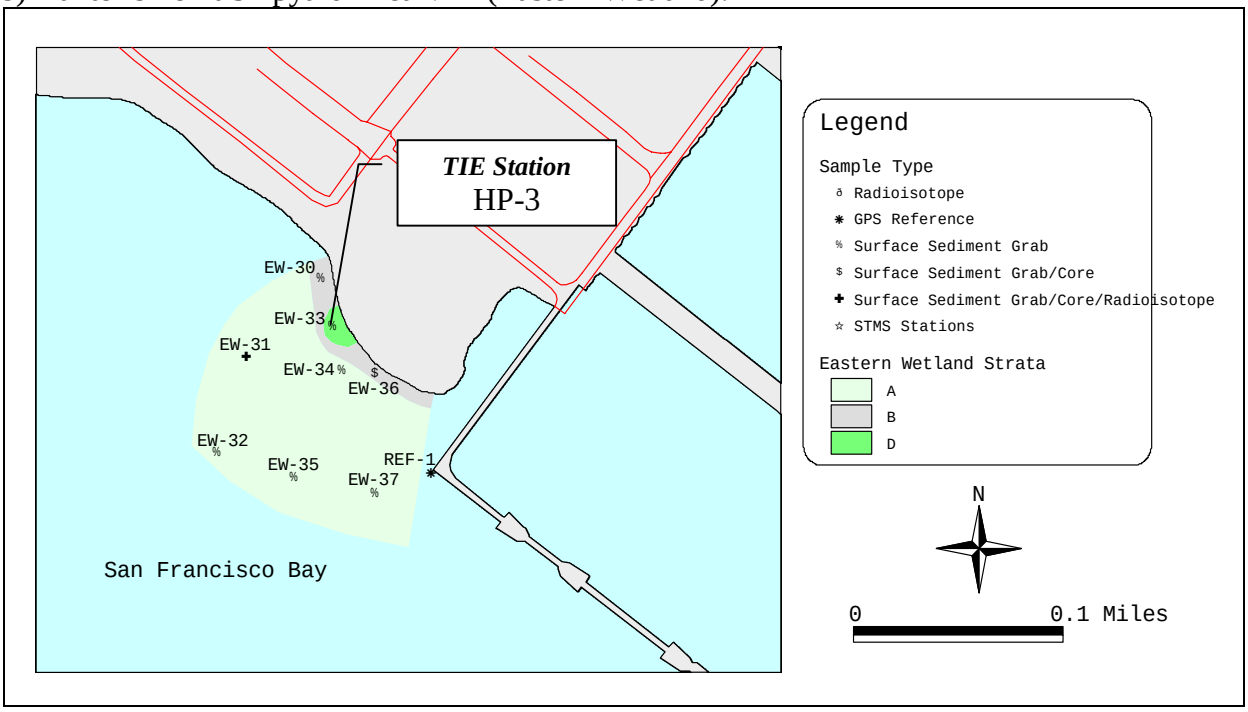
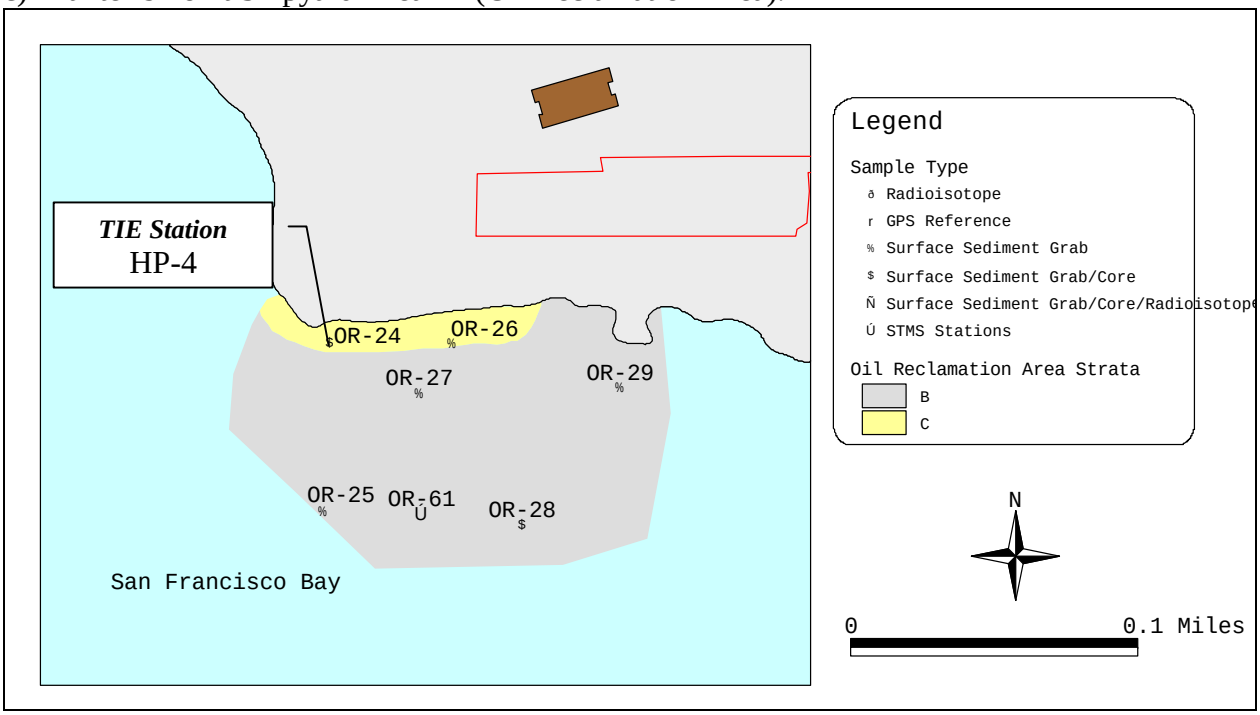


Figure 2.1-1. continued.

c) Hunter's Point Shipyard Area IX (Oil Reclamation Area).



d) Hunter's Point Shipyard Area X (South Basin).

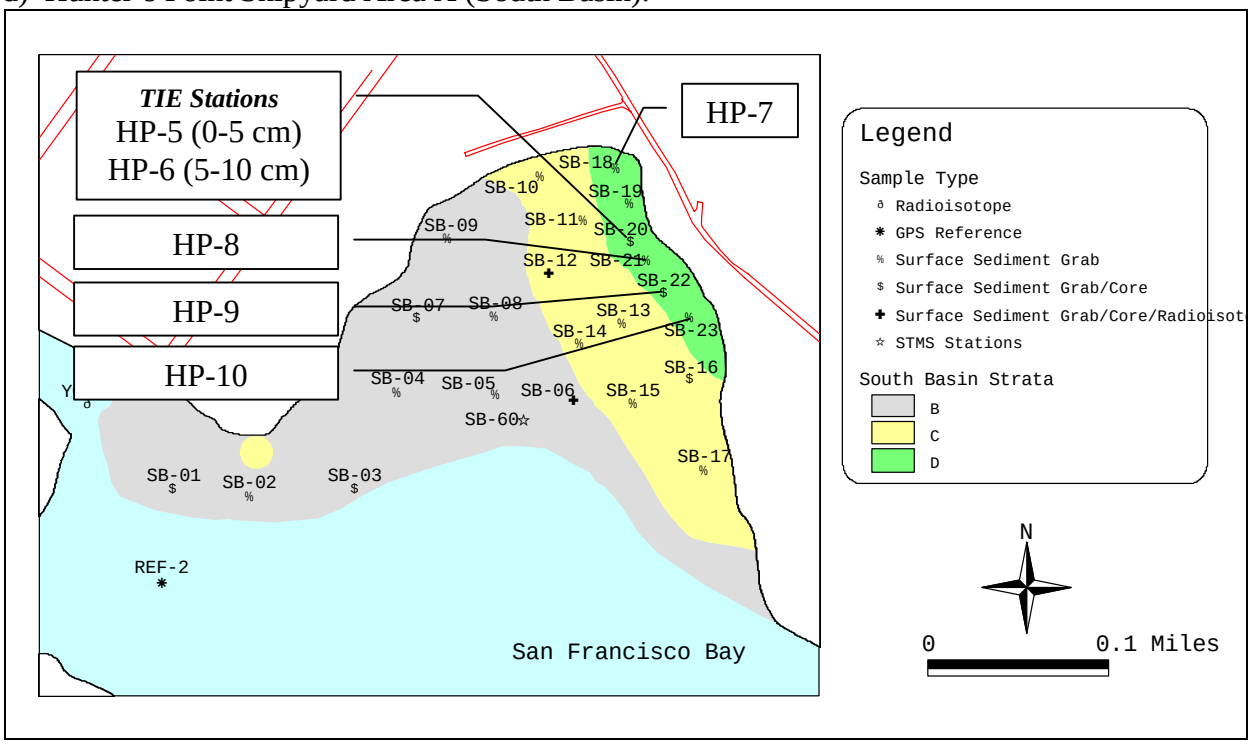


Figure 2.3-1. TIE fractionation procedure for the Hunter's Point TIE investigation.

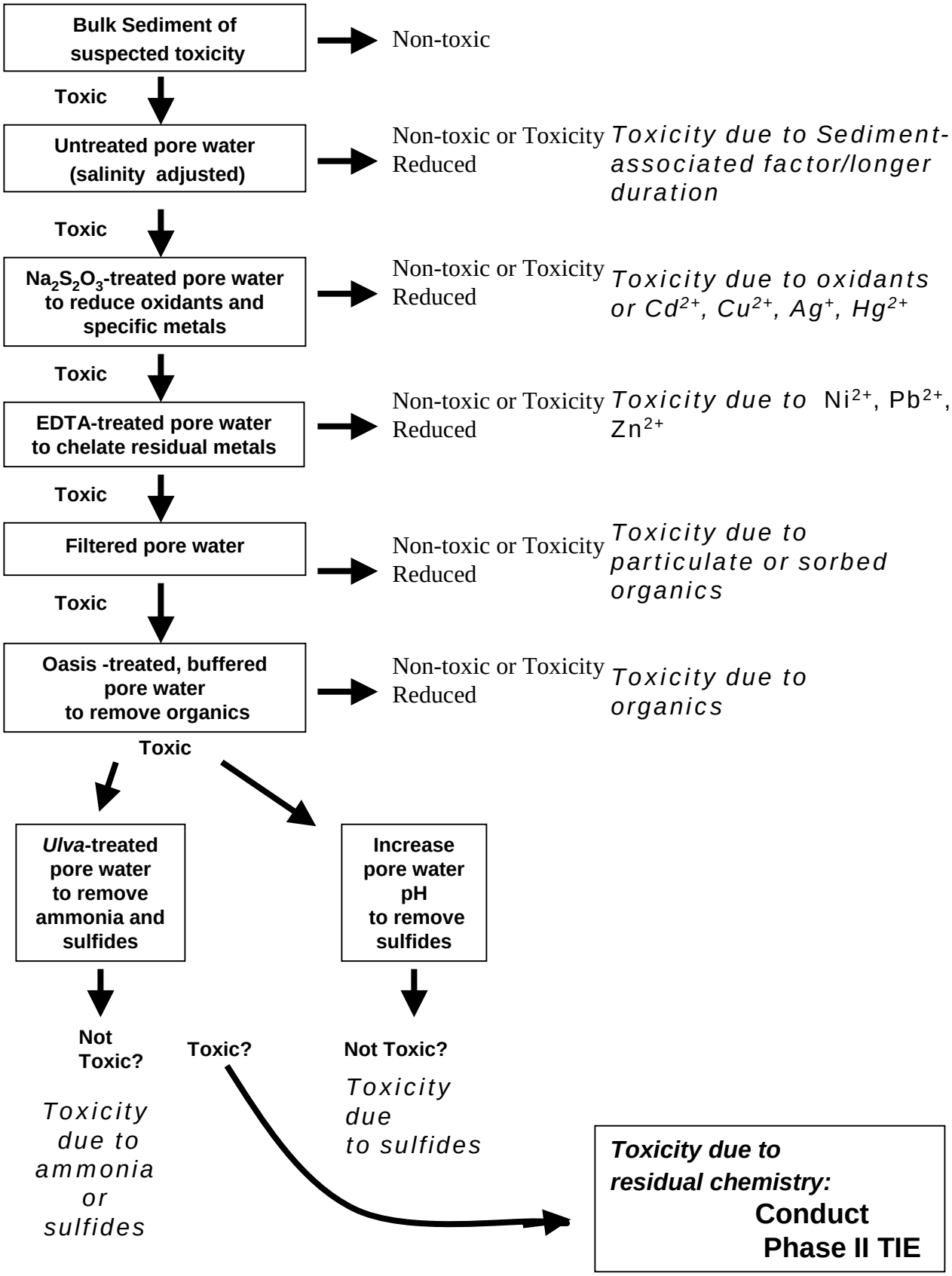


Table ES-1. Summary of findings from the Hunter's Point Toxicity Identification Evaluation (TIE).

Area	SAIC TIE ID	Treatment(s) that Reduced Pore Water Toxicity and Associated Probable Toxicant(s)[1]		
		Fish	**Urchin**	**Sand Dollar**
Point Avisadero	HP-1	STS>EDTA- Manganese, Copper	*Ulva* -NH_4> STS>EDTA- metals	ND
Point Avisadero	HP-2	NT	*Ulva* -NH_4> EDTA=STS- metals	ND
Eastern Wetland	HP-3	Low DO>*Ulva* - NH_4	*Ulva* -NH_4> EDTA- metals	ND
Oil Reclamation	HP-4	STS- Aluminum, Zinc, Copper	*Ulva* -NH_4> STS- metals	*Ulva* -NH_4 *Ulva* -NH_4>STS>EDTA-Aluminum, Zinc, Copper[2]
South Basin	HP-5	Filtered-particle fraction> STS-Manganese, Copper= *Ulva* -NH_4	*Ulva*- NH_4> STS- metals	*Ulva* -NH_4> EDTA>Filtration *Ulva* -NH_4>STS-Aluminum, Copper, Zinc[2]
South Basin	HP-6	NT	STS- metals> *Ulva* -NH_4>EDTA- metals =Filtration- particle fraction	ND
South Basin	HP-7	NT	*Ulva* -NH_4> STS- Aluminum, Copper, Zinc	ND
South Basin	HP-8	Low DO>*Ulva* -NH_4	*Ulva* -NH_4	ND
South Basin	HP-9	*Ulva* -NH_4> Filtered-particle fraction> EDTA- Manganese, Copper	*Ulva* -NH_4> STS- metals	*Ulva* -NH_4>Filtration-particle fraction=EDTA>STS- Aluminum, Zinc, Copper *Ulva* -NH_4>STS>EDTA-Aluminum, Zinc, Copper[2]
South Basin	HP-10	Low DO>*Ulva* -NH_4	*Ulva* -NH_4	ND
	HP-SPIKE	STS/EDTA- Copper Filtrtion-particle fraction Ulva- Copper, NH_4	Ulva-NH_4/EDTA-Copper	ND
Paradise Cove	HP-REF	NT	*Ulva* -NH_4=STS-Aluminum, Copper, Zinc>Filtration-particle fraction	*Ulva* -NH_4=EDTA>STS-Aluminum, Copper, Zinc *Ulva* -NH_4=STS>EDTA-Aluminum, Copper, Zinc[2]

1 - in order of percent of overall toxicity removed (Table 3.3-4, 3.3-5 and 3.3-6); see text for probable CoCs.
2 - observed in reverse treatment
NT = not toxic; ND = no data

Table 2.2-1. Selection of benchmarks used in calculating sediment Hazard Quotients for the Hunter's Point TIE investigation.

		Marine Sediment						Selected[1]	
Class	Analyte	ER-M	PEL	AET-H	AET-L	SQAL	EPA	BM	Source
MET	Aluminum								
MET	Antimony				9.3			9.3	AET-L
MET	Arsenic	70	42	700	57			70	ER-M
MET	Barium								
MET	Cadmium	9.6	4.2	9.6	5.1			9.6	ER-M
MET	Chromium	370	160	270	260			370	ER-M
MET	Cobalt				10			10	AET-L
MET	Copper	270	108	1300	390			270	ER-M
MET	Iron								
MET	Lead	218	112	660	450			218	ER-M
MET	Manganese				260			260	AET-L
MET	Mercury							0.7	ER-M
MET	Molybdenum								
MET	Nickel	52	43					52	ER-M
MET	Selenium				1.0			1.0	AET-L
MET	Silver	3.7	1.7	6.1	6.1			3.7	ER-M
BT	DBT								
BT	MBT								
BT	TBT				3.4			3.4	AET-L
BT	TTBT								
BT	Total Butyltins								
MET	Vanadium								
MET	Zinc	410	271	1600	410			410	ER-M
MET	SEM-AVS						5.0	5	EPA
PAH	2-Methylnaphthalene	670	201	1900	670			670	ER-M
PAH	Acenaphthene	500	89	2000	500	1300		500	ER-M
PAH	Acenaphthylene	640	128	1300	1300			640	ER-M
PAH	Anthracene	1100	245	13000	960			1100	ER-M
PAH	Benzo(a)anthracene	1600	693	5100	1600			1600	ER-M
PAH	Benzo[a]pyrene	1600	763	3600	1600			1600	ER-M
PAH	Benzo[b]fluoranthene			9900	3600			9900	AET-H
PAH	Benzo[ghi]perylene			2600	720			2600	AET-H
PAH	Benzo[k]fluoranthene			9900	3600			9900	AET-H
PAH	Chrysene	2800	846	9200	2800			2800	ER-M
PAH	Dibenz[a,h]anthracene	260	135	970	230			260	ER-M
PAH	Fluoranthene	5100	1494	30000	2500	6200		5100	ER-M
PAH	Fluorene	540	144	3600	540	540		540	ER-M
PAH	Indeno[1,2,3-cd]pyrene			2600	690			2600	AET-L
PAH	Naphthalene	2100	391	2700	2100	470		2100	ER-M
PAH	Phenanthrene	1500	544	6900	1500	1800		1500	ER-M
PAH	Pyrene	2600	1398	16000	3300	97000		2600	ER-M
PAH	Total LMW (L) PAHs	3160	1442	24000	5200			3160	ER-M
PAH	Total HMW (H) PAHs	9600	6676	69000	17000			9600	ER-M
PAH	Total PAHs	44792	16770					44792	ER-M
PCB	Total PCBs	180	189	3100	1000			180	ER-M
PST	2,4'-DDD	27	7.8	43	16			27	ER-M
PST	2,4'-DDE	27	374	15	9.0			27	ER-M
PST	2,4'-DDT	27	4.8	34	34			27	ER-M
PST	4,4'-DDD	27	7.8	43	16			27	ER-M
PST	4,4'-DDE	27	374	15	9.0			27	ER-M
PST	4,4'-DDT	27	4.8	34	34			27	ER-M
PST	alpha-Chlordane		4.8					4.8	PEL
PST	Dieldrin		4.3					4.3	PEL
PST	Endosulfan II					14		14	SQAL
PST	Endrin					42		42	SQAL
PST	gamma-Chlordane		4.8					4.8	PEL
PST	Heptachlor				0.3			0.3	AET-L

1- Benchmarks were selected in the following order of priority:
Marine Sediment: 1) ER-M; 2) PEL; 3) AET-H/L; 4) SQAL; 5) EPA.
Units: Metals = µg/g; PCBs, Pesticides (PST), PAHs = ng/g; AVS, SEM= µM/g.
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
ER-M = NOAA Effects Range-Median (Long et al. 1995 in U.S. EPA 1997).
PEL = Threshold Effects Levels (FDEP 1994 in U.S. EPA 1997).
AET-L/H = Apparent Effects Threshold Low/High (Barrick et al. 1988 in U.S. EPA 1997).
SQAL = EPA Sediment Quality Advisory Levels, based on 1% TOC (U.S. EPA 1997).
EPA = EPA SEM-AVS sediment quality screening value,µM/g dry weight (U.S. EPA 1997).

Table 2.2-2. Selection of benchmarks used in calculating pore water Hazard Quotients for the Hunter's Point TIE investigation.

		Water Quality Criteria		Selected Sediment[2]			Estimated	Selected Pore water[1]	
Class	Analyte	WQC-SA	WQC-FA	BM	Source	Koc	Pore water	BM	Source
MET	Aluminum		750					750	WQC-FA
MET	Arsenic	69	360	70	ER-M			69	WQC-SA
MET	Cadmium	42	3.9	9.6	ER-M			42	WQC-SA
MET	Chromium	1100	16	370	ER-M			1100	WQC-SA
MET	Copper	4.8	18	270	ER-M			4.8	WQC-SA
MET	Iron								
MET	Lead	210	83	218	ER-M			210	WQC-SA
MET	Manganese		1000	260	AET-L			1000	WQC-FA
MET	Nickel	74	1400	52	ER-M			74	WQC-SA
MET	Silver	1.9	4.1	3.7	ER-M			1.9	WQC-SA
MET	Zinc	90	120	410	ER-M			90	WQC-SA
MET	SEM-AVS			5	EPA				
PAH	2-Methylnaphthalene	300		670	ER-M	8.0E+3	8.4	300	WQC-SA
PAH	Acenaphthene		1700	500	ER-M	7.1E+3	7.0	1700	WQC-FA
PAH	Acenaphthylene	300		640	ER-M	9.6E+3	6.7	300	WQC-SA
PAH	Anthracene	300		1100	ER-M	3.0E+4	3.7	300	WQC-SA
PAH	Benzo(a)anthracene	300		1600	ER-M	4.0E+5	0.4	300	WQC-SA
PAH	Benzo[a]pyrene	300		1600	ER-M	1.0E+6	0.2	300	WQC-SA
PAH	Benzo[b]fluoranthene	300		9900	AET-H	1.2E+6	0.8	300	WQC-SA
PAH	Benzo[ghi]perylene	300		2600	AET-H	3.9E+6	6.7E-2	300	WQC-SA
PAH	Benzo[k]fluoranthene			9900	AET-H	1.2E+6	0.8	0.8	estimated
PAH	Chrysene	300		2800	ER-M	4.0E+5	0.7	300	WQC-SA
PAH	Dibenz[a,h]anthracene	300		260	ER-M	3.8E+6	6.9E-3	300	WQC-SA
PAH	Fluoranthene		3980	5100	ER-M	1.1E+5	4.7	3980	WQC-FA
PAH	Fluorene	300		540	ER-M	1.4E+4	3.9	300	WQC-SA
PAH	Indeno[1,2,3-cd]pyrene	300		2600	AET-L	3.4E+6	7.5E-2	300	WQC-SA
PAH	Naphthalene		2300	2100	ER-M	2.0E+3	104	2300	WQC-FA
PAH	Phenanthrene		30	1500	ER-M	3.0E+4	5.0	30	WQC-FA
PAH	Pyrene	300		2600	ER-M	1.1E+5	2.5	300	WQC-SA
PAH	Total LMW (L) PAHs	300		3160	ER-M			300	WQC-SA
PAH	Total HMW (H) PAHs	300		9600	ER-M			300	WQC-SA
PAH	Total PAHs	300		44792	ER-M	7.6E+4	59	300	WQC-SA
PCB	Total PCBs		2	180	ER-M	2.7E+6	6.7E-3	2.0	WQC-FA
PST	2,4'-DDD			27	ER-M	9.9E+5	2.7E-3	2.7E-3	estimated
PST	2,4'-DDE			27	ER-M	4.4E+6	6.1E-4	6.1E-4	estimated
PST	2,4'-DDT			27	ER-M	4.4E+6	6.1E-4	6.1E-4	estimated
PST	4,4'-DDD		0.6	27	ER-M	9.9E+5	2.7E-3	0.6	WQC-FA
PST	4,4'-DDE		1050	27	ER-M	4.4E+6	6.1E-4	1050	WQC-FA
PST	4,4'-DDT		1.1	27	ER-M	4.4E+6	6.1E-4	1.1	WQC-FA
PST	alpha-Chlordane			4.8	PEL	2.5E+6	2.0E-4	2.0E-4	estimated
PST	Dieldrin	0.71	2.5	4.3	PEL	1.9E+5	2.3E-3	0.7	WQC-SA
PST	Endosulfan II			14	SQAL	1.1E+4	0.1	0.1	estimated
PST	Endrin	3.7E-2	0.2	42	SQAL	9.4E+4	4.5E-2	3.7E-2	WQC-SA
PST	gamma-Chlordane			4.8	PEL	1.6E+6	2.9E-4	2.9E-4	estimated
PST	Heptachlor	5.3E-2	0.5	0.3	AET-L	2.5E+6	1.2E-5	5.3E-2	WQC-SA
AMM	Un-ionized Ammonia	0.23						0.23	WQC-SA

1- Benchmarks (units = µg/L (mg/L for AMM)) were selected in the following order of priority:
1) WQC-SA; 2) WQC-FA; 3) Estimated from sediment benchmark using equilibrium partitioning relationship (Di Toro *et al.*, 1992).
WQC-SA = saltwater acute (U.S. EPA 1999 [metals, dieldrin, endrin, heptachlor], NOAA 1999);
WQC-FA = freshwater acute (NOAA 1999); Estimated = sed. BM/(Koc*0.01) .
WQC-SA reported for Chromium VI.
2- See Table 2.2-1 for sediment benchmark selection process and definitions.
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.

Table 2.2-3. Summary of species-specific acute effects from water-only exposures for potentially toxic analytes in the Hunter's Point TIE investigation.

A. Contaminant effect concentrations.

	Purple Urchin *S. purpuratus* EC_{50} (µg/L)	Silverside fish *M. menidia* LC_{50} (µg/L)	Sand Dollar *D. excentricus* EC_{50} (µg/L)	Bivalves EC_{50} (µg/L)
Manganese	NA	3680 Rainbow trout [7]	NA	14,000-19,000 *C. virginica* embryos [8]
Copper	8 [2]	136 [3]	19.8 [4]	NA
Zinc	19 [2]	3,900 [2]	NA	
Aluminum	200 [10]	NA	NA	227 [9]
Barium			NA	200-900 *M. californicus* [4]
Sodium arsenite as Arsenic III	NA	16,000 [5]	NA	326 (*C. gigas* embryo) [6]
Fluoranthene[1]	NA	> 212 (saturation)	NA	> 212 (saturation) *M. lateralis*

1 - Spehar et al., 1999.
2 - summarized in Bay et al., 1993; geometric mean of three values.
3 - Cardin, 1982 in U.S. EPA, 1985a, EPA440/5-84-031; geometric mean of seven values derived with larvae in flow through tests with measured concentrations.
4 - Bailey et al., 1995.
5 - Cardin, 1982 in U.S. EPA, 1985b, EPA440/5-84-033, January 1985; nominal concentrations from a static test with juvenile fish.
6 - Martin et al., 1981 in U.S. EPA, 1985b, EPA440/5-84-033, January, 1985.
7 - Stubblefield et al., 1997.
8 – Calabrese et al., 1973.
9 – Wilson and Hyne, 1997.
10 – determined using the sea urchin, *Arbacia punctulata*; Waterman, 1937.
NA: No values available

B. Ammonia effect concentrations.

	E. estuarius EC_{50} (mg/L)	*S. purpuratus* EC_{50} (mg/L)	*D. excentricus* EC_{50} (mg/L)	*M. beryllina* EC_{50} (mg/L)
Total Ammonia	>60 (1)	2.0-3.5 (2) 1.25-3.26 @ pH 8.1-8.4 (3)		37.6 (4)
Un-ionized Ammonia	> 0.8 (1)	0.06 0.03-0.08 (2) 0.079-0.108 (3)	0.058 (5)	1.1-1.8 @ pH 7.9-8.6 (3)

1 – U.S. EPA, 1993.
2 – Battelle, 2000b.
3 - Greenstein et.al, 1995.
4 - U.S. EPA, 1986.
5 - Bay et al., 1993.

Table 2.4-1. Summary of test conditions for acute water-only toxicity tests with the silverside *Menidia menidia*[a], the purple sea urchin *Strongylocentrotus purpuratus*[b] and the sand dollar *Dendraster excentricus*[b].

	M. menidia	*S. purpuratus*	*D. excentricus*
Test Type	Static non-renewal	Static non-renewal	Static non-renewal
Test Duration	24 hr[1]	72 hr	72 hr
No. Replicates/Treatment	3	3	3
No. Organisms/Chamber	5	250 eggs/125,000 sperm	250 eggs/125,000 sperm
Test Chambers	20 mL vial	20 mL vial	20 mL vial
Test concentrations	2 (50, 100%)	4 (10, 25, 50, 100%)	4 (1, 10, 50, 100%)
Photoperiod	16:8	16:8	16:8
Age/Size of Test Organisms	1 day pre-hatch	~ 1 hr old	~ 1 hr old
Volume of Overlying Water	20 mL	10 mL	10 mL
Type of Water	clean seawater	clean seawater	clean seawater
Bay Feeding/Chamber	none	none	none
Endpoint	survival	normal dev't	normal dev't
Physical measurements[2]	Dissolved oxygen, pH ammonia, temp.	Dissolved oxygen, pH ammonia, temp.	Dissolved oxygen, pH ammonia, temp.
Acceptance Criteria	80% survival in control	80% normal dev't in control	80% normal dev't in control
Test Temperature[2]	18.9-21.6 ^{o}C	18.9-21.6 ^{o}C	13.6-16.9 ^{o}C
Dissolved Oxygen[2, 3]	0.5-7.6	0.5-7.6	1.0-7.9
pH[2]	7.2-8.6	7.2-8.6	7.9-8.5
Salinity[2]	27-34 ppt	27-34 ppt	32-38 ppt

[a] U.S. EPA, 1996.
[b] U.S. EPA, 1995.
1 - Test duration shorter than standard method (48 hr) to be compatible with TIE methodology.
2 - Measured for each treatment prior to addition of test organisms, as required to monitor stability and after test completion (final). Final water quality measurements reported as most representative of test conditions. Measurements not available for *M. menidia*; *S. purpuratus* measurements reported as test values for both species conducted on same days with aliquots taken from the same sample.
3 - Samples with DO < 7 mg/L at test start were oxygenated to >18mg/L with pure oxygen.

Table 2.4-2. Contaminants measured in sediments and pore waters for the Hunter's Point TIE investigation.

Class[1]	Analyte	Method	Description[2]	Units (dry wt.)	MDL[3]	Laboratory RL[3]
A. Sediment						
BT	DBT	SW3050B/6010B	ICP	µg/kg	1.9	1.7
BT	MBT	SW3050B/6010B	ICP	µg/kg	1.00	1.7
BT	TBT	SW3050B/6010B	ICP	µg/kg	2.7	3.4
BT	TTBT	SW3050B/6010B	ICP	µg/kg	2.4	1.7
MET	Aluminum	SW3050B/6010B	ICP	mg/kg	2.4	15.9
MET	Antimony	SW3050B/6010B	ICP	mg/kg	3.0E-2	3.0E-2
MET	Arsenic	SW3050B/6010B	ICP	mg/kg	6.8E-2	1.3
MET	Barium	SW3050B/6010B	ICP	mg/kg	1.8E-2	0.19
MET	Cadmium	SW3050B/6010B	ICP	mg/kg	1.8E-2	0.60
MET	Chromium	SW3050B/6010B	ICP	mg/kg	0.51	1.3
MET	Cobalt	SW3050B/6010B	ICP	mg/kg	5.3E-2	0.13
MET	Copper	SW3050B/6010B	ICP	mg/kg	0.24	0.30
MET	Iron	SW3050B/6010B	ICP	mg/kg	0.56	32.0
MET	Lead	SW3050B/6010B	ICP	mg/kg	0.20	0.16
MET	Manganese	SW3050B/6010B	ICP	mg/kg	7.4E-2	0.30
MET	Mercury	SW7471A	Cold Vapor	mg/kg	2.1E-3	6.0E-3
MET	Molybdenum	SW3050B/6010B	ICP	mg/kg	3.9E-2	0.25
MET	Nickel	SW3050B/6010B	ICP	mg/kg	3.9E-2	1.0
MET	Selenium	SW3050B/6010B	ICP	mg/kg	0.13	1.3
MET	Silver	SW3050B/6010B	ICP	mg/kg	6.6E-2	0.13
MET	Vanadium	SW3050B/6010B	ICP	mg/kg	0.35	0.60
MET	Zinc	SW3050B/6010B	ICP	mg/kg	0.11	1.3
PAH	2-Methylnaphthalene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Acenaphthene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Acenaphthylene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Anthracene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Benzo(a)anthracene	SW3540/8270C-Low	GC/ECD	µg/kg	6.0E-2	1.1
PAH	Benzo[a]pyrene	SW3540/8270C-Low	GC/ECD	µg/kg	5.0E-2	1.1
PAH	Benzo[b]fluoranthene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Benzo[ghi]perylene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Benzo[k]fluoranthene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Chrysene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Dibenz[a,h]anthracene	SW3540/8270C-Low	GC/ECD	µg/kg	8.0E-2	1.1
PAH	Fluoranthene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Fluorene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Indeno[1,2,3-cd]pyrene	SW3540/8270C-Low	GC/ECD	µg/kg	7.0E-2	1.1
PAH	Naphthalene	SW3540/8270C-Low	GC/ECD	µg/kg	1.3	1.1
PAH	Phenanthrene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Pyrene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Total PAH	SW3540/8270C-Low	GC/ECD	µg/kg	2.0	18.8

Class[1]	Analyte	Method	Description[2]	Units (dry wt.)	MDL[3]	Laboratory RL[3]
PCB	PCB 101	SW3540C/8089	GC/ECD	µg/kg	1.0	8.9
PCB	PCB 105	SW3540C/8090	GC/ECD	µg/kg	9.0E-2	0.88
PCB	PCB 110	SW3540C/8091	GC/ECD	µg/kg	0.11	0.89
PCB	PCB 118	SW3540C/8092	GC/ECD	µg/kg	0.12	0.89
PCB	PCB 126	SW3540C/8093	GC/ECD	µg/kg	0.14	0.88
PCB	PCB 128	SW3540C/8094	GC/ECD	µg/kg	0.19	0.89
PCB	PCB 129	SW3540C/8095	GC/ECD	µg/kg	8.0E-2	0.88
PCB	PCB 138	SW3540C/8096	GC/ECD	µg/kg	0.96	8.9
PCB	PCB 153	SW3540C/8097	GC/ECD	µg/kg	1.4	8.9
PCB	PCB 170	SW3540C/8098	GC/ECD	µg/kg	0.95	8.9
PCB	PCB 18	SW3540C/8099	GC/ECD	µg/kg	8.0E-2	0.89
PCB	PCB 180	SW3540C/8100	GC/ECD	µg/kg	1.0	8.9
PCB	PCB 187	SW3540C/8101	GC/ECD	µg/kg	0.93	8.8
PCB	PCB 195	SW3540C/8102	GC/ECD	µg/kg	9.0E-2	0.89
PCB	PCB 206	SW3540C/8103	GC/ECD	µg/kg	9.0E-2	0.89
PCB	PCB 209	SW3540C/8104	GC/ECD	µg/kg	9.0E-2	0.88
PCB	PCB 28	SW3540C/8105	GC/ECD	µg/kg	0.11	0.88
PCB	PCB 44	SW3540C/8106	GC/ECD	µg/kg	0.10	0.88
PCB	PCB 52	SW3540C/8107	GC/ECD	µg/kg	0.11	0.89
PCB	PCB 66	SW3540C/8108	GC/ECD	µg/kg	0.12	0.88
PCB	PCB 77	SW3540C/8109	GC/ECD	µg/kg	0.16	0.89
PCB	PCB 8	SW3540C/8110	GC/ECD	µg/kg	0.16	0.89
PST	2,4'-DDD	SW3540C/8081A	GC/ECD	µg/kg	0.10	0.88
PST	2,4'-DDE	SW3540C/8081A	GC/ECD	µg/kg	0.13	0.89
PST	2,4'-DDT	SW3540C/8081A	GC/ECD	µg/kg	0.12	0.89
PST	4,4'-DDD	SW3540C/8081A	GC/ECD	µg/kg	0.10	0.89
PST	4,4'-DDE	SW3540C/8081A	GC/ECD	µg/kg	9.0E-2	0.89
PST	4,4'-DDT	SW3540C/8081A	GC/ECD	µg/kg	9.0E-2	0.89
PST	alpha-Chlordane	SW3540C/8081A	GC/ECD	µg/kg	7.0E-2	0.89
PST	Dieldrin	SW3540C/8081A	GC/ECD	µg/kg	0.10	0.89
PST	Endosulfan II	SW3540C/8081A	GC/ECD	µg/kg	0.10	0.88
PST	Endrin	SW3540C/8081A	GC/ECD	µg/kg	9.0E-2	0.88
PST	gamma-Chlordane	SW3540C/8081A	GC/ECD	µg/kg	8.0E-2	0.89
PST	Heptachlor	SW3540C/8081A	GC/ECD	µg/kg	8.0E-2	0.89
SEM	Acid Volatile Sulfide	EPA 1991 Draft		µM/g	0.33	0.33
SEM	Copper	6010		µM/g	6.6E-4	6.6E-4
SEM	Lead	6010		µM/g	1.0E-4	1.0E-4
SEM	Nickel	6010		µM/g	3.7E-4	3.7E-4
SEM	Zinc	6010		µM/g	1.2E-3	1.2E-3
SEM[5]	Cadmium	6010		µM/g	3.0E-5	3.0E-5
TOC	Total Organic Carbon	EPA 9060		mg/kg	76.8	100.0

Class[1]	Analyte	Method	Description[2]	Units (dry wt.)	MDL[3]	Laboratory RL[3]
B. Pore Water						
MET	Aluminum	SW846 6010B	ICP/MS	µg/L	42.9	200
MET	Arsenic	SW846 6010B	ICP/MS	µg/L	1.7	10
MET	Cadmium	SW846 6010B	ICP/MS	µg/L	0.54	5
MET	Chromium	SW846 6010B	ICP/MS	µg/L	0.89	10
MET	Copper	SW846 6010B	ICP/MS	µg/L	1.4	10
MET	Iron	SW846 6010B	ICP/MS	µg/L	42.4	100
MET	Lead	SW846 6010B	ICP/MS	µg/L	8	15
MET	Manganese	SW846 6010B	ICP/MS	µg/L	1.2	15
MET	Nickel	SW846 6010B	ICP/MS	µg/L	2.4	10
MET	Silver	SW846 6010B	ICP/MS	µg/L	2.2	10
MET	Zinc	SW846 6010B	ICP/MS	µg/L	8.6	20

1 - MET = metals; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; PST = pesticide;
AVS = acid volatile sulfide; SEM = simultaneously extracted metals; TOC = total organic carbon; DBT = Dibutyl tin;
MBT = Monobutyl tin; TBT = Tributyl tin; TTBT = Tetrabutyl tin; BT = Butyltin
2 - ICP = Inductively-coupled Plasma; MS = Mass Spectroscopy; GC = Gas Chromatography;
ECD = Electron Capture Detector.
3 - MDL = Method Detection Limit; RL = Reporting Limit.
4 - Sediments analyses conducted under Validation Study (Battelle 2001);
NOAA Status and Trends methods used (NOAA, 1998) .
5 - For SEM and AVS, RL equals MDL.

Table 3.1-1. Summary of Hazard Quotients calculated from sediment concentrations measured in the Hunter's Point TIE study[1].

Class	Analyte	Benchmark Source[2]	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
MET	Aluminum	NA											
MET	Antimony	AET-L	-	-	-	-	-	-	-	-	-	-	-
MET	Arsenic	ER-M	-	-	-	-	-	-	-	-	-	-	-
MET	Barium	NA											
MET	Cadmium	ER-M	-	-	-	-	-	-	-	-	-	-	-
MET	Chromium	ER-M	-	-	-	+	-	-	-	-	-	-	-
MET	Cobalt	AET-L	+	+	+	+	+	+	+	+	+	+	+
MET	Copper	ER-M	+	+	-	-	-	-	-	+	-	+	-
MET	Iron	NA											
MET	Lead	ER-M	-	-	-	-	-	-	-	-	-	-	-
MET	Manganese	AET-L	+	+	+	+	+	+	+	+	+	+	+
MET	Mercury	ER-M	-	-	-	-	+	+	-	+	+	+	-
MET	Molybdenum	NA											
MET	Nickel	ER-M	+	+	+	++	+	+	+	++	+	+	+
MET	Selenium	AET-L	-	-	-	-	-	-	-	-	-	-	-
MET	Silver	ER-M	-	-	-	-	-	-	-	-	-	-	-
BT	DBT	NA											
BT	MBT	NA											
BT	TBT	AET-L	-	-	-	-	-	-	-	-	-	-	-
BT	TTBT	NA											
BT	Total Butyltins	NA											
MET	Vanadium	NA											
MET	Zinc	ER-M	-	-	-	-	-	-	-	-	-	-	-
SEM	SEM-AVS	EPA	-	-	-	-	-	-	-	-	-	-	-
PAH	2-Methylnaphthalene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Acenaphthene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Acenaphthylene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Anthracene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo(a)anthracene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo[a]pyrene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo[b]fluoranthene	AET-H	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo[ghi]perylene	AET-H	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo[k]fluoranthene	AET-H	-	-	-	-	-	-	-	-	-	-	-
PAH	Chrysene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Dibenz[a,h]anthracene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Fluoranthene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Fluorene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Indeno[1,2,3-cd]pyrene	AET-L	-	-	-	-	-	-	-	-	-	-	-
PAH	Naphthalene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Phenanthrene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Pyrene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Total LMW (L) PAHs	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Total HMW (H) PAHs	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Total PAHs	ER-M	-	-	-	-	-	-	-	-	-	-	-
PCB	Total PCBs	ER-M	++	-	-	+	++	+++	++	+++	+++	-	-
PST	2,4'-DDD	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	2,4'-DDE	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	2,4'-DDT	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	4,4'-DDD	ER-M	-	-	-	-	-	-	-	+	-	-	-
PST	4,4'-DDE	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	4,4'-DDT	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	alpha-Chlordane	PEL	-	-	-	-	-	-	-	-	-	-	-
PST	Dieldrin	PEL	-	-	-	-	-	++	-	-	-	-	-
PST	Endosulfan II	SQAL	-	-	-	-	-	-	-	-	-	-	-
PST	Endrin	SQAL	-	-	-	-	-	-	-	-	-	-	-
PST	gamma-Chlordane	PEL	-	-	-	-	-	-	-	-	-	-	-
PST	Heptachlor	AET-L	-	-	-	-	-	-	-	-	-	-	-

LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995); (methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995); (benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
1- Hazard Quotient (see Appendix A-2-1 for values) codes: <benchmark(BM) = "-"; >BM = "+"; >3xBM = "++"; >10xBM = "+++".
2- See Table 2.2-1 for benchmarks; NA = benchmark not available.

Table 3.1-2. Summary of Hazard Quotients calculated from pore water concentrations in sediments collected for the Hunter's Point TIE study[1].

Class	Analyte	Benchmark Source[2]	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)	HP-PC	HP-SPIKE
MET	Aluminum	WQC-FA	-	-	-	-	-	-	+++	++	-	+	+	-	-
MET	Arsenic	WQC-SA	-	-	+	-	-	-	-	-	-	-	-	-	-
MET	Cadmium	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Chromium	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Copper	WQC-SA	+	+	+	-	+	+	+++	++	+	++	+	-	+++
MET	Iron	NA													
MET	Lead	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Manganese	WQC-FA	++	+	+	++	++	+	+	++	++	+	+++	-	-
MET	Nickel	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Silver	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Zinc	WQC-SA	-	-	-	-	-	-	+	-	-	-	-	-	-
MET	SEM-AVS	NA													
PAH	2-Methylnaphthalene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Acenaphthene	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Acenaphthylene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Anthracene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo(a)anthracene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo[a]pyrene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo[b]fluoranthene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo[ghi]perylene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo[k]fluoranthene	estimated	-	-	-	-	-	-	-	-	-	-	-		
PAH	Chrysene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Dibenz[a,h]anthracene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Fluoranthene	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Fluorene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Indeno[1,2,3-cd]pyrene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Naphthalene	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Phenanthrene	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Pyrene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Total LMW (L) PAHs	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Total HMW (H) PAHs	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Total PAHs	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PCB	Total PCBs	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PST	2,4'-DDD	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	2,4'-DDE	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	2,4'-DDT	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	4,4'-DDD	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PST	4,4'-DDE	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PST	4,4'-DDT	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PST	alpha-Chlordane	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	Dieldrin	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PST	Endosulfan II	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	Endrin	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PST	gamma-Chlordane	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	Heptachlor	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
AMM	Un-ionized Ammonia	WQC-SA	-	-	++	++	+	-	+	++	++	++	-	-	-

LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995); (methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995); (benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
1- Hazard Quotient (see Appendix A-2-2 for values) codes: <benchmark(BM) = "-"; >BM = "+"; >3xBM = "++"; >10xBM = "+++".
2- See Table 2.2-2 for benchmarks; NA = benchmark not available.

Table 3.1-3. Species-specific Hazard Quotients for measured pore water concentrations associated with toxic TIE treatment responses observed in the Hunter's Point TIE study.

a) *S. purpuratus*

	HQs in 100% pore water			
	Copper	Zinc	Aluminum	Un-ionized Ammonia[2]
Sample ID/EC_{50} µg/L[1]	8.0	19	200	0.1
HP-1	1.0	1.1	1.4	3.2
HP-2	0.7	2.1	2.1	3.1
HP-3	0.8	1.0	2.4	37
HP-4	0.6	1.2	1.5	15
HP-5	1.4	1.0	2.4	10
HP-6	1.1	0.8	2.2	1.1
HP-7	16	11	61	5.4
HP-8	5.8	2.8	23	14
HP-9	1.2	1.3	2.8	19
HP-10	2.2	2.4	5.2	22
HP-REF	1.5	1.4	8.5	2.1
HP-PC	0.4	3.3	1.3	0.3
HP-SPIKE	39	1.0	1.3	1.5

b) *M. menidia*

	HQs in 100% pore water			
	Copper	Zinc	Manganese	Un-ionized Ammonia[2]
Sample ID/LC_{50} µg/L[1]	136	3900	3680	1.45
HP-1	0.1	5.46E-3	1.1	0.2
HP-2	0.04	0.0	0.6	0.2
HP-3	0.05	5.10E-3	0.7	2.0
HP-4	0.03	5.72E-3	1.0	0.8
HP-5	0.08	5.05E-3	1.2	0.6
HP-6	0.06	4.13E-3	0.5	0.1
HP-7	0.95	0.1	0.5	0.3
HP-8	0.34	0.0	2.3	0.8
HP-9	0.07	6.56E-3	1.5	1.0
HP-10	0.13	0.0	0.6	1.2
HP-REF	0.09	6.92E-3	3.9	0.1
HP-PC	0.03	0.02	1.63E-4	0.02
HP-SPIKE	2.3	4.69E-3	3.26E-4	0.1

c) *D. excentricus*

	HQs in 100% pore water			
	Copper	Zinc	Manganese	Unionized Ammonia[2]
Sample ID/EC_{50} µg/L[1]	20	NA	NA	NA
HP-1	0.4			
HP-2	0.3			
HP-3	0.3			
HP-4	0.2			
HP-5	0.6			
HP-6	0.4			
HP-7	6.5			
HP-8	2.3			
HP-9	0.5			
HP-10	0.9			
HP-REF	0.6			
HP-PC	0.2			
HP-SPIKE	16			

1 - median of range of literature values reported in Table 2.2-3.
2 - calculated from Total Ammonia; see Appendix A-3.
3 - calculated assuming 10% dilution of measured pore water (i.e. 100%) concentration.

Table 3.2-1. Toxicity test results from 10-day bulk sediment tests, sediment-water interface (SWI) and pore water TIE tests on samples collected at Hunter's Point[1].

Sample			Bulk Sediment Test[2, 3]	SWI Test[2]	Pore water TIE Test; 10%	Pore water TIE Test; 100%	
SAIC TIE ID	**Area**	**Station**	**%Survival** *E. estuarius*	**%Normal** *S. purpuratus*	**%Normal** *S. purpuratus*	**%Normal** *S. purpuratus*	**%Survival** *M. menidia*
HP-1	Area III	PA-41 (0-5cm)	75	98	20	0	100
HP-2	Area III	PA-41 (5-10cm)	75		17	0	125
HP-3	Area IIX	EW-33 (0-5cm)	102	56	4	0	0
HP-4	Area IX	OR-24 (0-5cm)	96	81	35	0	58
HP-5	Area X	SB-20 (0-5cm)	93	93	52	0	8
HP-6	Area X	SB-20 (5-10cm)	72		7	0	125
HP-7	Area X	SB-18 (0-5cm)	100	92	0	0	125
HP-8	Area X	SB-21 (0-5cm)	101	98	0	0	0
HP-9	Area X	SB-22 (0-5cm)	76	95	4	0	0
HP-10	Area X	SB-23 (0-5cm)	100	90	0	0	0
HP-REF	Paradise Cove	PC-63 (0-5cm)			4	0	117
Control			100	100	100	100	100
Spike						0	0

1 - Results normalized to mean control responses.

2 - Data source: Battelle, 2001.

3 -normalized to test-specific control (not mean control).

Table 3.2-2. Summary of measured sediment and water quality parameters in samples tested for toxicity for the Hunter's Point Validation Study/TIE evaluation.

Sample			Sediment Characteristics			Bulk Sediment Test	SWI Test		TIE Pore Water	
SAIC TIE ID	**Area**	**Station[2]**	**TOC (%)**	**Moisture Content (%)**	**Fines Content (%)**	**Total Ammonia-N; Pore Water (mg/L)[1]**	**Total Ammonia-N (mg/L)**	**Un-ionized Ammonia-N (mg/L)**	**Total Ammonia-N (mg/L)**	**Un-ionized Ammonia-N (mg/L)[3]**
HP-1	Area III	PA-41 (0-5cm)	1.1	55.3	80.0	6.2	1.8	7.0E-03	3.5	0.3
HP-2	Area III	PA-41 (5-10cm)	1.1	51.7	71.7	9.3			4.3	0.3
HP-3	Area IIX	EW-33 (0-5cm)	0.89	31.8	14.4	42.4	2.6	9.5E-03	26.5	2.9
HP-4	Area IX	OR-24 (0-5cm)	1.8	39.3	53.9	20.8	1.7	1.0E-02	13.0	1.2
HP-5	Area X	SB-20 (0-5cm)	1.6	50.0	92.7	16.2	0	0	11.3	0.82
HP-6	Area X	SB-20 (5-10cm)	1.6	53.8	92.7	4.4			1.5	0.09
HP-7	Area X	SB-18 (0-5cm)	0.43	25.5	15.8	20.8	0	0	18.0	0.44
HP-8	Area X	SB-21 (0-5cm)	0.69	38.8	28.2	30.2	0.6	2.0E-03	30.0	1.1
HP-9	Area X	SB-22 (0-5cm)	1.7	55.2	87.4	16.8	0.9	3.5E-03	16.5	1.5
HP-10	Area X	SB-23 (0-5cm)	0.70	31.8	19.2	34.9	0.4	1.5E-03	30.0	1.8
HP-REF	Paradise Cove	PC-63 (0-5cm)	1.0	57.1	98.3	2.8	0	0	2.8	0.17
Control									0	0
Spike									1.3	0.024
Median of TIE samples			1.1	50.0	82.8	12.8	0	0	11.3	0.4

1 - Ammonia concentration at test start reported; concentration tended to decrease over time.

2 - See Figure 2.1-1 for station locations. Sampling depth indicated in parenthesis.

3 - Calculated using fish test water quality conditions; see Appendix A-3.

Table 3.3-1. Percent normal embryo-larval development in the purple sea urchin, *Strongylocentrotus purpuratus*, exposed to Hunter's Point TIE treatments.

	TIE Treatment Result (% normal development)[1]					
		Metals		Particulates	Organics	NH_4
Station-dilution	Untreated	STS	EDTA	Filtered	Oasis	*Ulva*
HPSPIKE - 10	**0**	**8**	**58**	**26**	**19**	55
HPSPIKE - 25	**0**	**0**	**43**	**15**	**6**	**47**
HPSPIKE - 50	**0**	**0**	**6**	**4**	**0**	**51**
HPSPIKE - 100	**0**	**0**	**0**	**1**	**0**	60
HP1 - 10	**12**	**47**	63	**57**	**33**	**50**
HP1 - 25	**0**	**23**	**30**	**27**	**12**	**43**
HP1 - 50	**0**	**0**	**0**	0	**0**	**48**
HP1 - 100	**0**	**0**	**0**	0	**0**	55
HP2 - 10	**10**	**29**	**57**	**56**	**30**	**53**
HP2 - 25	**4**	**18**	**28**	**18**	**4**	**41**
HP2 - 50	**0**	**0**	**0**	**0**	**0**	**44**
HP2 - 100	**0**	**0**	**0**	**0**	**0**	**55**
HP3 - 10	**2**	**6**	**28**	**0**	**0**	**53**
HP3 - 25	**0**	**0**	**0**	**0**	**0**	**45**
HP3 - 50	**0**	**0**	**0**	**0**	**0**	**45**
HP3 - 100	**0**	**0**	**0**	**0**	**0**	**53**
HP4 - 10	**21**	**64**	**56**	**58**	**37**	54
HP4 - 25	**0**	**13**	**14**	**6**	**6**	58
HP4 - 50	**0**	**0**	**0**	**0**	**0**	49
HP4 - 100	**0**	**0**	**0**	**0**	**0**	**28**
HP5 - 10	**31**	**68**	**32**	**59**	**24**	56
HP5 - 25	**0**	**0**	**4**	**0**	**1**	**50**
HP5 - 50	**0**	**0**	**0**	**0**	**0**	**36**
HP5 - 100	**0**	**0**	**0**	**0**	**0**	**51**
HP6 - 10	**4**	**50**	**48**	60	**37**	48
HP6 - 25	**13**	**57**	**44**	59	**32**	**36**
HP6 - 50	**3**	**33**	**31**	**22**	**21**	52
HP6 - 100	**0**	**0**	**14**	**0**	**2**	63
HP7 - 10	**0**	**39**	**36**	NP	**31**	43
HP7 - 25	**0**	**0**	**2**	NP	**2**	31
HP7 - 50	**0**	**0**	**0**	NP	**0**	29
HP7 - 100	**0**	**0**	**0**	NP	**0**	39
HP8 - 10	**0**	**0**	**1**	**0**	**0**	41
HP8 - 25	**0**	**0**	**0**	**0**	**0**	37
HP8 - 50	**0**	**0**	**0**	NP	**0**	40
HP8 - 100	**0**	**0**	**0**	NP	**0**	31
HP9 - 10	**2**	**51**	**36**	**43**	**33**	**43**
HP9 - 25	**0**	**0**	**3**	**0**	**0**	**42**
HP9 - 50	**0**	**0**	**0**	**0**	**0**	**43**
HP9 - 100	**0**	**0**	**0**	**0**	**0**	**43**
HP10 - 10	**0**	**1**	**4**	**0**	**0**	**31**
HP10 - 25	**0**	**0**	**0**	**0**	**0**	**18**
HP10 - 50	**0**	**0**	**0**	**0**	**0**	**35**
HP10 - 100	**0**	**0**	**0**	**0**	**0**	**3**
HPREF - 10	3	**44**	**35**	62	**29**	49
HPREF - 25	14	**34**	**35**	**49**	**20**	**42**
HPREF - 50	2	**9**	**2**	**6**	**4**	**37**
HPREF - 100	0	**0**	**0**	**0**	**0**	**41**
PC-100	59	78	67	66	58	67

NP = no pore water available.

1 - Shaded values indicate improvement (greater than or equal to 5%) relative to previous treatment(s). Bold values are statistically different (α=0.05) from performance control as determined by Dunnett's t-test.

Table 3.3-2. Percent survival in the fish, *Menidia menidia*, exposed to Hunter's Point TIE treatments.

	TIE Treatment Result (% Survival)[1]						
		Metals		Particulates	Organics	NH_4	NH_3
Station-dilution	Untreated	STS	EDTA	Filtered	Oasis	*Ulva*	High pH[2]
Spike - 50	100	100	100	100	100	90	100
Spike - 100	7	47	53	80	73	100	80
HP1 - 50	100	100	100	100	100	100	100
HP1 - 100	80	93	100	100	80	100	80
HP2 - 50	100	100	100	100	100	100	100
HP2 - 100	100	80	100	100	60	93	100
HP3 - 50	100	100	90	100	90	100	100
HP3 - 100	**0**	**0**	**0**	**0**	**0**	100	**0**
HP4 - 50	100	100	100	100	100	100	100
HP4 - 100	**47**	100	100	100	87	100	50
HP5 - 50	100	100	100	100	100	100	100
HP5 - 100	**7**	20	13	87	**7**	93	73
HP6 - 50	100	100	100	100	100	100	100
HP6 - 100	100	100	93	100	73	100	100
HP7 - 50	100	100	100	NP	100	100	100
HP7 - 100	NP	NP	NP	NP	NP	87	60
HP8 - 50	100	100	100	100	100	100	100
HP8 - 100	**0**	**0**	**0**	**0**	**0**	87	**0**
HP9 - 50	100	100	100	100	100	100	100
HP9 - 100	**0**	**0**	13	47	**33**	100	0
HP10 - 50	100	100	100	100	100	100	100
HP10 - 100	**0**	**0**	**0**	**0**	**0**	100	100
HPREF - 50	100	100	100	90	100	100	100
HPREF - 100	93	93	93	100	87	100	100
PC-100	80	73	60	60	67	93	87

NP = no pore water available.

1 - Shaded values indicate improvement (greater than or equal to 5%) relative to previous treatment(s). Bold values are statistically different (α=0.05) from performance control as determined by Dunnett's t-test.

2 - Decreased survival associated with the High pH treatment is consistent with the shift to a larger proportion of the more toxic unionized form of ammonia.

Table 3.3-3. Percent normal embryo-larval development in the sand dollar, *Dendraster excentricus*, exposed to Hunter's Point TIE treatments.

	TIE Treatment Result (% normal development)[1]									
		Metals		Particulates	Organics	NH_4	NH_3	NH_4	Metals	Metals
Station-dilution	Untreated	STS	EDTA	Filtered	Oasis	*Ulva*	High pH[2]	*Ulva* 1st *Ulva*[3]	*Ulva* 1st STS[3]	*Ulva* 1st EDTA[3]
HP4 - 1	95	96	95	95	91	89	92	91	94	94
HP4 - 10	96	94	95	93	84	91	90	95	93	91
HP4 - 50	**1**	**0**	**0**	**0**	**0**	82	**0**	91	92	94
HP4 - 100	**1**	**0**	**0**	**0**	**0**	82	**0**	**49**	**66**	**75**
HP5 - 1	96	94	98	91	85	88	89	95	91	94
HP5 - 10	**32**	**33**	**60**	**65**	**38**	84	**41**	93	96	95
HP5 - 50	**0**	**0**	**0**	**0**	**0**	67	**1**	**1**	**14**	**5**
HP5 - 100	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
HP9 - 1	95	92	95	92	87	89	93	88	96	91
HP9 - 10	**7**	**14**	**30**	**54**	**18**	75	**83**	84	93	95
HP9 - 50	**0**	**0**	**0**	**0**	**0**	69	**0**	**51**	90	96
HP9 - 100	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**5**
HPREF - 1	95	95	94	93	92	86	90	91	94	91
HPREF - 10	94	94	95	94	95	84	87	89	92	88
HPREF - 50	**30**	**33**	**77**	**69**	**60**	81	**62**	**84**	82	**79**
HPREF - 100	**0**	**2**	**0**	**0**	**1**	**49**	**0**	**61**	**72**	**80**
PC-100	96	93	93	90	92	60	94	92	90	95

1 - Shaded values indicate improvement (greater than or equal to 5%) relative to previous treatment(s). Bold values are statistically different (α=0.05) from performance control as determined by Dunnett's t-test.

2 - Decreased survival associated with the High pH treatment is consistent with the shift to a larger proportion of the more toxic unionized form of ammonia.

3 - In a second round of manipulations, the order of select treatments was reversed to reduce masking effect of ammonia.

Table 3.3-4. Summary of toxicity removed by TIE treatment for the purple sea urchin, *Strongylocentrotus purpuratus*, exposed to Hunters Point TIE sediment pore waters.

Station	Total Toxicity Removed by TIE[1]	Reduction in Toxicity due to each TIE Treatment (as % of total effects observed in untreated sample)[2]				Treatments that Removed Toxicity, in order of Relative Effectiveness[3]
		STS	EDTA	Filtraton	*Ulva*	
HP-SPIKE	79	4	46	0	51	*Ulva* = EDTA
HP-1	72	29	11	0	63	*Ulva* > *S* TS>EDTA
HP-2	70	17	19	0	63	*Ulva* >EDTA=STS
HP-3	73	2	10	0	87	*Ulva* >EDTA
HP-4	68	29	1	0	72	*Ulva* >STS
HP-5	68	20	2	0	82	*Ulva* >STS
HP-6	72	62	7	6	38	STS>*Ulva* >EDTA=Filtration
HP-7	53	18	1	0	71	*Ulva* >STS
HP-8	56	0	0	0	99	*Ulva*
HP-9	64	23	1	0	74	*Ulva* >STS
HP-10	32	0	1	0	95	*Ulva*
HP-REF	60	35	1	16	44	*Ulva* = STS>Filtration

[1] % of Normal development that was restored by the cumulative TIE treatment in all 4 dilutions as a % of the *Ulva* control response (67%).

[2] % of Normal development that was restored by each individual TIE treatment in all 4 dilutions, expressed as a percent of the total toxicity removed (e.g. for HP-spike, 4% of the 79% overall improvement was due to STS treatment).

Zero values are reported when no reduction in effect was observed relative to previous treatment.

Oasis SPE is not included because no reductions in toxicity were associated with this treatment.

[3] ">" = 10% or higher difference in toxicity reduction; treatments resulting in <5% reduction not listed.

Table 3.3-5. Summary of toxicity removed by TIE treatment for the fish, *Menidia menidia*, exposed to Hunter's Point TIE sediment pore waters.

Station	Total Toxicity Removed by TIE[1]	Reduction in Toxicity due to each TIE Treatment (as % of total effects observed in untreated sample)[2]				Treatments that Removed Toxicity, in order of Relative Effectiveness[3]
		STS	EDTA	Filtraton	*Ulva*	
HP-SPIKE[a]	100	43	6	29	21	STS>Filtration=*Ulva*> EDTA
HP-1[a]	100	65	35	0	0	STS>EDTA
HP-2	NT					No toxicity observed in untreated sample
HP-3[a, b]	100	0	0	0	100	*Ulva*
HP-4[a]	100	100	0	0	0	STS
HP-5[a]	92	15	0	78	7	Filtration>STS=*Ulva*
HP-6	NT					No toxicity observed in untreated sample
HP-7	NT					No toxicity observed in untreated sample
HP-8[a, b]	87	0	0	0	100	*Ulva*
HP-9[a]	100	0	13	34	53	*Ulva*> Filtraton>EDTA
HP-10[a, b]	100	0	0	0	100	*Ulva*
HP-REF[a]	NT					No toxicity observed in untreated sample

[a] Toxicity observed in 100% dilution only.

[b] Low DO alone would have resulted in complete mortality.

[1] % of Normal development that was restored by the cumulative TIE treatment in all 4 dilutions as a % of the treatment control response.

[2] % of Normal development that was restored by each individual TIE treatment in all 4 dilutions, expressed as a percent of the total toxicity removed, (e.g. for HP-spike, 43% of the 100% overall improvement was due to STS treatment).
Zero values are reported when no reduction in effect was observed relative to previous treatment.
Oasis SPE is not included because no reductions in toxicity were associated with this treatment.
NT= Not toxic.

[3] ">" = 10% or higher difference in toxicity reduction; treatments resulting in <5% reduction not listed.

Table 3.3-6. Summary of toxicity removed by TIE treatment for the sand dollar, *Dendraster excentricus*, exposed to Hunter's Point TIE sediment pore waters.

Series I (Normal TIE)

Station	Total Toxicity Removed by TIE[1]	Reduction in Toxicity due to each TIE Treatment (as % of total effects observed in untreated sample)[2]				Treatments that Removed Toxicity, in order of Relative Effectiveness[3]
		STS	EDTA	Filtraton	*Ulva*	
HP-4	88	1	0	0	100	*Ulva*
HP-5	48	1	24	4	72	*Ulva* >EDTA>Filtration
HP-9	50	5	12	18	66	*Ulva* >Filtration=EDTA
HP-REF	64	5	45	0	51	*Ulva*= EDTA>STS

Series II (*Ulva* first)

Station	Total Toxicity Removed by TIE[1]	Reduction in Toxicity due to each TIE Treatment (as % of total effects observed in untreated sample)[2]			Treatments that Removed Toxicity, in order of Relative Effectiveness[3]
		Ulva	STS	EDTA	
HP-4	91	83	11	7	*Ulva* >STS>EDTA
HP-5	31	81	21	0	*Ulva* >STS
HP-9	70	68	28	5	*Ulva* >STS>EDTA
HP-REF	86	86	8	6	*Ulva* >STS=EDTA

[1] % of Normal development that was restored by the cumulative TIE treatment in all 4 dilutions as a % of the mean control response across treatments (90%).
Note: The sum of % changes deviates from 100% in some cases (e.g. *Ulva* 1st, HP-5) where treatment control exceeded mean control response.

[2] % of Normal development that was restored by each individual TIE treatment in all 4 dilutions, expressed as a percent of the total toxicity removed.
Zero values are reported when no reduction in effect was observed relative to previous treatment.
Oasis SPE is not included because no reductions in toxicity were associated with this treatment.

[3] ">" = 10% or higher difference in toxicity reduction; treatments resulting in <5% reduction not listed.

Table 4.1-1. Summary of findings from the Hunter's Point TIE investigation.

Area	SAIC TIE ID	Treatment(s) that Reduced Pore Water Toxicity and Associated Probable Toxicant(s)[1]			Potential Toxicants Identified in Porewater and Sediment HQs
		Fish	Urchin	Sand Dollar	
Point Avisadero	HP-1	STS>EDTA- Manganese, Copper	*Ulva* -NH_4> STS>EDTA- metals	ND	Sed. HQs: Cobalt (1.7), Copper (1.9), Manganese (1.9), Nickel (2.3), Total PCBs (3.9) PW HQs: Copper (1.7), Manganese (4.1)
Point Avisadero	HP-2	NT	*Ulva* -NH_4> EDTA=STS- metals	ND	Sed. HQs: Cobalt (1.8), Copper (1.0), Manganese (1.8), Nickel (2.1) PW HQs: Copper (1.1), Manganese (2.3)
Eastern Wetland	HP-3	Low DO>*Ulva* - NH_4	*Ulva* -NH_4> EDTA- metals	ND	Sed. HQs: Cobalt (1.3), Manganese (2.2), Nickel (1.2) PW HQs: Arsenic (1.1), Copper (1.4), Manganese (2.5), Un-ionized ammonia (9.3)
Oil Reclamation	HP-4	STS- Aluminum, Zinc, Copper	*Ulva* -NH_4> STS- metals	*Ulva* -NH_4 *Ulva* -NH_4>STS>EDTA-Aluminum, Zinc, Copper[2]	Sed. HQs: Chromium (1.2), Cobalt (2.0), Manganese (2.4), Nickel (3.1), Total PCBs (2.4) PW HQs: Manganese (3.6), Un-ionized ammonia (3.7)
South Basin	HP-5	Filtered-particle fraction> STS-Manganese, Copper= *Ulva* -NH_4	*Ulva*- NH_4> STS- metals	*Ulva* -NH_4> EDTA>Filtration *Ulva* -NH_4>STS-Aluminum, Copper, Zinc[2]	Sed. HQs: Cobalt (1.7), Manganese (1.7), Mercury (1.3), Nickel (2.3), Total PCBs (8.7) PW HQs: Copper (2.4), Manganese (4.6), Un-ionized ammonia (2.6)
South Basin	HP-6	NT	STS- metals> *Ulva* -NH_4>EDTA- metals =Filtration- particle fraction	ND	Sed. HQs: Cobalt (1.8), Manganese (1.6), Mercury (1.2), Nickel (2.5), Dieldrin (4.7), Total PCBs (11) PW HQs: Copper (1.8), Manganese (1.9)
South Basin	HP-7	NT	*Ulva* -NH_4> STS- Aluminum, Copper, Zinc	ND	Sed. HQs: Cobalt (1.1), Manganese (1.4), Nickel (1.8), Total PCBs (4.6) PW HQs: Aluminum (16), Copper (27), Manganese (1.7), Zinc (2.4), Un-ionized ammonia (1.4)
South Basin	HP-8	Low DO>*Ulva* -NH_4	*Ulva* -NH_4	ND	Sed. HQs: Cobalt (2.2), Copper (1.2), Manganese (1.7), Mercury (2.1), Nickel (3.1), Total PCBs (29), 4,4'-DDD (1.6) PW HQs: Aluminum (6.2), Copper (9.7), Manganese (8.4), Un-ionized ammonia (3.5)
South Basin	HP-9	*Ulva* -NH_4> Filtered-particle fraction> EDTA- Manganese, Copper	*Ulva* -NH_4> STS- metals	*Ulva* -NH_4>Filtration-particle fraction=EDTA>STS- Aluminum, Zinc, Copper *Ulva* -NH_4>STS>EDTA-Aluminum, Zinc, Copper[2]	Sed. HQs: Cobalt (1.8), Manganese (1.7), Mercury (1.8), Nickel (2.5), Total PCBs (10) PW HQs: Copper (2.0), Manganese (5.6), Un-ionized ammonia (4.7)
South Basin	HP-10	Low DO>*Ulva* -NH_4	*Ulva* -NH_4	ND	Sed. HQs: Cobalt (1.0), Copper (1.0), Manganese (1.2), Mercury (1.2), Nickel (2.4) PW HQs: Aluminum (1.4), Copper (3.7), Manganese (2.0), Un-ionized ammnia (5.5)
Paradise Cove	HP-REF	NT	*Ulva* -NH_4=STS-Aluminum, Copper, Zinc>Filtration-particle fraction	*Ulva* -NH_4=EDTA>STS-Aluminum, Copper, Zinc *Ulva* -NH_4=STS>EDTA-Aluminum, Copper, Zinc[2]	Sed. HQs: Cobalt (1.7), Manganese (2.1), Nickel (1.7) PW HQs: Aluminum (2.3), Copper (2.4), Manganese (14)

1 - in order of percent of overall toxicity removed (Table 3.3-4, 3.3-5 and 3.3-6); see text for probable CoCs.
2 - observed in reverse treatment
NT = not toxic; ND = no data

Appendix A-1-1. Measured sediment concentrations of chemicals for the Hunter's Point TIE study[1].

Class	Analyte	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
MET	Aluminum	66500	67700	43500	57300	70050	70100	49200	46400	65300	47900	72100
MET	Antimony	1.09	2.64	3.64	2.38 J	5.48 J	4.96 J	3.95	0.65	7.43 J	7.26	0.77
MET	Arsenic	11	12	6.12	11 J	12 J	12 J	5.86	9.95	13 J	7.03	12
MET	Barium	568	501	372	381	481	489	458	761	459	726	472
MET	Cadmium	0.33 J	0.33 J	0.26 J	0.34 J	0.65	0.84	0.43 J	0.26 J	0.57 J	0.40 J	0.19 J
MET	Chromium	349	303	225	434	240	270	175	338	256	292	161
MET	Cobalt	17	18	13	20	17	18	11	22	18	11	17
MET	Copper	525 J	279 J	21	98	133	164	66 J	319 J	163	277 J	40 J
MET	Iron	42500	41800	27200	45600	45600	44800	25500	31000	42600	21000	41200
MET	Lead	109 J	105 J	19	60	110	133	122 J	12 J	142	114 J	22 J
MET	Manganese	494	463	579	624	451	421	357	453	446	305	554
MET	Mercury	0.48	0.53	0.14 J	0.48 J	0.91	0.84 J	0.23 J	1.47 J	1.26 J	0.84 J	0.29
MET	Molybdenum	1.12	1.75	0.49	1.41 J	1.10	1.58 J	0.70	0.77	1.50 J	0.83	0.82
MET	Nickel	119 J	108 J	60	160	121	128	93	161	130	123	87 J
MET	Selenium	0.51 J	0.44 J	0.06 U	0.24 J	0.39 J	0.41 J	0.15 J	0.18 J	0.36 J	0.20 J	0.29 J
MET	Silver	0.29	0.33	0.07 J	0.36 J	0.64 J	0.73 J	0.26 J	0.14 J	0.70 J	0.37 J	0.24
BT	DBT	0.06	0.13	6.2E-4 U	0.02	0.02	0.02	0.01	0.03	0.04	0.05	1.0E-3 U
BT	MBT	5.0E-4 UJ	5.0E-4 UJ	3.3E-4 UJ	2.7E-3 J	5.7E-4 UJ	5.2E-4 UJ	3.3E-4 UJ	3.7E-4 UJ	5.3E-4 UJ	3.5E-4 U	5.4E-4 UJ
BT	TBT	0.21 D	0.38 D	4.4E-4 U	0.07	0.03	0.02	0.02	0.06	0.06	0.13 D	7.2E-4 U
BT	TTBT	1.2E-3 U	1.2E-3 U	7.8E-4 U	1.1E-3 U	1.3E-3 U	1.2E-3 U	7.7E-4 U	8.8E-4 U	1.3E-3 U	8.2E-4 U	1.3E-3 U
BT	Total Butyltins	0.26	0.51		0.09	0.05	0.04	0.03	0.09	0.09	0.18	
MET	Vanadium	128	133	83	134	138	144	78	172	141	51	139
MET	Zinc	207	170	80	179	246	267	209 J	297 J	243	212 J	105
MET	SEM-AVS	1.24	-2.50	-6.14	-9.31	-3.39	-11.03	-5.83	1.27	-7.60	-3.54	0.40
PAH	2-Methylnaphthalene	20 B	15 B	1.59	9.85	20	40	21	27	24	19	3.88
PAH	Acenaphthene	182	42	1.63	7.62	7.70	12	11	21	6.97	12	2.51
PAH	Acenaphthylene	18	18	1.09	10	11	14	13	31	12	44	5.00
PAH	Anthracene	143	102	4.87	61	43	60	51	234	35	187	16
PAH	Benzo(a)anthracene	601	350	13	151	186	184	293	629	199	393	46
PAH	Benzo[a]pyrene	706	449	22	202	297	323	315	632	343	434	97
PAH	Benzo[b]fluoranthene	550	355	14	149	239	242	277	484	254	304	62
PAH	Benzo[ghi]perylene	481 B	332 B	21	170	296	327	194	384	319	283	88
PAH	Benzo[k]fluoranthene	546	361	16	169	248	253	290	500	260	346	61
PAH	Chrysene	715	394	17	262	276	255	453	744	269	551	65
PAH	Dibenz[a,h]anthracene	95 J	63 J	1.64	25	36	42	52 J	104 J	46	65 J	8.09
PAH	Fluoranthene	1214	683	38	291	406	346	466	953	320	650	118
PAH	Fluorene	92	53	1.55	11	12	21	16	81	11	49	4.11
PAH	Indeno[1,2,3-cd]pyrene	506	347	17	148 J	243	278	206	413	281	293	80
PAH	Naphthalene	18 B	25 B	1.76 U	15 B	40	60	57	41	42	25	8.34
PAH	Phenanthrene	751 B	375 B	19	135	147	147	153	668	104	469	51
PAH	Pyrene	1339 B	766 B	46	328	466	437	518	1065	406	749	152
PAH	Total LMW (L) PAHs	1225	631	33	250	281	354	323	1104	234	805	91
PAH	Total HMW (H) PAHs	4670	2705	138	1259	1666	1587	2096	4126	1583	2843	486
PAH	Total PAHs	5895	3336	171	1509	1947	1941	2419	5230	1817	3647	576
PCB	PCB 101	20 J	7.17	0.51 J	13 J	42 D	76 J	26 D	125 J	55 J	0.04 U	0.12 J
PCB	PCB 105	0.05 U	1.40	0.11 J	1.08 J	6.01	17 J	2.57	14 J	5.30 J	0.03 U	0.05 UJ
PCB	PCB 110	8.24 J	4.46 J	0.60 J	6.75 J	30 J	68 J	17 J	66 J	38 J	0.04 U	0.16 J
PCB	PCB 118	6.39	2.75	0.31 J	4.60 J	24 D	48 J	11	34 J	25 J	0.04 U	0.11 J
PCB	PCB 126	0.07 U	0.07 U	0.05 U	0.07 UJ	0.08 U	0.08 UJ	0.05 U	0.05 UJ	0.07 UJ	0.05 U	0.08 UJ
PCB	PCB 128	4.86	0.86 J	0.22 J	2.61 J	9.83	18 J	5.96	29 J	14 J	0.06 U	0.10 UJ
PCB	PCB 129	0.04 U	0.04 U	0.03 U	0.04 UJ	0.05 U	0.04 UJ	0.03 U	0.03 UJ	0.04 UJ	0.03 U	0.05 UJ
PCB	PCB 138	60 J	6.18	1.77	35 J	129 D	157 J	76 D	442 J	160 J	0.03 U	0.19 J
PCB	PCB 153	89 J	11	2.58	59 J	185 D	213 J	105 D	638 J	217 J	0.05 U	0.25 J
PCB	PCB 170	41 J	3.19	0.81	18 J	78 D	86 J	38 D	292 J	89 J	0.03 U	0.36 J
PCB	PCB 18	0.74 J	0.50 J	0.03 U	0.09 J	0.46 J	0.86 J	0.35 J	0.30 J	0.41 J	0.03 U	0.04 UJ
PCB	PCB 180	72 J	5.35	1.65	43 J	151 D	162 J	74 D	569 J	172 J	0.04 U	0.19 J
PCB	PCB 187	35 J	3.35	1.06	23 J	86 D	86 J	40 D	288 J	92 J	0.03 U	0.09 J
PCB	PCB 195	5.02 J	0.56 J	0.18 J	2.70 J	17 J	18 J	6.04 J	60 J	18 J	0.03 UJ	0.02 J
PCB	PCB 206	1.48	0.47 J	0.18 J	1.01 J	9.10 J	7.48 J	2.86 J	23 J	7.81 J	0.03 U	0.05 UJ
PCB	PCB 209	0.05 U	0.05 U	0.16 J	0.27 J	1.69 J	1.44 J	1.26 J	2.75 J	1.98 J	0.03 UJ	0.05 UJ
PCB	PCB 28	1.16	0.92	0.04 U	0.29 J	1.05	1.46 J	0.73	0.57 J	0.82 J	0.04 U	0.06 UJ
PCB	PCB 44	1.64 J	1.84 J	0.03 U	0.80 J	2.59	15 J	2.30	1.85 J	2.58 J	0.03 U	0.06 UJ
PCB	PCB 52	4.00	4.50	0.13 J	1.97 J	7.74	31 J	5.22	7.70 J	7.22 J	0.04 U	0.06 UJ
PCB	PCB 66	0.06 U	0.06 U	0.04 U	0.06 UJ	2.45	4.71 J	1.45	1.24 J	2.29 J	0.04 U	0.06 UJ
PCB	PCB 77	0.08 U	0.08 U	0.06 U	0.08 UJ	0.09 U	0.09 UJ	0.06 U	0.06 UJ	0.09 UJ	0.06 U	0.09 UJ
PCB	PCB 8	1.07 J	0.08 UJ	0.05 UJ	0.08 UJ	0.55 J	0.93 J	0.48 J	0.06 UJ	0.44 J	0.05 UJ	0.09 UJ
PCB	Total PCBs	705	110	22	426	1565	2026	831	5186	1818	3.18	6.18

Appendix A-1-1. continued.

Class	Analyte	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
PST	2,4'-DDD	0.05 U	0.05 U	0.04 U	0.05 UJ	0.06 U	0.06 UJ	0.04 U	0.04 UJ	0.06 UJ	0.04 U	0.06 UJ
PST	2,4'-DDE	0.07 U	0.07 U	0.04 U	0.06 UJ	0.08 U	0.07 UJ	0.04 U	0.05 UJ	0.07 UJ	0.04 U	0.07 UJ
PST	2,4'-DDT	0.06 UJ	0.06 UJ	0.04 U	0.06 UJ	0.07 U	0.07 UJ	0.04 U	0.05 UJ	0.06 UJ	0.04 U	0.07 UJ
PST	4,4'-DDD	1.74	1.71	0.27 J	3.08 J	5.38	6.76 J	4.05	44 J	5.11 J	0.03 U	0.43 J
PST	4,4'-DDE	1.48	0.82 J	0.31 J	0.33 J	9.52	12 J	6.51	5.55 J	4.29 J	0.03 U	0.33 J
PST	4,4'-DDT	0.64 J	1.06	0.03 UJ	0.78 J	0.93 J	0.69 J	0.03 UJ	3.60 J	0.78 J	0.03 UJ	0.05 UJ
PST	alpha-Chlordane	0.19 J	0.19 J	0.03 U	0.41 J	2.37	1.85 J	0.70	0.70 J	1.38 J	0.03 U	0.02 J
PST	Dieldrin	0.05 U	0.05 U	0.03 U	0.44 J	3.63	20 J	1.25	0.04 UJ	2.75 J	0.03 U	0.05 UJ
PST	Endosulfan II	0.05 U	0.05 U	0.03 U	0.05 UJ	0.06 U	0.05 UJ	0.03 U	0.04 UJ	0.05 UJ	0.03 U	0.05 UJ
PST	Endrin	0.05 U	0.05 U	0.03 U	0.04 UJ	0.05 U	0.05 UJ	0.03 U	0.03 UJ	0.05 UJ	0.03 U	0.05 UJ
PST	gamma-Chlordane	0.04 U	0.04 U	0.03 U	0.41 J	3.60	3.54 J	2.01	0.86 J	2.35 J	0.03 U	0.04 UJ
PST	Heptachlor	0.04 U	0.04 U	0.03 U	0.04 UJ	0.05 U	0.04 UJ	0.03 U	0.03 UJ	0.04 UJ	0.03 U	0.05 UJ
TOC	TOC(%)	1.08	1.14	0.89	1.75	1.63	1.64	0.43	0.69	1.70	0.70	0.97

1 - Data source: Battelle, 2001.
Units: metals = µg/g; PCBs, Pesticides (PST), PAHs = ng/g; SEM-AVS= µM/g.
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene)
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene)
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2
Data Qualifiers: "U"= not detected as at/above limit (half Method Detection Limit (MDL) reported), "J"=estimated value,
"D"=dilution- initial run outside instrument range, "B"=analyte found in both sample and associated blank.
SEM-AVS = Sum SEM ([Cu]+[Cd]+[Pb]+[Ni]+[Zn]) - AVS; Appendix A-1-2.

Appendix A-1-2. Measured concentrations of simultaneously extracted metals (SEM) and acid volatile sulfides (AVS) in sediments collected for the Hunter's Point TIE investigation.

CLASS	ANALYTE	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
SEM	Cadmium	2.3E-3	2.5E-3	1.8E-3	2.1E-3	3.0E-3	3.7E-3	3.2E-3	2.6E-3	4.2E-3	2.2E-3	2.0E-3
SEM	Copper	1.20	0.90	0.19	0.43	0.61	0.76	0.35	1.70	0.88	0.93	0.23
SEM	Lead	0.10	0.09	0.09	0.11	0.23	0.29	0.34	0.27	0.29	0.14	0.06
SEM	Nickel	0.24	0.25	0.14	0.27	0.27	0.32	0.18	0.30	0.43	0.19	0.18
SEM	Zinc	1.10	0.96	0.54	0.78	1.20	1.40	1.30	2.20	1.60	1.30	0.47
SEM	Sum SEM	2.64	2.20	0.96	1.59	2.31	2.77	2.17	4.47	3.20	2.56	0.94
AVS	Acid Volatile Sulfide	1.40	4.70	7.10	11	5.70	14	8.00	3.20	11	6.10	0.27 U
SEM	SEM-AVS	1.24	-2.50	-6.14	-9.31	-3.39	-11.0	-5.83	1.27	-7.60	-3.54	0.40

units = µM/g dry wt
Data Qualifiers: "U"=Undetected (half Method Detection Limit (MDL)) reported.
Sum SEM = [Cu]+[Cd]+[Pb]+[Ni]+[Zn].

Appendix A-1-3. Measured pore water concentrations of metals for the Hunter's Point TIE study.

Class	Analyte	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)	HP-PC	HP-SPIKE
MET	Aluminum	289	426	479	304	480	434	12200	4630	558	1040	1690	255	257
MET	Arsenic	38	39	73	33	49	15	52	29	41	28	18	0.85 U	0.85 U
MET	Cadmium	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U
MET	Chromium	4.50 B	4.80 B	4.60 B	4.80 B	7.30 B	7.00 B	90	23	6.40 B	8.40 B	7.80 B	3.40 B	3.60 B
MET	Copper	8.20 B	5.30 B	6.50 B	4.50 B	11	8.70 B	129	47	9.80 B	18	12	3.40 B	315
MET	Iron	16500	9960	11200	10800	19200	9070	18700	5740	11600	11000	2450	110	92 B
MET	Lead	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	86	19	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
MET	Manganese	4120	2320	2450	3590	4590	1860	1670	8350	5570	2040	14400	0.60 U	0.60 U
MET	Nickel	8.50 B	6.40 B	8.80 B	5.20 B	7.10 B	5.00 B	56	20	5.40 B	11	13	1.20 U	1.20 U
MET	Silver	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U
MET	Zinc	21	40	20 B	22	20 B	16 B	216	54	26	46	27	63	18 B
AMM	Un-ionized Ammonia	0.19	0.18	2.17	0.86	0.60	0.06	0.32	0.82	1.09	1.29	0.12	0.02	0.09

Units MET = µg/L; AMM = mg/L.
Un-ionized Ammonia from urchin (*Strongylocentrotus purpuratus*) test reported as urchin is most sensitive to ammonia of species tested; calculated from measured Total Ammonia (Appendix A-3).
Data Qualifiers: "U"=Undetected (half Method Detection Limit (MDL) reported, "J"=Estimated, "B"=<reporting limit but >MDL.

Appendix A-1-4. Predicted pore water concentrations of organics for the Hunter's Point TIE investigation[1].

Class	Analyte	Koc	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)	HP-PC	HP-SPIKE
PAH	2-Methylnaphthalene	8.0E+03	0.24	0.17	0.02	0.07	0.16	0.30	0.60	0.49	0.18	0.34	0.05		
PAH	Acenaphthene	7.1E+03	2.36	0.52	0.03	0.06	0.07	0.10	0.37	0.43	0.06	0.23	0.04		
PAH	Acenaphthylene	9.6E+03	0.17	0.17	0.01	0.06	0.07	0.09	0.31	0.47	0.08	0.66	0.05		
PAH	Anthracene	3.0E+04	0.44	0.30	0.02	0.12	0.09	0.12	0.40	1.14	0.07	0.90	0.05		
PAH	Benzo(a)anthracene	4.0E+05	0.14	0.08	3.6E-3	0.02	0.03	0.03	0.17	0.23	0.03	0.14	0.01		
PAH	Benzo[a]pyrene	1.0E+06	0.06	0.04	2.4E-3	0.01	0.02	0.02	0.07	0.09	0.02	0.06	9.8E-3		
PAH	Benzo[b]fluoranthene	1.2E+06	0.04	0.03	1.2E-3	6.9E-3	0.01	0.01	0.05	0.06	0.01	0.04	5.1E-3		
PAH	Benzo[ghi]perylene	3.9E+06	0.01	7.6E-3	6.1E-4	2.5E-3	4.7E-3	5.2E-3	0.01	0.01	4.9E-3	0.01	2.3E-3		
PAH	Benzo[k]fluoranthene	1.2E+06	0.04	0.03	1.4E-3	7.8E-3	0.01	0.01	0.05	0.06	0.01	0.04	5.0E-3		
PAH	Chrysene	4.0E+05	0.17	0.09	4.8E-3	0.04	0.04	0.04	0.26	0.27	0.04	0.20	0.02		
PAH	Dibenz[a,h]anthracene	3.8E+06	2.3E-3	1.5E-3	4.9E-5	3.8E-4	5.8E-4	6.8E-4	3.2E-3	4.0E-3	7.1E-4	2.5E-3	2.2E-4		
PAH	Fluoranthene	1.1E+05	1.04	0.56	0.04	0.15	0.23	0.20	0.99	1.28	0.17	0.87	0.11		
PAH	Fluorene	1.4E+04	0.62	0.34	0.01	0.05	0.05	0.09	0.27	0.86	0.05	0.51	0.03		
PAH	Indeno[1,2,3-cd]pyrene	3.4E+06	0.01	8.9E-3	5.6E-4	2.5E-3	4.3E-3	4.9E-3	0.01	0.02	4.8E-3	0.01	2.4E-3		
PAH	Naphthalene	2.0E+03	0.84	1.10	0.10	0.43	1.23	1.81	6.55	2.95	1.24	1.80	0.43		
PAH	Phenanthrene	3.0E+04	2.34	1.11	0.07	0.26	0.30	0.30	1.19	3.26	0.21	2.27	0.18		
PAH	Pyrene	1.1E+05	1.17	0.64	0.05	0.18	0.27	0.25	1.13	1.46	0.23	1.02	0.15		
PAH	Total LMW (L) PAHs	NA	7.02	3.70	0.26	1.04	1.97	2.83	9.69	9.61	1.87	6.72	0.83		
PAH	Total HMW (H) PAHs	NA	2.59	1.40	0.10	0.40	0.59	0.53	2.63	3.34	0.49	2.29	0.30		
PAH	Total PAHs	7.6E+04	9.60	5.11	0.36	1.44	2.56	3.36	12	13	2.36	9.00	1.12		
PCB	Total PCBs	2.7E+06	0.02	3.6E-3	9.1E-4	9.1E-3	0.04	0.05	0.07	0.28	0.04	1.7E-4	2.4E-4		
PST	2,4'-DDD	9.9E+05	4.7E-6	4.4E-6	3.9E-6	2.6E-6	3.7E-6	3.4E-6	8.1E-6	5.9E-6	3.3E-6	5.1E-6	5.7E-6		
PST	2,4'-DDE	4.4E+06	1.4E-6	1.3E-6	1.0E-6	7.8E-7	1.0E-6	9.0E-7	2.1E-6	1.6E-6	8.7E-7	1.3E-6	1.6E-6		
PST	2,4'-DDT	4.4E+06	1.3E-6	1.2E-6	1.0E-6	7.1E-7	9.7E-7	9.0E-7	2.1E-6	1.5E-6	8.0E-7	1.3E-6	1.5E-6		
PST	4,4'-DDD	9.9E+05	1.6E-4	1.5E-4	3.0E-5	1.8E-4	3.3E-4	4.2E-4	9.4E-4	6.4E-3	3.0E-4	4.3E-6	4.4E-5		
PST	4,4'-DDE	4.4E+06	3.1E-5	1.6E-5	7.8E-6	4.3E-6	1.3E-4	1.7E-4	3.4E-4	1.8E-4	5.7E-5	9.8E-7	7.7E-6		
PST	4,4'-DDT	4.4E+06	1.3E-5	2.1E-5	7.6E-7	1.0E-5	1.3E-5	9.5E-6	1.6E-6	1.2E-4	1.0E-5	9.8E-7	1.2E-6		
PST	alpha-Chlordane	2.5E+06	7.2E-6	6.8E-6	1.1E-6	9.5E-6	5.9E-5	4.6E-5	6.6E-5	4.1E-5	3.3E-5	1.5E-6	8.4E-7		
PST	Dieldrin	1.9E+05	2.4E-5	2.1E-5	1.8E-5	1.3E-4	1.2E-3	6.5E-3	1.5E-3	2.7E-5	8.5E-4	2.3E-5	2.7E-5		
PST	Endosulfan II	1.1E+04	4.3E-4	4.1E-4	3.1E-4	2.4E-4	3.1E-4	2.8E-4	6.4E-4	4.7E-4	2.7E-4	4.0E-4	4.8E-4		
PST	Endrin	9.4E+04	4.4E-5	4.2E-5	3.6E-5	2.4E-5	3.3E-5	2.9E-5	7.3E-5	4.6E-5	2.8E-5	4.6E-5	4.9E-5		
PST	gamma-Chlordane	1.6E+06	2.3E-6	2.2E-6	1.7E-6	1.4E-5	1.4E-4	1.3E-4	2.8E-4	7.6E-5	8.5E-5	2.2E-6	2.5E-6		
PST	Heptachlor	2.5E+06	1.5E-6	1.4E-6	1.1E-6	8.2E-7	1.1E-6	9.9E-7	2.3E-6	1.8E-6	9.6E-7	1.5E-6	1.9E-6	1.7E-6	1.9E-6

1- Predicted concentration = sediment conc. (Appendix A-1-1)/(Koc *%TOC (Appendix A-1-1)*0.01).
units = µg/L
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene)
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene)
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2

Appendix A-2-1. Hazard Quotients for chemicals in sediment collected for the Hunter's Point TIE investigation.

Class	Analyte	Benchmark	Benchmark Source	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
MET	Aluminum	NA	NA											
MET	Antimony	9.3	AET-L	0.12	0.28	0.39	0.26	0.59	0.53	0.42	0.07	0.80	0.78	0.08
MET	Arsenic	70	ER-M	0.16	0.17	0.09	0.16	0.16	0.18	0.08	0.14	0.18	0.10	0.16
MET	Barium	NA	NA											
MET	Cadmium	9.6	ER-M	0.03	0.03	0.03	0.04	0.07	0.09	0.04	0.03	0.06	0.04	0.02
MET	Chromium	370	ER-M	0.94	0.82	0.61	1.17	0.65	0.73	0.47	0.91	0.69	0.79	0.44
MET	Cobalt	10	AET-L	1.65	1.83	1.28	1.98	1.73	1.76	1.13	2.19	1.82	1.05	1.72
MET	Copper	270	ER-M	1.94	1.03	0.08	0.36	0.49	0.61	0.24	1.18	0.60	1.03	0.15
MET	Iron	NA	NA											
MET	Lead	218	ER-M	0.50	0.48	0.08	0.28	0.50	0.61	0.56	0.05	0.65	0.52	0.10
MET	Manganese	260	AET-L	1.90	1.78	2.23	2.40	1.73	1.62	1.37	1.74	1.72	1.17	2.13
MET	Mercury	0.71	ER-M	0.67	0.74	0.20	0.68	1.28	1.18	0.33	2.07	1.77	1.19	0.41
MET	Molybdenum	NA	NA											
MET	Nickel	51.6	ER-M	2.31	2.09	1.16	3.10	2.34	2.48	1.80	3.12	2.52	2.38	1.68
MET	Selenium	1.0	AET-L	0.51	0.44	0.06	0.24	0.39	0.41	0.15	0.18	0.36	0.20	0.29
MET	Silver	3.7	ER-M	0.08	0.09	0.02	0.10	0.17	0.20	0.07	0.04	0.19	0.10	0.07
BT	DBT	NA	NA											
BT	MBT	NA	NA											
BT	TBT	3.4	AET-L	0.06	0.11	1.3E-4	0.02	8.1E-3	5.4E-3	5.0E-3	0.02	0.02	0.04	2.1E-4
BT	TTBT	NA	NA											
BT	Total Butyltins	NA	NA											
MET	Vanadium	NA	NA											
MET	Zinc	410	ER-M	0.50	0.41	0.19	0.44	0.60	0.65	0.51	0.72	0.59	0.52	0.26
MET	SEM-AVS	5	EPA	0.25	-0.50	-1.23	-1.86	-0.68	-2.21	-1.17	0.25	-1.52	-0.71	0.08
PAH	2-Methylnaphthalene	670	ER-M	0.03	0.02	2.4E-3	0.01	0.03	0.06	0.03	0.04	0.04	0.03	5.8E-3
PAH	Acenaphthene	500	ER-M	0.36	0.08	3.3E-3	0.02	0.02	0.02	0.02	0.04	0.01	0.02	5.0E-3
PAH	Acenaphthylene	640	ER-M	0.03	0.03	1.7E-3	0.02	0.02	0.02	0.02	0.05	0.02	0.07	7.8E-3
PAH	Anthracene	1100	ER-M	0.13	0.09	4.4E-3	0.06	0.04	0.05	0.05	0.21	0.03	0.17	0.01
PAH	Benzo(a)anthracene	1600	ER-M	0.38	0.22	8.0E-3	0.09	0.12	0.11	0.18	0.39	0.12	0.25	0.03
PAH	Benzo[a]pyrene	1600	ER-M	0.44	0.28	0.01	0.13	0.19	0.20	0.20	0.39	0.21	0.27	0.06
PAH	Benzo[b]fluoranthene	9900	AET-H	0.06	0.04	1.4E-3	0.02	0.02	0.02	0.03	0.05	0.03	0.03	6.3E-3
PAH	Benzo[ghi]perylene	2600	AET-H	0.18	0.13	8.1E-3	0.07	0.11	0.13	0.07	0.15	0.12	0.11	0.03
PAH	Benzo[k]fluoranthene	9900	AET-H	0.06	0.04	1.6E-3	0.02	0.03	0.03	0.03	0.05	0.03	0.03	6.1E-3
PAH	Chrysene	2800	ER-M	0.26	0.14	6.2E-3	0.09	0.10	0.09	0.16	0.27	0.10	0.20	0.02
PAH	Dibenz[a,h]anthracene	260	ER-M	0.36	0.24	6.3E-3	0.10	0.14	0.16	0.20	0.40	0.18	0.25	0.03
PAH	Fluoranthene	5100	ER-M	0.24	0.13	7.5E-3	0.06	0.08	0.07	0.09	0.19	0.06	0.13	0.02
PAH	Fluorene	540	ER-M	0.17	0.10	2.9E-3	0.02	0.02	0.04	0.03	0.15	0.02	0.09	7.6E-3
PAH	Indeno[1,2,3-cd]pyrene	2600	AET-L	0.19	0.13	6.6E-3	0.06	0.09	0.11	0.08	0.16	0.11	0.11	0.03
PAH	Naphthalene	2100	ER-M	8.7E-3	0.01	8.4E-4	7.1E-3	0.02	0.03	0.03	0.02	0.02	0.01	4.0E-3
PAH	Phenanthrene	1500	ER-M	0.50	0.25	0.01	0.09	0.10	0.10	0.10	0.45	0.07	0.31	0.03
PAH	Pyrene	2600	ER-M	0.52	0.29	0.02	0.13	0.18	0.17	0.20	0.41	0.16	0.29	0.06
PAH	Total LMW (L) PAHs	3160	ER-M	0.39	0.20	0.01	0.08	0.09	0.11	0.10	0.35	0.07	0.25	0.03
PAH	Total HMW (H) PAHs	9600	ER-M	0.49	0.28	0.01	0.13	0.17	0.17	0.22	0.43	0.16	0.30	0.05
PAH	Total PAHs	44792	ER-M	0.13	0.07	3.8E-3	0.03	0.04	0.04	0.05	0.12	0.04	0.08	0.01
PCB	Total PCBs	180	ER-M	3.92	0.61	0.12	2.37	8.70	11	4.61	29	10	0.02	0.03
PST	2,4'-DDD	27	ER-M	1.9E-3	1.9E-3	1.3E-3	1.7E-3	2.2E-3	2.0E-3	1.3E-3	1.5E-3	2.0E-3	1.3E-3	2.0E-3
PST	2,4'-DDE	27	ER-M	2.4E-3	2.4E-3	1.5E-3	2.2E-3	2.8E-3	2.4E-3	1.5E-3	1.9E-3	2.4E-3	1.5E-3	2.6E-3
PST	2,4'-DDT	27	ER-M	2.2E-3	2.2E-3	1.5E-3	2.0E-3	2.6E-3	2.4E-3	1.5E-3	1.7E-3	2.2E-3	1.5E-3	2.4E-3
PST	4,4'-DDD	27	ER-M	0.06	0.06	0.01	0.11	0.20	0.25	0.15	1.62	0.19	1.1E-3	0.02
PST	4,4'-DDE	27	ER-M	0.05	0.03	0.01	0.01	0.35	0.45	0.24	0.21	0.16	1.1E-3	0.01
PST	4,4'-DDT	27	ER-M	0.02	0.04	1.1E-3	0.03	0.03	0.03	1.1E-3	0.13	0.03	1.1E-3	1.9E-3
PST	alpha-Chlordane	4.79	PEL	0.04	0.04	5.2E-3	0.09	0.49	0.39	0.15	0.15	0.29	5.2E-3	4.2E-3
PST	Dieldrin	4.3	PEL	0.01	0.01	7.0E-3	0.10	0.84	4.74	0.29	8.1E-3	0.64	7.0E-3	0.01
PST	Endosulfan II	14	SQAL	3.6E-3	3.6E-3	2.1E-3	3.2E-3	3.9E-3	3.6E-3	2.1E-3	2.5E-3	3.6E-3	2.1E-3	3.6E-3
PST	Endrin	42	SQAL	1.1E-3	1.1E-3	7.1E-4	9.5E-4	1.2E-3	1.1E-3	7.1E-4	7.1E-4	1.1E-3	7.1E-4	1.1E-3
PST	gamma-Chlordane	4.8	PEL	8.4E-3	8.4E-3	5.2E-3	0.09	0.75	0.74	0.42	0.18	0.49	5.2E-3	8.4E-3
PST	Heptachlor	0.3	AET-L	0.13	0.13	0.08	0.12	0.15	0.13	0.08	0.10	0.13	0.08	0.15

LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
NA = benchmark not available.
Hazard Quotient = concentration(Appendix A-1-1)/benchmark(Table 2.2-1).

Appendix A-2-2. Hazard Quotients for pore water concentrations of chemicals in sediments collected for the Hunter's Point TIE investigation.

Class	Analyte	Benchmark	Benchmark Source	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)	HP-PC	HP-SPIKE
MET	Aluminum	750	WQC-FA	0.39	0.57	0.64	0.41	0.64	0.58	16	6.17	0.74	1.39	2.25	0.34	0.34
MET	Arsenic	69	WQC-SA	0.56	0.57	1.05	0.48	0.71	0.22	0.75	0.41	0.60	0.40	0.27	0.01	0.01
MET	Cadmium	42	WQC-SA	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3
MET	Chromium	1100	WQC-SA	4.1E-3	4.4E-3	4.2E-3	4.4E-3	6.6E-3	6.4E-3	0.08	0.02	5.8E-3	7.6E-3	7.1E-3	3.1E-3	3.3E-3
MET	Copper	4.8	WQC-SA	1.71	1.10	1.35	0.94	2.35	1.81	27	9.69	2.04	3.73	2.42	0.71	66
MET	Iron	NA	NA													
MET	Lead	210	WQC-SA	0.02	0.02	0.02	0.02	0.02	0.02	0.41	0.09	0.02	0.02	0.02	0.02	0.02
MET	Manganese	1000	WQC-FA	4.12	2.32	2.45	3.59	4.59	1.86	1.67	8.35	5.57	2.04	14	6.0E-4	6.0E-4
MET	Nickel	74	WQC-SA	0.11	0.09	0.12	0.07	0.10	0.07	0.75	0.27	0.07	0.15	0.18	0.02	0.02
MET	Silver	1.9	WQC-SA	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
MET	Zinc	90	WQC-SA	0.24	0.45	0.22	0.25	0.22	0.18	2.40	0.60	0.28	0.51	0.30	0.69	0.20
MET	SEM-AVS	NA	NA													
PAH	2-Methylnaphthalene	300	WQC-SA	7.9E-4	5.7E-4	7.4E-5	2.3E-4	5.2E-4	1.0E-3	2.0E-3	1.6E-3	5.9E-4	1.1E-3	1.7E-4		
PAH	Acenaphthene	1700	WQC-FA	1.4E-3	3.1E-4	1.5E-5	3.6E-5	3.9E-5	6.0E-5	2.2E-4	2.5E-4	3.4E-5	1.4E-4	2.1E-5		
PAH	Acenaphthylene	300	WQC-SA	5.8E-4	5.6E-4	4.3E-5	2.0E-4	2.3E-4	3.1E-4	1.0E-3	1.6E-3	2.5E-4	2.2E-3	1.8E-4		
PAH	Anthracene	300	WQC-SA	1.5E-3	1.0E-3	6.1E-5	3.9E-4	2.9E-4	4.1E-4	1.3E-3	3.8E-3	2.3E-4	3.0E-3	1.8E-4		
PAH	Benzo(a)anthracene	300	WQC-SA	4.6E-4	2.6E-4	1.2E-5	7.2E-5	9.5E-5	9.3E-5	5.6E-4	7.6E-4	9.7E-5	4.7E-4	3.9E-5		
PAH	Benzo[a]pyrene	300	WQC-SA	2.1E-4	1.3E-4	7.9E-6	3.8E-5	6.0E-5	6.5E-5	2.4E-4	3.0E-4	6.6E-5	2.0E-4	3.3E-5		
PAH	Benzo[b]fluoranthene	300	WQC-SA	1.4E-4	8.4E-5	4.1E-6	2.3E-5	3.9E-5	4.0E-5	1.7E-4	1.9E-4	4.0E-5	1.2E-4	1.7E-5		
PAH	Benzo[ghi]perylene	300	WQC-SA	3.8E-5	2.5E-5	2.0E-6	8.4E-6	1.6E-5	1.7E-5	3.9E-5	4.8E-5	1.6E-5	3.5E-5	7.8E-6		
PAH	Benzo[k]fluoranthene	0.8	estimated	0.05	0.03	1.8E-3	9.8E-3	0.02	0.02	0.07	0.07	0.02	0.05	6.3E-3		
PAH	Chrysene	300	WQC-SA	5.5E-4	2.9E-4	1.6E-5	1.2E-4	1.4E-4	1.3E-4	8.7E-4	9.0E-4	1.3E-4	6.6E-4	5.5E-5		
PAH	Dibenz[a,h]anthracene	300	WQC-SA	7.8E-6	4.9E-6	1.6E-7	1.3E-6	1.9E-6	2.3E-6	1.1E-5	1.3E-5	2.4E-6	8.2E-6	7.3E-7		
PAH	Fluoranthene	3980	WQC-FA	2.6E-4	1.4E-4	9.9E-6	3.9E-5	5.8E-5	4.9E-5	2.5E-4	3.2E-4	4.4E-5	2.2E-4	2.8E-5		
PAH	Fluorene	300	WQC-SA	2.1E-3	1.1E-3	4.2E-5	1.6E-4	1.7E-4	3.1E-4	8.9E-4	2.9E-3	1.5E-4	1.7E-3	1.0E-4		
PAH	Indeno[1,2,3-cd]pyrene	300	WQC-SA	4.5E-5	3.0E-5	1.9E-6	8.2E-6	1.4E-5	1.6E-5	4.6E-5	5.8E-5	1.6E-5	4.1E-5	8.0E-6		
PAH	Naphthalene	2300	WQC-FA	3.7E-4	4.8E-4	4.2E-5	1.8E-4	5.3E-4	7.9E-4	2.8E-3	1.3E-3	5.4E-4	7.8E-4	1.9E-4		
PAH	Phenanthrene	30	WQC-FA	0.08	0.04	2.3E-3	8.7E-3	0.01	0.01	0.04	0.11	6.8E-3	0.08	5.9E-3		
PAH	Pyrene	300	WQC-SA	3.9E-3	2.1E-3	1.6E-4	5.9E-4	9.0E-4	8.4E-4	3.8E-3	4.9E-3	7.5E-4	3.4E-3	4.9E-4		
PAH	Total LMW (L) PAHs	300	WQC-SA	0.02	0.01	8.6E-4	3.5E-3	6.6E-3	9.4E-3	0.03	0.03	6.2E-3	0.02	2.8E-3		
PAH	Total HMW (H) PAHs	300	WQC-SA	8.6E-3	4.7E-3	3.3E-4	1.3E-3	2.0E-3	1.8E-3	8.8E-3	0.01	1.6E-3	7.6E-3	9.9E-4		
PAH	Total PAHs	300	WQC-SA	0.03	0.02	1.2E-3	4.8E-3	8.5E-3	0.01	0.04	0.04	7.9E-3	0.03	3.7E-3		
PCB	Total PCBs	2.0	WQC-FA	0.01	1.8E-3	4.5E-4	4.5E-3	0.02	0.02	0.04	0.14	0.02	8.5E-5	1.2E-4		
PST	2,4'-DDD	2.7E-3	estimated	1.7E-3	1.6E-3	1.4E-3	9.5E-4	1.4E-3	1.2E-3	3.0E-3	2.2E-3	1.2E-3	1.9E-3	2.1E-3		
PST	2,4'-DDE	6.1E-4	estimated	2.2E-3	2.1E-3	1.7E-3	1.3E-3	1.7E-3	1.5E-3	3.4E-3	2.7E-3	1.4E-3	2.1E-3	2.7E-3		
PST	2,4'-DDT	6.1E-4	estimated	2.1E-3	2.0E-3	1.7E-3	1.2E-3	1.6E-3	1.5E-3	3.4E-3	2.4E-3	1.3E-3	2.1E-3	2.5E-3		
PST	4,4'-DDD	0.6	WQC-FA	2.7E-4	2.5E-4	5.1E-5	3.0E-4	5.5E-4	6.9E-4	1.6E-3	0.01	5.0E-4	7.2E-6	7.4E-5		
PST	4,4'-DDE	1050	WQC-FA	3.0E-8	1.6E-8	7.5E-9	4.1E-9	1.3E-7	1.6E-7	3.2E-7	1.7E-7	5.4E-8	9.3E-10	7.3E-9		
PST	4,4'-DDT	1.1	WQC-FA	1.2E-5	1.9E-5	6.9E-7	9.2E-6	1.2E-5	8.7E-6	1.4E-6	1.1E-4	9.4E-6	8.9E-7	1.1E-6		
PST	alpha-Chlordane	2.0E-4	estimated	0.04	0.03	5.8E-3	0.05	0.30	0.24	0.34	0.21	0.17	7.5E-3	4.3E-3		
PST	Dieldrin	0.7	WQC-SA	3.4E-5	2.9E-5	2.5E-5	1.9E-4	1.6E-3	9.2E-3	2.1E-3	3.8E-5	1.2E-3	3.2E-5	3.8E-5		
PST	Endosulfan II	0.1	estimated	3.3E-3	3.1E-3	2.4E-3	1.8E-3	2.4E-3	2.2E-3	4.9E-3	3.6E-3	2.1E-3	3.1E-3	3.7E-3		
PST	Endrin	0.0	WQC-SA	1.2E-3	1.1E-3	9.6E-4	6.6E-4	8.8E-4	7.9E-4	2.0E-3	1.2E-3	7.6E-4	1.2E-3	1.3E-3		
PST	gamma-Chlordane	2.9E-4	estimated	7.7E-3	7.4E-3	5.8E-3	0.05	0.46	0.45	0.97	0.26	0.29	7.5E-3	8.6E-3		
PST	Heptachlor	0.1	WQC-SA	2.8E-5	2.7E-5	2.2E-5	1.5E-5	2.1E-5	1.9E-5	4.4E-5	3.3E-5	1.8E-5	2.8E-5	3.6E-5	3.2E-5	3.5E-5
AMM	Un-ionized Ammonia	0.23	WQC-SA	0.82	0.77	9.31	3.69	2.58	0.26	1.37	3.52	4.68	5.54	0.52	0.09	0.39

Benchmark is for Chromium VI. Measured concentration is for total Chromium.
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
Hazard Quotient for metals = concentration(Appendix A-1-3)/benchmark(Table 2.2-2).
Hazard Quotient for organics = concentration(Appendix A-1-4)/benchmark(Table 2.2-2);
if estimated benchmark used, benchmark x %TOC(Appendix A-1-1). NA = benchmark not available.

Appendix A-3. Calculation of pore water unionized ammonia concentrations and species-specific Hazard Quotients for the Hunter's Point TIE study.

a) Fish (*Menidia menidia*)

Sample ID	Total Ammonia (mg/L)	Temp (C)	pH	Un-ionized Ammonia[1] (mg/L)	Un-ionized Ammonia HQ[2]	HQ Interpretation[3]
HP-1	3.50	20	8.40	0.26	0.18	-
HP-2	4.25	20	8.30	0.25	0.17	-
HP-3	27	20	8.60	2.94	2.03	+
HP-4	13	20	8.50	1.17	0.81	-
HP-5	11	20	8.40	0.82	0.57	-
HP-6	1.50	20	8.30	0.09	0.06	-
HP-7	18	20	7.90	0.44	0.30	-
HP-8	30	20	8.10	1.14	0.79	-
HP-9	17	20	8.50	1.49	1.03	+
HP-10	30	20	8.30	1.77	1.22	+
HP-REF[5]	2.80	20	8.30	0.17	0.12	-
HP-PC	1.25	20	7.80	0.02	0.02	-
HP-Spike[4]	5.00	20	7.90	0.12	0.08	-

b) Urchin (*Strongylocentrotus purpuratus*)

Sample ID	Total Ammonia (mg/L)	Temp (C)	pH	Un-ionized Ammonia[1] (mg/L)	Un-ionized Ammonia HQ[2]	HQ Interpretation[3]
HP-1	3.50	15	8.40	0.19	3.11	++
HP-2	4.25	15	8.30	0.18	3.04	++
HP-3	27	15	8.60	2.17	36	+++
HP-4	13	15	8.50	0.86	14	+++
HP-5	11	15	8.40	0.60	10	+++
HP-6	1.50	15	8.30	0.06	1.07	+
HP-7	18	15	7.90	0.32	5.25	++
HP-8	30	15	8.10	0.82	14	+++
HP-9	17	15	8.50	1.09	18	+++
HP-10	30	15	8.30	1.29	21	+++
HP-REF[5]	2.8	15	8.30	0.12	2.00	+
HP-PC	1.25	15	7.80	0.02	0.29	-
HP-Spike[4]	5.00	15	7.90	0.09	1.46	+

c) Sand Dollar (*Dendraster excentricus*)

Sample ID	Total Ammonia (mg/L)	Temp (C)	pH	Un-ionized Ammonia[1] (mg/L)	Un-ionized Ammonia HQ[2]	HQ Interpretation[3]
HP-1						
HP-2						
HP-3						
HP-4	23	15	8.50	1.52	25	+++
HP-5	24	15	8.40	1.28	21	+++
HP-6						
HP-7						
HP-8						
HP-9	26	15	8.50	1.72	29	+++
HP-10						
HP-REF	4.30	15	8.30	0.18	3.07	++
HP-PC	0.80	15	8.00	0.02	0.29	-

1 - Unionized ammonia = Total ammonia/(1+10(pK+0.0324(298-Temp.(K))+0.0415(1/Temp.(K))-pH)); (Hampson 1977); calculated for the untreated TIE treatment.

2- Hazard Quotient (HQ) = Unionized Ammonia Conc./median of LC_{50} or EC_{50} "benchmark" reported in Table 2.2-3.

3 - Hazard Quotient (see Appendix A-2-2 for values) codes: <benchmark(BM) = "-"; >BM = "+"; >3xBM = "++"; >10xBM = "+++".

4 - pH estimated as median of pH measured during toxicity testing (Table 2.4-1).

5 - Data source: bulk sediment test with *E. estuarius* , Battelle, 2001.

Appendix A-4. Statistical summary of moisture content and grain size data for sediments collected for the Hunter's Point TIE investigation[1].

Percent content

Station	Moisture Content[1]	Coarse Gravel	Fine Gravel	Total Gravel	Coarse Sand	Medium Sand	Fine Sand	Total Sand	Fines	Total
HP-01,PA-41(0-5 cm)	55.3	0.0	0.0	0.0	0.0	2.9	17.1	20.0	80.0	100
HP-02,PA-41(5-10 cm)	51.7	0.0	5.4	5.4	0.8	4.8	17.3	22.9	71.7	100
HP-03,EW-33(0-5 cm)	31.8	0.0	0.0	0.0	0.0	10.8	74.8	85.6	14.4	100
HP-04,OR-24(0-5 cm)	39.3	0.0	0.0	0.0	0.0	3.3	42.8	46.1	53.9	100
HP-05,SB-20(0-5 cm)	50.0	0.0	0.0	0.0	0.0	0.4	6.9	7.3	92.7	100
HP-06,SB-20(5-10 cm)	53.8	0.0	0.0	0.0	0.0	0.4	6.9	7.3	92.7	100
HP-07,SB-18(0-5 cm)	25.5	0.0	0.0	0.0	0.0	0.7	83.5	84.2	15.8	100
HP-08,SB-21(0-5 cm)	38.8	0.0	0.0	0.0	0.3	7.0	64.5	71.8	28.2	100
HP-09,SB-22(0-5 cm)	55.2	0.0	0.0	0.0	0.0	0.8	11.8	12.6	87.4	100
HP-10,SB-23(0-5 cm)	31.8	0.0	0.0	0.0	0.0	22.6	58.2	80.8	19.2	100
HP-REF,PC-63(0-5 cm)	57.1	0.0	0.0	0.0	0.0	0.0	1.7	1.7	98.3	100

1 - Data source (except moisture content): Battelle, 2001.

2 - measured during SEM/AVS analysis.

APPENDIX B-1
TIE Toxicity Lab Reports

APPENDIX B-1-1
Screening Lab Report

Aquatec Biological Sciences

August 6, 2001

Ms. Sherry Poucher
SAIC
221 Third Street
Newport, Rhode Island 02840

Dear Ms. Poucher:

Enclosed please find a report (two copies) of the results (tabulated and copies of bench sheets), methods, and qualifiers for screening toxicity tests completed for the Hunter's Point sediment porewater samples (SDG 5238). These tests were run as preliminary screening tests for the Hunter's Point sediment porewater TIE investigation, reported separately (SDG 5254).

If you have any questions regarding the report, please contact Dr. Philip C. Downey or me.

Sincerely,

John Williams
Manager, Environmental Toxicology

373 Commerce Street, Williston, VT 05495 Tel 802 860 1638 Fax

Aquatec Biological Sciences

Toxicity Screen Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/2/01
Project: 01025
SDG 5238
Site: Hunters Pt. TIE

Method: SPScreen Species: *Strongylocentrotus purpuratus*

Number	Sample Name	HP Sample Name	Conc (%)	Day	Start	Replicate Normal Development 1	2	3
020384	Duxbury Seawater		100	3	100	95	89	93
019759	EW-33-SS1	HP:3	100	3	100	0	0	0
019760	SB-23-SS1	HP:10	100	3	100	0	0	0
019761	SB-20-SS1	HP:5	100	3	100	0	0	0
019762	SB-18-SS1	HP:7	100	3	100	0	0	0
019763	OR-24-SS1	HP:4	100	3	100	0	0	0
019764	SB-19-SS1		100	3	100	0	0	0
019765	SB-20-SS2	HP:6	100	3	100	0	0	0
019766	PA-41-SS1	HP:1	100	3	100	0	0	0
019767	PA-41-SS2	HP:2	100	3	100	0	0	0
019768	PC-63-SS1	REF	100	3	100	0	0	0
019769	SB-21-SS1	HP:8	100	3	100	0	0	0
019770	SB-22-SS1	HP:9	100	3	100	0	0	0

273 Commerce Street, Williston, VT 05495 Tel 802.860.1638 Fax [illegible]

Toxicity Screen Report

Science Applications International Corp		Date:	8/2/01
221 Third Street		Project:	01025
		SDG	5238
Newport, RI	02840	Site:	Hunters Pt. TIE

Special Conditions and Qualifiers

Qualifiiers

Porewater dissolved oxygen concentrations were measured prior to initiating toxicity tests. Several of the porewater samples had low dissolved oxygen concentrations (< 4.0 mg/L), including samples 19759 (EW-33-SS1), 19760 (SB-23-SS1), and 19762 (SB-18-SS1). The porewater for these samples was aerated approximately 1 hour to raise the dissolved oxygen concentration above 6 mg/L before dispensing the porewater to the test vials.

Submitted By: _____

Supportive Documentation

Chain-Of-Custody

Toxicity Test Methods

Screening test, Strongylocentrotus purpuratus

Standard Reference Toxicant Control Charts

Available Upon Request

Science Applications International Corporation

APPENDIX B-1-2
TIE Toxicity Lab Report

Aquatec Biological Sciences

August 6, 2001

Ms. Sherry Poucher
SAIC
221 Third Street
Newport, Rhode Island 02840

Dear Ms. Poucher:

Enclosed please find a report (two copies) of the results, methods, and narrative for toxicity testing completed for the Hunter's Point sediment porewater TIE study (SDG 5254). The following text files have also been sent to you by e-mail:

5254DE
5254MM
5254SP

If you have any questions regarding the report, please contact me or Dr. Philip C. Downey.

Sincerely,

John Williams
Manager, Environmental Toxicology

[illegible] Commerce Street, Williston, VT 05495 Tel 802.860.1638 Fax [illegible]

Aquatec Biological Sciences

Narrative

Science Applications International Corp		Date:	8/3/01
221 Third Street		Project:	01025
		SDG:	5254
Newport, RI	02840	Site:	Hunter's Pt TIE

General comments:

Centrifugation: Porewaters for sediment samples 19759 (EW-33-SS1/HP-3), 19760 (SB-23-SS1/HP10), 19761 (SB-20-SS1/HP-5), 19763 (OR-24-SS1), 19765 (SB-20-SS2/HP-6), and 19766 (PA-41-SS1/HP1), and 19970 (SB-22-SS1/HP-9) tests were extracted by centrifuge on June 4, 2001 using a IEC PR7000 centrifuge (30 min at 5200 rpm). Porewaters for sediment samples 19762 (SB-18-SS1/HP-7), 19767 (PA-41-SS2/HP-2), 19768 (PC-63-SS1/REF), and 19769 (SB-21-SS1/HP8) were extracted by centrifuge on June 5, 2001 using a IEC B-22M centrifuge (15 min at 7500 rpm). Porewaters were shipped to SAIC on June 5, 2001. Sediment sample 19764 (SB-19-SS1) was not extracted due to the sand/gravel character with apparently little porewater.

Test starts: Porewaters for TIE testing were received on June 8, 2001. The *Menidia menidia* and the *Strongylocentrotus purpuratus* toxicity tests were started on the same day as samples were received.

Use of oxygen: Several porewater samples received for the TIE exhibited low dissolved oxygen concentrations when measured prior to testing. Samples with dissolved oxygen measurements of less than 7 mg/L oxygenated by bubbling pure oxygen through the solutions until the dissolved oxygen concentration was greater than 18 mg/L. Samples treated with oxygen were noted on the bench sheets.

High pH exposure system: The high pH test vials were isolated in a large, sealed plastic box. Four small beakers containing a 5% KOH solution with a paper-towel wick were placed within the plastic box with the vials to elevate the pH of solutions with the test vials.

Sample not tested: A sample for HP-7 Filtered was not received and therefore was not tested as part of the TIE.

Initial chemistry: Initial chemistry measurements (100% porewater) were measured before distributing test solutions to test vials. The measurements are common to toxicity tests for both species.

Final chemistry: Final chemistry measurements (of 10%, 25%, 50%, and 100% porewater) were completed in a set of vials not containing test organisms. The final chemistry vials were held at approximately 20°C for Days 0, 1, and 2 and then transferred to an incubator and held at approximately 15 °C from Day 2 to Day 3 when the sea urchin development test was ended.

Comments specific to the *Menidia menidia* toxicity tests:

Shortage of organisms: A combination of embryos and larvae were used for the porewater TIE tests for this species due to a shortage of both embryos and larvae to run the tests uniformly with either life stage. In general, embryos were used for the 50% test concentration and larvae were used for the 100% test concentration. Concentrations of 10% or 25% were not tested. Also, due to the shortage of embryos, in general only two replicates rather than three were tested for the 50% concentration. For some treatments (e.g., High pH), only two replicates were tested for the 100% porewater due to organism limitations. A standard reference toxicant (SRT) test for *Menidia menidia* was not performed due to insufficient organisms for SRT testing.

Dissolved oxygen: On Day 1 no surviving larvae were remaining in the 100% concentration for several of the TIE porewaters (with the exception of the *Ulva* treatment) for samples HP3, HP-8, and HP-10. The measured dissolved oxygen concentrations were less than 3 mg/L in the test vials on Day 1 for those vials where 100% mortality was observed for HP3, HP-8, and HP-10.

Detox not tested: The Detox treatment was not tested with *Menidia Menidia*.

Photoactivation: On Day 2 (June 10, 2001) all test vials were moved outside for photoactivation a spiked compound as requested by SAIC. The ambient air temperature was measured as 19.2°C and the condition was partly cloudy when the outdoor 4-hour exposure was started. When the outdoor exposure was completed it was discovered that the temperature of the test vials had risen above the target temperature range. Temperatures exceeding 30°C were measured, therefore it is possible that heat-related stress resulted in organism mortality on Day 2.

Day 1 test data reported: Survival data for Day 1 were reported, rather than the Day 2 data since the photoactivation procedure may have affected organism survival on Day 2. On Day 2 the final number of surviving larvae were recorded on the bench sheets but the data were not tabulated for reporting purposes.

Comments specific to the *Strongylocentrotus purpuratus* toxicity tests:

Screening-level toxicity tests: Screening-level toxicity tests (undiluted porewater) were conducted with sea urchin embryos from June 1-June 4, 2001. Porewater for the screening toxicity tests was collected by the syringe method (from May 31-June 1, 2001). A control consisting of Cape Cod Bay seawater was included in the test array. A standard reference toxicant (SRT, $CuSO_4$) test using Cape Cod Bay as dilution water was also performed. The EC50 (22.7 ug/L) for the SRT fell within the Aquatec Biological Sciences, Inc. control chart limits (13.5-38.8 ug/L).

Replicates not tested: A few replicates for the sea urchin embryo development tests were not included in the overall test array for the porewater TIE. These included Filtered HP-8 (50% and 100%, not tested). Two vials for the *Ulva* HP-8 50% had very low solution volumes that may have affected embryo development (no normal embryos observed). The data for these vials were excluded from the data tabulation.

Tests not scored: The TIE exposures for the Detox treatment and the High pH treatments were performed, however the embryos for these manipulations were not scored, as specified by SAIC.

Performance control responses: Embryos in the untreated and manipulated performance controls had less than 80% normal development. A series of seawater test trials performed subsequent to the TIE suggested that the batch of seawater used for the TIE performance controls and also as dilution water for the TIE may have contributed to abnormal embryo development. Copies of data generated for the seawater trials are included in the data package.

Dissolved oxygen: Low dissolved oxygen concentrations (<3 mg/L) were observed at the end of the test (as measured in the chemistry vials) for several of the porewater samples – most commonly in the 100% porewater solutions. The data were recorded on the final chemistry bench sheets.

Generally, decreasing dissolved oxygen concentrations were observed to correspond to increasing concentration of porewater, however, for the High pH treatments of samples 19901 (HP-5), 19902 (HP-6), and 19905 (HP-9) a trend of increasing dissolved oxygen concentration was observed with increasing porewater concentration (the lowest dissolved oxygen concentrations were observed in the 10% solution). It is possible that the measurements for these tests were measured or recorded in an incorrect order.

Standard reference toxicant test: A SRT test conducted concurrently with the sea urchin embryo TIE tests was not plotted on the Aquatec Biological Sciences, Inc. control chart because the seawater control (Narragansett Bay Seawater) did

not meet the acceptance criterion of at least 80% normally developed. A copy of the SRT test data is included in the data package.

Comments specific to the *Dendraster excentricus* toxicity tests:

Porewater extraction: Porewaters for the sand dollar embryo development tests were extracted using a IEC B-22-M centrifuge on June 25, 2001 from sediment samples 19763 (OR-24-SS1/HP-4), 19761 (SB-20-SS1/HP5), 19770 (SB-22-SS1/HP9), and 19768 (PC-63-SS1/REF) and shipped to SAIC for TIE manipulations.

Test starts: TIE porewaters were received on June 29, 2001 and the sand dollar embryo development tests were started on the same day.

High pH test: The test vials for the High pH TIE were tested without the 5% KOH exposure system.

Dissolved oxygen: Porewater samples prepared for testing on June 29, 2001 did not exhibit very low dissolved oxygen concentrations. The lowest observed dissolved oxygen concentration in 100% porewater was 6.2 mg/L, therefore, the samples were prepared for testing without the use of pure oxygen or aeration prior to testing. At the end of the test, low dissolved oxygen concentrations (<3.0 mg/L) were observed in the *Ulva* 1st thiosulfate and the *Ulva* 1st EDTA treatments of samples 20170 (HP-5), 20171 (HP-9), 20175 (HP-5), and 20176 (HP-9) and also in the Oasis treatment for 20149 (HP-4).

Scoring of embryos: In scoring the embryos for normal / abnormal development, some of the transitional concentrations had embryos which appeared to be normally shaped but were somewhat stunted in size. These were generally judged to be "normal" and an annotation regarding the observation was recorded on the bench sheet.

Vial not preserved: One replicate of the Ulva 1st thiosulfate 10% treatment apparently was not preserved with formalin when the test was ended, because the embryos were found to be degraded.

Aquatec Biological Sciences

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: Control Method: A48MMS Species: *Menidia menidia*

Number	Treatment	Conc (%)	Day	Start	Replicate Survival 1	2	3
019818	Untreated	100	1	5	5	4	3
019831	Thiosulfate	100	1	5	3	4	4
019844	EDTA	100	1	5	4	2	3
019857	Filtered	100	1	5	4	2	3
019869	Oasis	100	1	5	4	3	3
019895	Ph high	100	1	5	5	4	4
019908	Ulva	100	1	5	5	4	5

273 Commerce Street, Williston VT 05495 Tel 802.860.1638 Fax 802.[illegible]

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:1 Method: A48MMS Species: *Menidia menidia*

Number	Treatment	Conc (%)	Day	Start	Replicate Survival 1	2	3
019820	Untreated	50	1	5	5	5	
019820	Untreated	100	1	5	4	5	3
019833	Thiosulfate	50	1	5	5	5	
019833	Thiosulfate	100	1	5	5	4	5
019846	EDTA	50	1	5	5	5	
019846	EDTA	100	1	5	5	5	5
019859	Filtered	50	1	5	5	5	5
019859	Filtered	100	1	5	5	5	5
019871	Oasis	50	1	5	5	5	
019871	Oasis	100	1	5	5	3	4
019897	Ph high	50	1	5	5	5	5
019897	Ph high	100	1	5	5	5	
019910	Ulva	50	1	5	5	5	
019910	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:10 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019829	Untreated	50	1	5	5	5	
019829	Untreated	100	1	5	0	0	0
019842	Thiosulfate	50	1	5	5	5	
019842	Thiosulfate	100	1	5	0	0	0
019855	EDTA	50	1	5	5	5	
019855	EDTA	100	1	5	0	0	0
019867	Filtered	50	1	5	5	5	
019867	Filtered	100	1	5	0	0	0
019880	Oasis	50	1	5	5	5	
019880	Oasis	100	1	5	0	0	0
019906	Ph high	50	1	5	5	5	5
019906	Ph high	100	1	5	0		
019919	Ulva	50	1	5	5	5	
019919	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:2 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019821	Untreated	50	1	5	5	5	
019821	Untreated	100	1	5	5	5	5
019834	Thiosulfate	50	1	5	5	5	
019834	Thiosulfate	100	1	5	3	4	5
019847	EDTA	50	1	5	5	5	
019847	EDTA	100	1	5	5	5	5
019860	Filtered	50	1	5	5	5	
019860	Filtered	100	1	5	5	5	5
019872	Oasis	50	1	5	5	5	
019872	Oasis	100	1	5	2	4	3
019898	Ph high	50	1	5	5	5	5
019898	Ph high	100	1	5	5	5	
019911	Ulva	50	1	5	5	5	
019911	Ulva	100	1	5	4	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:3 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019822	Untreated	50	1	5	5	5	
019822	Untreated	100	1	5	0	0	0
019835	Thiosulfate	50	1	5	5	5	
019835	Thiosulfate	100	1	5	0	0	0
019848	EDTA	50	1	5	4	5	
019848	EDTA	100	1	5	0	0	0
019861	Filtered	50	1	5	5	5	
019861	Filtered	100	1	5	0	0	0
019873	Oasis	50	1	5	4	5	
019873	Oasis	100	1	5	0	0	0
019899	Ph high	50	1	5	5	5	5
019899	Ph high	100	1	5	0	0	
019912	Ulva	50	1	5	5	5	
019912	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:4 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019823	Untreated	50	1	5	5	5	
019823	Untreated	100	1	5	3	2	2
019836	Thiosulfate	50	1	5	5	5	
019836	Thiosulfate	100	1	5	5	5	5
019849	EDTA	50	1	5	5	5	
019849	EDTA	100	1	5	5	5	5
019862	Filtered	50	1	5	5	5	
019862	Filtered	100	1	5	5	5	5
019874	Oasis	50	1	5	5	5	
019874	Oasis	100	1	5	4	5	4
019900	Ph high	50	1	5	5	5	5
019900	Ph high	100	1	5	2	3	
019913	Ulva	50	1	5	5	5	
019913	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:5 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019824	Untreated	50	1	5	5	5	
019824	Untreated	100	1	5	0	1	0
019837	Thiosulfate	50	1	5	5	5	
019837	Thiosulfate	100	1	5	1	1	1
019850	EDTA	50	1	5	5	5	
019850	EDTA	100	1	5	1	0	1
019863	Filtered	50	1	5	5	5	
019863	Filtered	100	1	5	4	5	4
019875	Oasis	50	1	5	5	5	
019875	Oasis	100	1	5	0	0	1
019901	Ph high	50	1	5	5	5	5
019901	Ph high	100	1	5	4	4	3
019914	Ulva	50	1	5	5	5	
019914	Ulva	100	1	5	4	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:6 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019825	Untreated	50	1	5	5	5	
019825	Untreated	100	1	5	5	5	5
019838	Thiosulfate	50	1	5	5	5	
019838	Thiosulfate	100	1	5	5	5	5
019851	EDTA	50	1	5	5	5	
019851	EDTA	100	1	5	4	5	5
019864	Filtered	50	1	5	5	5	
019864	Filtered	100	1	5	5	5	5
019876	Oasis	50	1	5	5	5	
019876	Oasis	100	1	5	4	3	4
019902	Ph high	50	1	5	5	5	5
019902	Ph high	100	1	5	5	5	
019915	Ulva	50	1	5	5	5	
019915	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:7 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019826	Untreated	50	1	5	5	5	
019839	Thiosulfate	50	1	5	5	5	
019839	Thiosulfate	100	1	5	0		
019852	EDTA	50	1	5	5	5	
019852	EDTA	100	1	5	0		
019877	Oasis	50	1	5	5	5	
019877	Oasis	100	1	5	0	0	0
019903	Ph high	50	1	5	5	5	5
019903	Ph high	100	1	5	5	1	
019916	Ulva	50	1	5	5	5	
019916	Ulva	100	1	5	4	4	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:8 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019827	Untreated	50	1	5	5	5	
019827	Untreated	100	1	5	0	0	0
019840	Thiosulfate	50	1	5	5	5	
019840	Thiosulfate	100	1	5	0	0	0
019853	EDTA	50	1	5	5	5	
019853	EDTA	100	1	5	0	0	0
019865	Filtered	50	1	5	5	5	
019865	Filtered	100	1	5	0	0	0
019878	Oasis	50	1	5	5	5	
019878	Oasis	100	1	5	0	0	0
019904	Ph high	50	1	5	5	5	5
019904	Ph high	100	1	5	0	0	
019917	Ulva	50	1	5	5	5	
019917	Ulva	100	1	5	5	4	4

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:9 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019828	Untreated	50	1	5	5	5	
019828	Untreated	100	1	5	0	0	0
019841	Thiosulfate	50	1	5	5	5	
019841	Thiosulfate	100	1	5	0	0	0
019854	EDTA	50	1	5	5	5	
019854	EDTA	100	1	5	0	0	2
019866	Filtered	50	1	5	5	5	
019866	Filtered	100	1	5	2	4	1
019879	Oasis	50	1	5	5	5	
019879	Oasis	100	1	5	1	1	3
019905	Ph high	50	1	5	5	5	5
019905	Ph high	100	1	5	2	3	
019918	Ulva	50	1	5	5	5	
019918	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: REF Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019830	Untreated	50	1	5	5	5	
019830	Untreated	100	1	5	5	4	5
019843	Thiosulfate	50	1	5	5	5	
019843	Thiosulfate	100	1	5	5	4	5
019856	EDTA	50	1	5	5	5	
019856	EDTA	100	1	5	4	5	5
019868	Filtered	50	1	5	4	5	
019868	Filtered	100	1	5	5	5	5
019881	Oasis	50	1	5	5	5	
019881	Oasis	100	1	5	4	4	5
019907	Ph high	50	1	5	5	5	5
019907	Ph high	100	1	5	5	5	
019920	Ulva	50	1	5	5	5	
019920	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: Spike Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019819	Untreated	50	1	5	5	5	
019819	Untreated	100	1	5	1	0	0
019832	Thiosulfate	50	1	5	5	5	
019832	Thiosulfate	100	1	5	3	3	1
019845	EDTA	50	1	5	5	5	
019845	EDTA	100	1	5	2	4	2
019858	Filtered	50	1	5	5	5	5
019858	Filtered	100	1	5	4	4	4
019870	Oasis	50	1	5	5	5	
019870	Oasis	100	1	5	3	4	4
019896	Ph high	50	1	5	5	5	5
019896	Ph high	100	1	5	4	4	4
019909	Ulva	50	1	5	5	4	
019909	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp		Date:	8/3/01
221 Third Street		Project:	01025
		SDG	5254
Newport, RI	02840	Site:	Hunters Pt TIE

Submitted By: _____

Aquatec Biological Sciences

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: Control Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019818	Untreated	100	3	100	61	61	56
019831	Thiosulfate	100	3	100	75	80	78
019844	EDTA	100	3	100	69	69	64
019857	Filtered	100	3	100	60	69	70
019869	Oasis	100	3	100	60	55	59
019908	Ulva	100	3	100	67	67	66

273 Commerce Street, Williston, VT 05495 Tel 802.860.1638 Fax 802.658.[illegible]

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:1 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019820	Untreated	10	3	100	13	0	23
019820	Untreated	25	3	100	1	0	0
019820	Untreated	50	3	100	0	0	0
019820	Untreated	100	3	100	0	0	0
019833	Thiosulfate	10	3	100	36	50	54
019833	Thiosulfate	25	3	100	25	23	21
019833	Thiosulfate	50	3	100	0	0	0
019833	Thiosulfate	100	3	100	0	0	0
019846	EDTA	10	3	100	63	61	66
019846	EDTA	25	3	100	36	30	25
019846	EDTA	50	3	100	0	0	0
019846	EDTA	100	3	100	0	0	0
019859	Filtered	10	3	100	61	56	55
019859	Filtered	25	3	100	27	26	29
019859	Filtered	50	3	100	0	0	0
019859	Filtered	100	3	100	0	0	0
019871	Oasis	10	3	100	27	32	39
019871	Oasis	25	3	100	13	12	10
019871	Oasis	50	3	100	0	0	0
019871	Oasis	100	3	100	0	0	0
019910	Ulva	10	3	100	60	44	47
019910	Ulva	25	3	100	52	40	38
019910	Ulva	50	3	100	50	44	49
019910	Ulva	100	3	100		49	58
019910	Ulva	100	3	80	47		

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:10 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019829	Untreated	10	3	100	0	0	0
019829	Untreated	25	3	100	0	0	0
019829	Untreated	50	3	100	0	0	0
019829	Untreated	100	3	100	0	0	0
019842	Thiosulfate	10	3	100	2	2	0
019842	Thiosulfate	25	3	100	0	0	0
019842	Thiosulfate	50	3	100	0	0	0
019842	Thiosulfate	100	3	100	0	0	0
019855	EDTA	10	3	100	5	4	4
019855	EDTA	25	3	100	0	0	0
019855	EDTA	50	3	100	0	0	0
019855	EDTA	100	3	100	0	0	0
019867	Filtered	10	3	100	0	0	0
019867	Filtered	25	3	100	0	0	0
019867	Filtered	50	3	100	0	0	0
019867	Filtered	100	3	100	0	0	0
019880	Oasis	10	3	100	0	0	0
019880	Oasis	25	3	100	0	0	0
019880	Oasis	50	3	100	0	0	0
019880	Oasis	100	3	100	0	0	0
019919	Ulva	10	3	100	25	32	37
019919	Ulva	25	3	100	13	23	19
019919	Ulva	50	3	100	43	29	34
019919	Ulva	100	3	100	1	1	6

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:2 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019821	Untreated	10	3	100	2	13	15
019821	Untreated	25	3	100	0	6	6
019821	Untreated	50	3	100	0	0	0
019821	Untreated	100	3	100	0	0	0
019834	Thiosulfate	10	3	100	34	28	26
019834	Thiosulfate	25	3	100	19	16	18
019834	Thiosulfate	50	3	100	0	0	0
019834	Thiosulfate	100	3	100	0	0	0
019847	EDTA	10	3	100	60	53	58
019847	EDTA	25	3	100	29	30	26
019847	EDTA	50	3	100	0	0	0
019847	EDTA	100	3	100	0	0	0
019860	Filtered	10	3	100	55	54	58
019860	Filtered	25	3	100	17	20	17
019860	Filtered	50	3	100	0	0	0
019860	Filtered	100	3	100	0	0	0
019872	Oasis	10	3	100	30	28	31
019872	Oasis	25	3	100	3	4	5
019872	Oasis	50	3	100	0	0	0
019872	Oasis	100	3	100	0	0	0
019911	Ulva	10	3	100	61	43	54
019911	Ulva	25	3	100	44	38	42
019911	Ulva	50	3	100	40	42	50
019911	Ulva	100	3	100	59	53	52

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:3 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019822	Untreated	10	3	100	1	5	1
019822	Untreated	25	3	100	0	0	0
019822	Untreated	50	3	100	0	0	0
019822	Untreated	100	3	100	0	0	0
019835	Thiosulfate	10	3	100	0	7	11
019835	Thiosulfate	25	3	100	0	0	0
019835	Thiosulfate	50	3	100	0	0	0
019835	Thiosulfate	100	3	100	0	0	0
019848	EDTA	10	3	100	29	22	33
019848	EDTA	25	3	100	0	0	0
019848	EDTA	50	3	100	0	0	0
019848	EDTA	100	3	100	0	0	0
019861	Filtered	10	3	100	1	0	0
019861	Filtered	25	3	100	0	0	0
019861	Filtered	50	3	100	0	0	0
019861	Filtered	100	3	100	0	0	0
019873	Oasis	10	3	100	0	0	0
019873	Oasis	25	3	100	0	0	0
019873	Oasis	50	3	100	0	0	0
019873	Oasis	100	3	100	0	0	0
019912	Ulva	10	3	100	50	58	52
019912	Ulva	25	3	100	52	40	44
019912	Ulva	50	3	100	45	45	46
019912	Ulva	100	3	100	59	53	
019912	Ulva	100	3	48			22

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:4 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019823	Untreated	10	3	100	22	3	38
019823	Untreated	25	3	100	0	0	0
019823	Untreated	50	3	100	0	0	0
019823	Untreated	100	3	100	0	0	0
019836	Thiosulfate	10	3	100	69	61	63
019836	Thiosulfate	25	3	100	6	12	21
019836	Thiosulfate	50	3	100	0	0	0
019836	Thiosulfate	100	3	100	0	0	0
019849	EDTA	10	3	100	55	55	57
019849	EDTA	25	3	100	16	14	11
019849	EDTA	50	3	100	0	0	0
019849	EDTA	100	3	100	0	0	0
019862	Filtered	10	3	100	60	60	53
019862	Filtered	25	3	100	6	6	7
019862	Filtered	50	3	100	0	0	0
019862	Filtered	100	3	100	0	0	0
019874	Oasis	10	3	100	41	42	29
019874	Oasis	25	3	100	3	3	11
019874	Oasis	50	3	100	0	0	0
019874	Oasis	100	3	100	0	0	0
019913	Ulva	10	3	100	49	69	44
019913	Ulva	25	3	100	50	64	59
019913	Ulva	50	3	100	34	56	57
019913	Ulva	100	3	82			22
019913	Ulva	100	3	100	29		
019913	Ulva	100	3	74		20	

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:5 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019824	Untreated	10	3	100	36	29	28
019824	Untreated	25	3	100	0	0	0
019824	Untreated	50	3	100	0	0	0
019824	Untreated	100	3	100	0	0	0
019837	Thiosulfate	10	3	100	64	69	70
019837	Thiosulfate	25	3	100	0	0	0
019837	Thiosulfate	50	3	100	0	0	0
019837	Thiosulfate	100	3	100	0	0	0
019850	EDTA	10	3	100	29	30	37
019850	EDTA	25	3	100	7	6	0
019850	EDTA	50	3	100	0	0	0
019850	EDTA	100	3	100	0	0	0
019863	Filtered	10	3	100	58	56	63
019863	Filtered	25	3	100	0	0	0
019863	Filtered	50	3	100	0	0	0
019863	Filtered	100	3	100	0	0	0
019875	Oasis	10	3	100	26	20	25
019875	Oasis	25	3	100	3	0	1
019875	Oasis	50	3	100	0	0	0
019875	Oasis	100	3	100	0	0	0
019914	Ulva	10	3	100	48	58	61
019914	Ulva	25	3	100	40	54	55
019914	Ulva	50	3	100	23	41	43
019914	Ulva	100	3	100	58	50	46

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:6 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019825	Untreated	10	3	100	0	6	6
019825	Untreated	25	3	100	2	22	16
019825	Untreated	50	3	100	4	6	0
019825	Untreated	100	3	100	0	0	0
019838	Thiosulfate	10	3	100	49	55	46
019838	Thiosulfate	25	3	100	62	58	50
019838	Thiosulfate	50	3	100	37	32	31
019838	Thiosulfate	100	3	100	0	0	0
019851	EDTA	10	3	100	49	44	52
019851	EDTA	25	3	100	41	48	43
019851	EDTA	50	3	100	29	30	33
019851	EDTA	100	3	100	22	7	12
019864	Filtered	10	3	100	65	58	58
019864	Filtered	25	3	100	56	63	57
019864	Filtered	50	3	100	29	20	16
019864	Filtered	100	3	100	0	0	0
019876	Oasis	10	3	100	34	34	44
019876	Oasis	25	3	100	34	35	28
019876	Oasis	50	3	100	23	23	18
019876	Oasis	100	3	100	5	0	0
019915	Ulva	10	3	100	51	49	43
019915	Ulva	25	3	100	40	29	40
019915	Ulva	50	3	100	65	44	47
019915	Ulva	100	3	100	83	48	59

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:7 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019826	Untreated	10	3	100	0	0	0
019826	Untreated	25	3	100	0	0	0
019826	Untreated	50	3	100	0	0	0
019826	Untreated	100	3	100	0	0	0
019839	Thiosulfate	10	3	100	45	40	33
019839	Thiosulfate	25	3	100	0	0	0
019839	Thiosulfate	50	3	100	1	0	0
019839	Thiosulfate	100	3	100	0	0	
019852	EDTA	10	3	100	34	38	37
019852	EDTA	25	3	100	3	2	0
019852	EDTA	50	3	100	0	0	0
019852	EDTA	100	3	100	0	0	
019877	Oasis	10	3	100	32	30	30
019877	Oasis	25	3	100	4	0	2
019877	Oasis	50	3	100	0	0	0
019877	Oasis	100	3	100	0	0	0
019916	Ulva	10	3	100	35	48	46
019916	Ulva	25	3	100	26	32	36
019916	Ulva	50	3	100	12	50	26
019916	Ulva	100	3	100	39		

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:8 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019827	Untreated	10	3	100	0	0	0
019827	Untreated	25	3	100	0	0	0
019827	Untreated	50	3	100	0	0	0
019827	Untreated	100	3	100	0	0	0
019840	Thiosulfate	10	3	100	0	0	0
019840	Thiosulfate	25	3	100	0	0	0
019840	Thiosulfate	50	3	100	0	0	0
019840	Thiosulfate	100	3	100	0	0	0
019853	EDTA	10	3	100	0	0	2
019853	EDTA	25	3	100	0	0	0
019853	EDTA	50	3	100	0	0	0
019853	EDTA	100	3	100	0	0	0
019865	Filtered	10	3	100		0	0
019865	Filtered	25	3	100	0	0	0
019878	Oasis	10	3	100	0	0	1
019878	Oasis	25	3	100	0	0	0
019878	Oasis	50	3	100	0	0	0
019878	Oasis	100	3	100	0	0	0
019917	Ulva	10	3	100	48	38	38
019917	Ulva	25	3	100	44	29	38
019917	Ulva	50	3	100	40		
019917	Ulva	100	3	100	39	23	31

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:9 Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019828	Untreated	10	3	100	1	5	1
019828	Untreated	25	3	100	0	0	0
019828	Untreated	50	3	100	0	0	0
019828	Untreated	100	3	100	0	0	0
019841	Thiosulfate	10	3	100	55	50	48
019841	Thiosulfate	25	3	100	0	0	1
019841	Thiosulfate	50	3	100	0	0	0
019841	Thiosulfate	100	3	100	0	0	0
019854	EDTA	10	3	100	40	34	35
019854	EDTA	25	3	100	2	6	2
019854	EDTA	50	3	100	0	0	0
019854	EDTA	100	3	100	0	0	0
019866	Filtered	10	3	100	42	48	38
019866	Filtered	25	3	100	0	0	0
019866	Filtered	50	3	100	0	0	0
019866	Filtered	100	3	100	0	0	0
019879	Oasis	10	3	100	31	33	35
019879	Oasis	25	3	100	0	0	0
019879	Oasis	50	3	100	0	0	0
019879	Oasis	100	3	100	0	0	0
019918	Ulva	10	3	100	49	42	38
019918	Ulva	25	3	100	41	46	38
019918	Ulva	50	3	100	48	46	35
019918	Ulva	100	3	100	46	34	48

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: REF Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019830	Untreated	10	3	100		5	0
019830	Untreated	10	3	60	7		
019830	Untreated	25	3	100	24	14	3
019830	Untreated	50	3	100	0	0	7
019830	Untreated	100	3	100	0	0	0
019843	Thiosulfate	10	3	100	43	48	40
019843	Thiosulfate	25	3	100	35	36	30
019843	Thiosulfate	50	3	100	11	4	13
019843	Thiosulfate	100	3	100	0	0	0
019856	EDTA	10	3	100	33	37	36
019856	EDTA	25	3	100	34	35	35
019856	EDTA	50	3	100	5	1	0
019856	EDTA	100	3	100	0	0	0
019868	Filtered	10	3	100	59	65	61
019868	Filtered	25	3	100	48	47	51
019868	Filtered	50	3	100	7	7	5
019868	Filtered	100	3	100	0	0	0
019881	Oasis	10	3	100	27	28	32
019881	Oasis	25	3	100	15	22	24
019881	Oasis	50	3	100	0	9	4
019881	Oasis	100	3	100	0	0	0
019920	Ulva	10	3	100	54	48	45
019920	Ulva	25	3	100	54	38	35
019920	Ulva	50	3	100	53	22	37
019920	Ulva	100	3	100		37	34
019920	Ulva	100	3	78	40		

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: Spike Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019819	Untreated	10	3	100	0	0	0
019819	Untreated	25	3	100	0	0	0
019819	Untreated	50	3	100	0	0	0
019819	Untreated	100	3	100	0	0	0
019832	Thiosulfate	10	3	100	10	13	2
019832	Thiosulfate	25	3	100	0	0	0
019832	Thiosulfate	50	3	100	0	0	0
019832	Thiosulfate	100	3	100	0	0	0
019845	EDTA	10	3	100	49	58	67
019845	EDTA	25	3	100	45	44	39
019845	EDTA	50	3	100	5	4	8
019845	EDTA	100	3	100	0	0	1
019858	Filtered	10	3	100	26	23	28
019858	Filtered	25	3	100	18	8	20
019858	Filtered	50	3	100	4	6	3
019858	Filtered	100	3	100	0	1	1
019870	Oasis	10	3	100	15	21	20
019870	Oasis	25	3	100	4	7	6
019870	Oasis	50	3	100	1	0	0
019870	Oasis	100	3	100	0	0	0
019909	Ulva	10	3	100	63	50	53
019909	Ulva	25	3	100	35	59	48
019909	Ulva	50	3	100	46	53	55
019909	Ulva	100	3	100	57	56	66

Toxicity Detail Report

Science Applications International Corp		Date:	8/3/01
221 Third Street		Project:	01025
		SDG	5254
Newport, RI	02840	Site:	Hunters Pt TIE

Submitted By: _____

Aquatec Biological Sciences

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: Control Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020127	Untreated	100	3	100	97	97	93
020132	Thiosulfate	100	3	100	91	93	96
020137	EDTA	100	3	100	92	93	94
020142	Filtered	100	3	100	93	86	92
020147	Oasis	100	3	100	93	96	87
020157	pH-High	100	3	100	95	93	94
020152	Ulva	100	3	100	55	63	63
020162	Ulva 1st Ulva	100	3	100	94	90	93
020167	Ulva 1st Thiosu	100	3	100	89	94	86
020172	Ulva 1st EDTA	100	3	100	97	91	97

273 Commerce Street, Williston, VT 05495 Tel 802 860 1638 Fax [illegible]

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:4 (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020129	Untreated	1	3	100	97	92	95
020129	Untreated	10	3	100	94	96	97
020129	Untreated	50	3	100	1	2	1
020129	Untreated	100	3	100	1	0	1
020134	Thiosulfate	1	3	100	96	95	97
020134	Thiosulfate	10	3	100	93	95	94
020134	Thiosulfate	50	3	100	0	0	0
020134	Thiosulfate	100	3	100	0	0	0
020139	EDTA	1	3	100	89	97	99
020139	EDTA	10	3	100	91	99	95
020139	EDTA	50	3	87	2		
020139	EDTA	50	3	100		0	0
020139	EDTA	100	3	100	0	0	0
020144	Filtered	1	3	100	94	97	93
020144	Filtered	10	3	100	95	93	92
020144	Filtered	50	3	100		0	0
020144	Filtered	50	3	89	3		
020144	Filtered	100	3	100	0	0	0
020149	Oasis	1	3	100	93	94	86
020149	Oasis	10	3	100	82	92	78
020149	Oasis	50	3	100	0	0	0

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:4 (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020149	Oasis	100	3	100	0	1	0
020159	pH-High	1	3	100	96	93	88
020159	pH-High	10	3	100	92	90	89
020159	pH-High	50	3	100	0	0	0
020159	pH-High	100	3	100	0	0	0
020154	Ulva	1	3	100	92	86	90
020154	Ulva	10	3	100	92	91	90
020154	Ulva	50	3	100	83	84	79
020154	Ulva	100	3	100	78	84	83
020164	Ulva 1st Ulva	1	3	100	93	91	89
020164	Ulva 1st Ulva	10	3	100	97	93	95
020164	Ulva 1st Ulva	50	3	100	92	91	90
020164	Ulva 1st Ulva	100	3	100	55	50	41
020169	Ulva 1st Thiosu	1	3	100	91	95	95
020169	Ulva 1st Thiosu	10	3	100	91	95	93
020169	Ulva 1st Thiosu	50	3	100	96	95	86
020169	Ulva 1st Thiosu	100	3	100	68	62	67
020174	Ulva 1st EDTA	1	3	100	93	94	95
020174	Ulva 1st EDTA	10	3	100	93	88	92
020174	Ulva 1st EDTA	50	3	100	92	92	97
020174	Ulva 1st EDTA	100	3	100	73	76	75

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:5 (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020130	Untreated	1	3	100	97	96	94
020130	Untreated	10	3	100	29	41	26
020130	Untreated	50	3	100	0	0	0
020130	Untreated	100	3	100	0	0	0
020135	Thiosulfate	1	3	100	95	92	95
020135	Thiosulfate	10	3	100	34	30	36
020135	Thiosulfate	50	3	100	0	0	0
020135	Thiosulfate	100	3	100	0	0	0
020140	EDTA	1	3	100	98	100	95
020140	EDTA	10	3	100	67	62	52
020140	EDTA	50	3	100	0	0	0
020140	EDTA	100	3	100	0	0	0
020145	Filtered	1	3	100	91	90	91
020145	Filtered	10	3	100	62	67	65
020145	Filtered	50	3	100	0	0	0
020145	Filtered	100	3	100	0	0	0
020150	Oasis	1	3	100	88	89	78
020150	Oasis	10	3	100	43	37	33
020150	Oasis	50	3	100	0	0	0
020150	Oasis	100	3	100	0	1	1
020160	pH-High	1	3	100	91	88	89

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:5 (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020160	pH-High	10	3	100	54	37	31
020160	pH-High	50	3	100	2	0	0
020160	pH-High	100	3	100	0	0	0
020155	Ulva	1	3	100	88	89	86
020155	Ulva	10	3	100	84	83	84
020155	Ulva	50	3	100	70	67	63
020155	Ulva	100	3	100	0	0	0
020165	Ulva 1st Ulva	1	3	100	96	96	94
020165	Ulva 1st Ulva	10	3	100	91	96	92
020165	Ulva 1st Ulva	50	3	100	2	1	0
020165	Ulva 1st Ulva	100	3	100	0	0	0
020170	Ulva 1st Thiosu	1	3	100	94	88	92
020170	Ulva 1st Thiosu	10	3	100	95	95	97
020170	Ulva 1st Thiosu	50	3	100	19	10	13
020170	Ulva 1st Thiosu	100	3	100	0	0	0
020175	Ulva 1st EDTA	1	3	100	93	94	95
020175	Ulva 1st EDTA	10	3	100	93	94	98
020175	Ulva 1st EDTA	50	3	100	5	10	1
020175	Ulva 1st EDTA	100	3	100	0	0	0

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:9 (2) Method: C72DES Species: *Dendraster excentricus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
020131	Untreated	1	3	100	97	95	92
020131	Untreated	10	3	100	8	8	6
020131	Untreated	50	3	100	0	0	0
020131	Untreated	100	3	100		0	0
020136	Thiosulfate	1	3	100	93	94	89
020136	Thiosulfate	10	3	100	17	17	9
020136	Thiosulfate	50	3	100	0	0	0
020136	Thiosulfate	100	3	100	0	0	0
020141	EDTA	1	3	100	94	92	98
020141	EDTA	10	3	100	24	31	36
020141	EDTA	50	3	100	0	0	0
020141	EDTA	100	3	100	0	0	0
020146	Filtered	1	3	100	92	95	88
020146	Filtered	10	3	100	56	55	50
020146	Filtered	50	3	100	0	0	0
020146	Filtered	100	3	100	0	0	0
020151	Oasis	1	3	100	91	88	83
020151	Oasis	10	3	100	19	18	16
020151	Oasis	50	3	100	0	0	0
020151	Oasis	100	3	100	0	0	1
020161	pH-High	1	3	100	93	92	95

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:9 (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020161	pH-High	10	3	100	84	85	79
020161	pH-High	50	3	100	0	0	0
020161	pH-High	100	3	100	0	0	0
020156	Ulva	1	3	100	93	89	86
020156	Ulva	10	3	100	79	74	73
020156	Ulva	50	3	100	69	71	67
020156	Ulva	100	3	100	0	0	0
020166	Ulva 1st Ulva	1	3	100	85	89	91
020166	Ulva 1st Ulva	10	3	100	81	90	80
020166	Ulva 1st Ulva	50	3	100	39	63	52
020166	Ulva 1st Ulva	100	3	100	0	0	0
020171	Ulva 1st Thiosu	1	3	100	96	96	97
020171	Ulva 1st Thiosu	10	3	100	92	90	96
020171	Ulva 1st Thiosu	50	3	100	90	91	89
020171	Ulva 1st Thiosu	100	3	100	3	3	2
020176	Ulva 1st EDTA	1	3	100	94	93	87
020176	Ulva 1st EDTA	10	3	100	96	94	94
020176	Ulva 1st EDTA	50	3	100	93	98	96
020176	Ulva 1st EDTA	100	3	100	4	5	7

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: REF (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020128	Untreated	1	3	100	93	95	96
020128	Untreated	10	3	100	98	96	88
020128	Untreated	50	3	100	35	32	23
020128	Untreated	100	3	100	0	0	1
020133	Thiosulfate	1	3	100	93	98	94
020133	Thiosulfate	10	3	100	97	94	91
020133	Thiosulfate	50	3	100	22	34	43
020133	Thiosulfate	100	3	100	0	5	0
020138	EDTA	1	3	100	95	91	97
020138	EDTA	10	3	100	95	96	95
020138	EDTA	50	3	100	87	73	71
020138	EDTA	100	3	100	1	0	0
020143	Filtered	1	3	100	95	92	92
020143	Filtered	10	3	100	97	91	93
020143	Filtered	50	3	100	64	65	77
020143	Filtered	100	3	100	0	0	1
020148	Oasis	1	3	100	93	96	88
020148	Oasis	10	3	100	96	94	94
020148	Oasis	50	3	100	78	54	47
020148	Oasis	100	3	100	0	0	3
020158	pH-High	1	3	100	93	84	93

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: REF (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020158	pH-High	10	3	100	90	90	81
020158	pH-High	50	3	100	71	66	49
020158	pH-High	100	3	100	0	1	0
020153	Ulva	1	3	100	86	88	85
020153	Ulva	10	3	100	79	88	86
020153	Ulva	50	3	100	85	78	80
020153	Ulva	100	3	100	54	43	50
020163	Ulva 1st Ulva	1	3	100	90	92	90
020163	Ulva 1st Ulva	10	3	100	86	92	89
020163	Ulva 1st Ulva	50	3	100	85	87	81
020163	Ulva 1st Ulva	100	3	100	62	56	65
020168	Ulva 1st Thiosu	1	3	100	94	93	94
020168	Ulva 1st Thiosu	10	3	100		94	90
020168	Ulva 1st Thiosu	50	3	100	82	80	85
020168	Ulva 1st Thiosu	100	3	100	85	65	65
020173	Ulva 1st EDTA	1	3	100	91	94	87
020173	Ulva 1st EDTA	10	3	100	92	89	84
020173	Ulva 1st EDTA	50	3	100	80	82	74
020173	Ulva 1st EDTA	100	3	100	93	74	74

Submitted By: _____

Supportive Documentation

Chain-Of-Custody

Toxicity Test Methods

Menidia 48 h static acute

Sand Dollar, Dendraster excentricus, 72 Hour Larval Development

West Coast sea urchin 72h embryo development test

Standard Reference Toxicant Control Charts

Available Upon Request

APPENDIX B-2
Toxicity calculations
(Sample pages provided – full document available upon request)

Larval Fish Growth and Survival Test-48 Hr Survival

Start Date:	6/8/01	Test ID:	HP-MUNT-4	Sample ID:	HP4
End Date:	6/10/01	Lab ID:	AQUATEC	Sample Type:	AMB1-Ambient water
Sample Date:		Protocol:	EPAM 87-EPA Marine	Test Species:	MI-Menidia menidia
Comments:	actual organism: M. menidia				

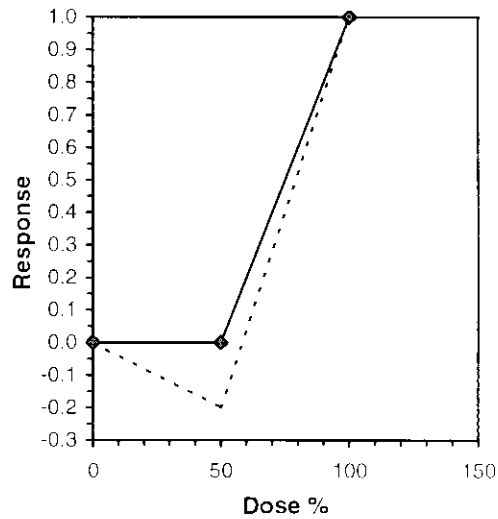
Conc-%	1	2	3
B-Control	1.0000	0.8000	0.6000
50	1.0000	1.0000	
100	0.6000	0.4000	0.4000

			Transform: Arcsin Square Root					Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Mean	N-Mean
B-Control	0.8000	1.0000	1.0135	0.8861	1.1071	11.281	3	0.9167	1.0000
50	1.0000	1.2500	1.0472	1.0472	1.0472	0.000	2	0.9167	1.0000
100	0.4667	0.5833	0.7518	0.6847	0.8861	15.463	3	0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96734	0.749	0.17461	-0.6988
Equality of variance cannot be confirmed				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC01	50.500	0.176	51.912	54.500	1.3032
IC05	52.500	0.880	59.559	72.500	1.3032
IC10	55.000	1.760	69.118	95.000	1.3032
IC15	57.500	2.640	78.676	117.500	1.3032
IC20	60.000	3.520	88.235	140.000	1.3032
IC25	62.500	4.399	97.794	162.500	1.3032
IC40	70.000				
IC50	75.000				
IC60	80.000				
IC75	87.500				
IC80	90.000				
IC85	92.500				
IC90	95.000				
IC95	97.500				
IC99	99.500				



 ToxCalc v5.0.23 Reviewed by:_____

Larval Fish Growth and Survival Test-48 Hr Survival

Start Date:	6/8/01	Test ID:	HP-MUNT-4	Sample ID:	HP4
End Date:	6/10/01	Lab ID:	AQUATEC	Sample Type:	AMB1-Ambient water
Sample Date:		Protocol:	EPAM 87-EPA Marine	Test Species:	MI-Menidia menidia
Comments:	actual organism: M. menidia				

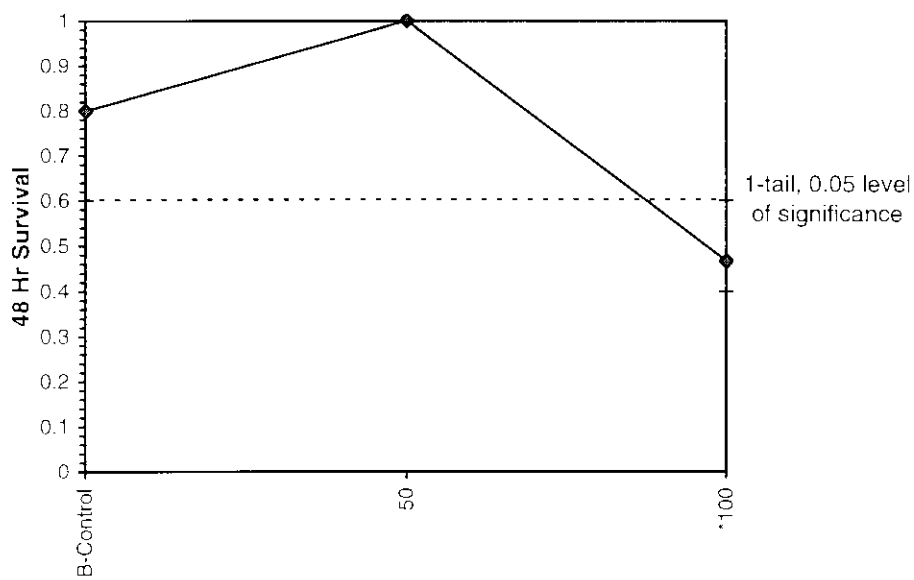
Conc-%	1	2	3
B-Control	1.0000	0.8000	0.6000
50	1.0000	1.0000	
100	0.6000	0.4000	0.4000

			Transform: Arcsin Square Root						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
B-Control	0.8000	1.0000	1.0135	0.8861	1.1071	11.281	3			
50	1.0000	1.2500	1.0472	1.0472	1.0472	0.000	2	-0.358	2.440	0.2297
*100	0.4667	0.5833	0.7518	0.6847	0.8861	15.463	3	3.107	2.440	0.2054

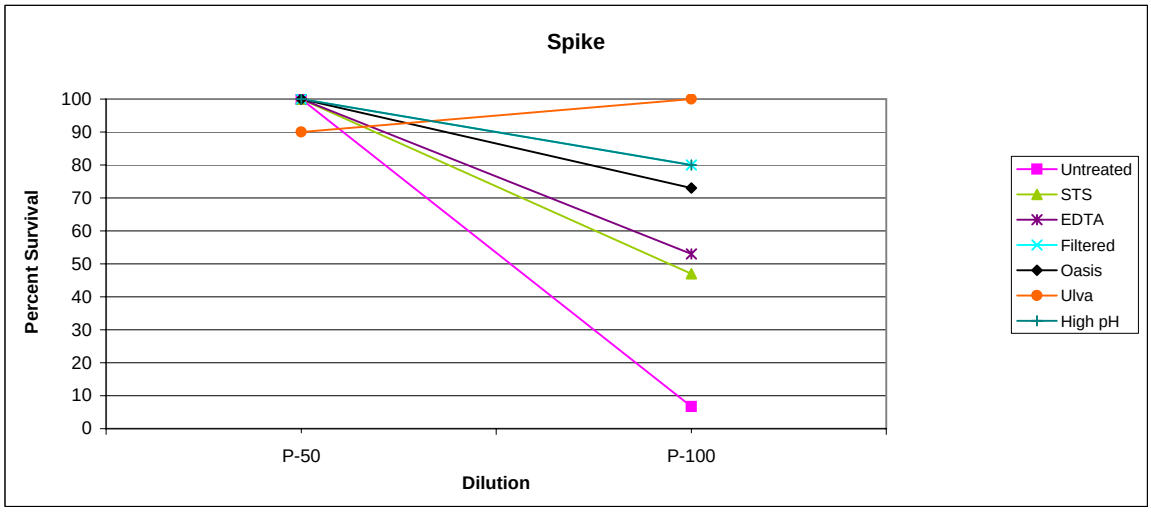
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96734	0.749	0.17461	-0.6988
Equality of variance cannot be confirmed				

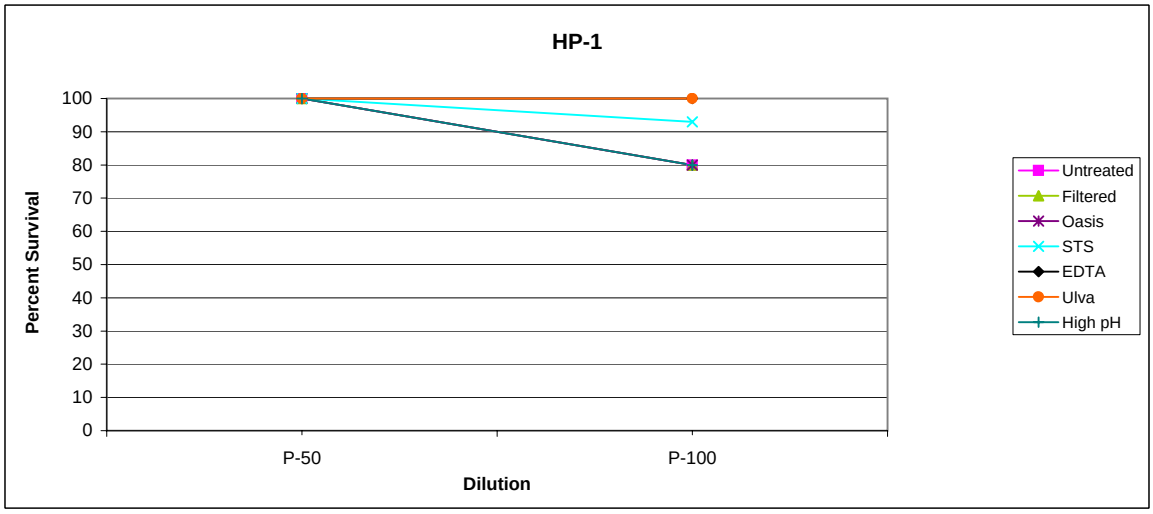
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.7107	2	0.19763	0.27439	0.07165	0.01063	0.03811	2, 5

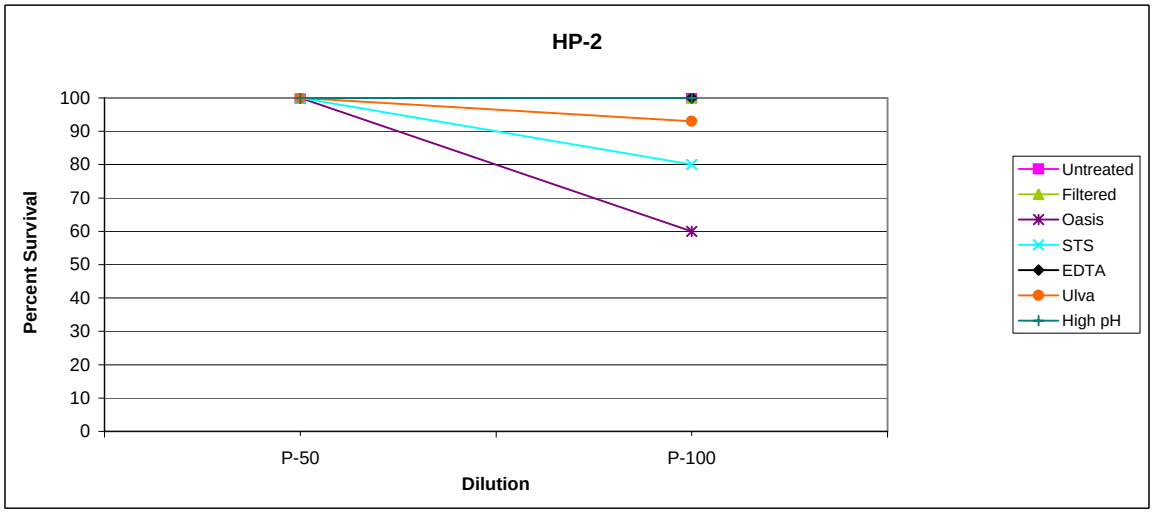
Dose-Response Plot

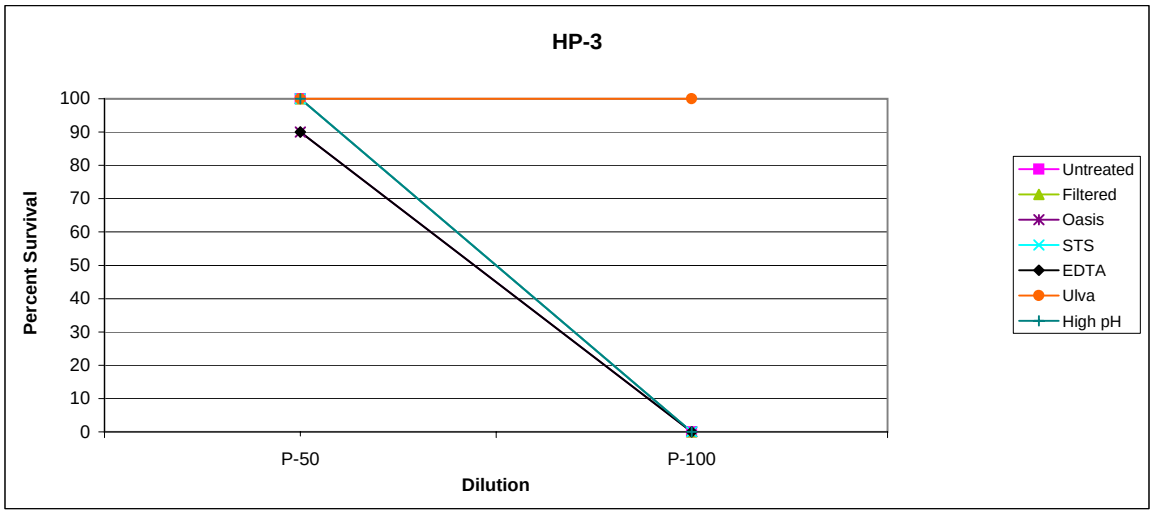


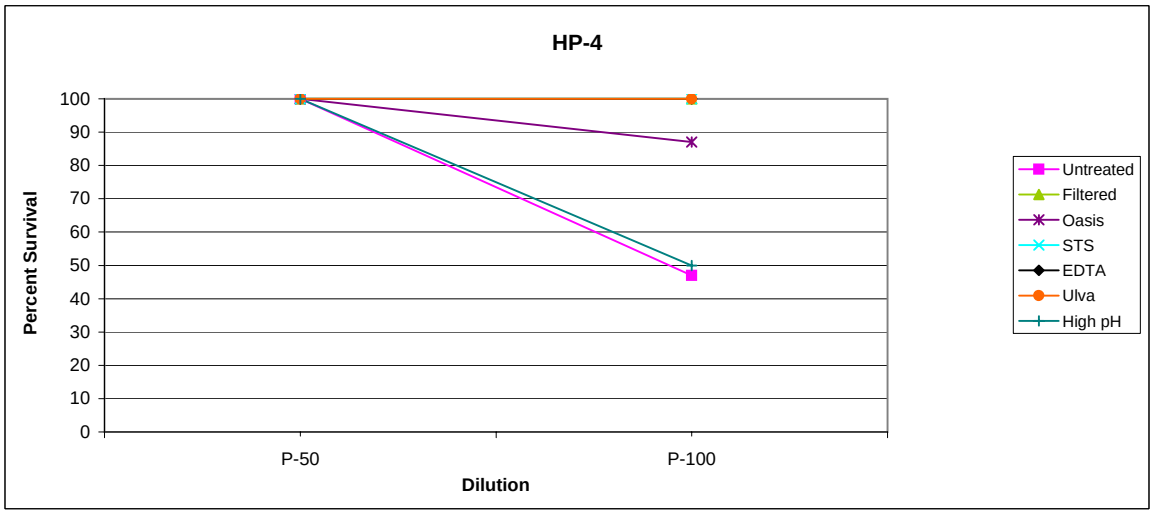
Appendix B-3-1. Plots of percent survival of *Menidia menidia* vs. sample dilution by station for the Hunter's Point TIE study.

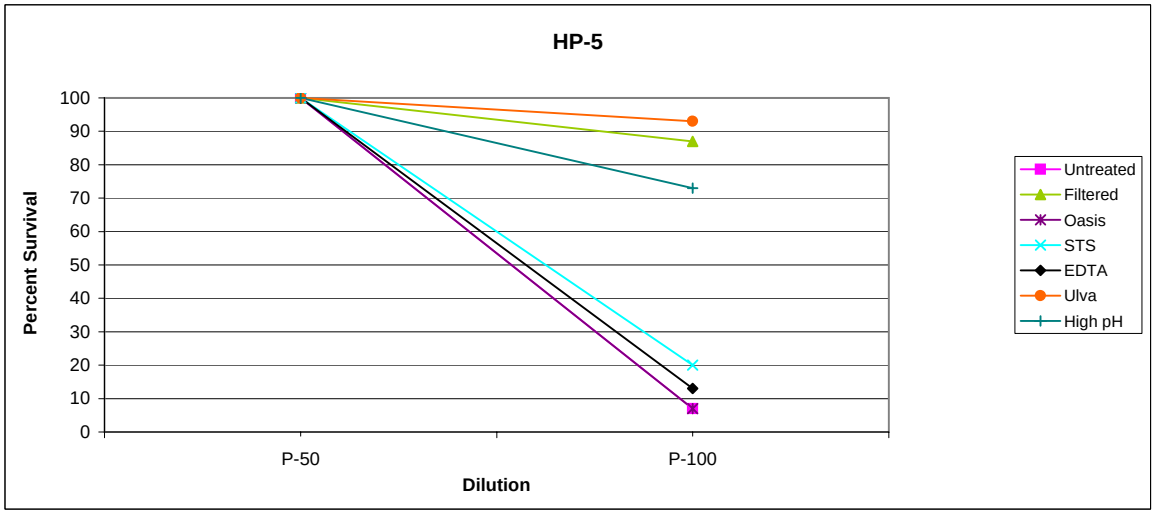


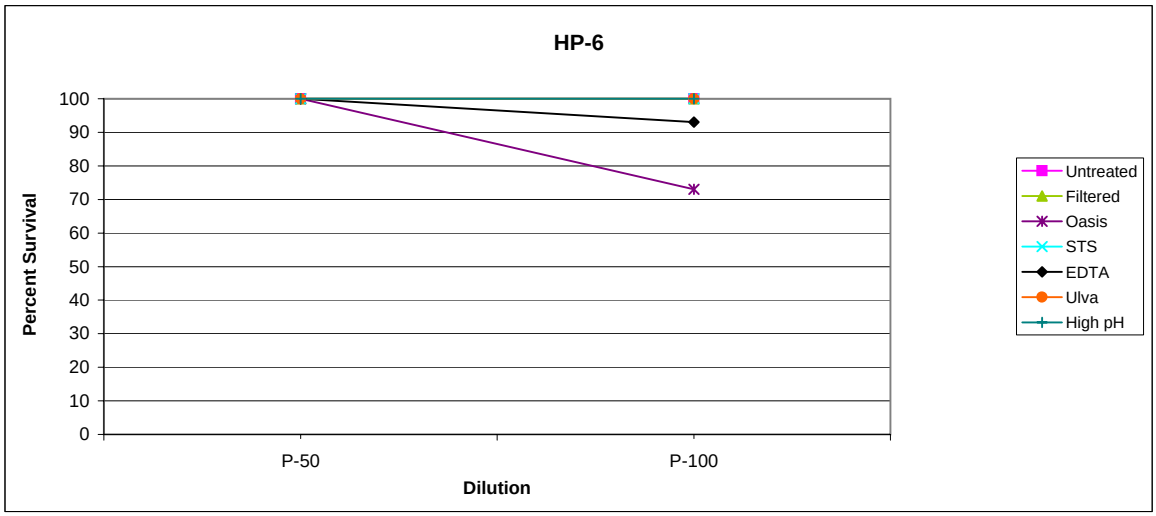


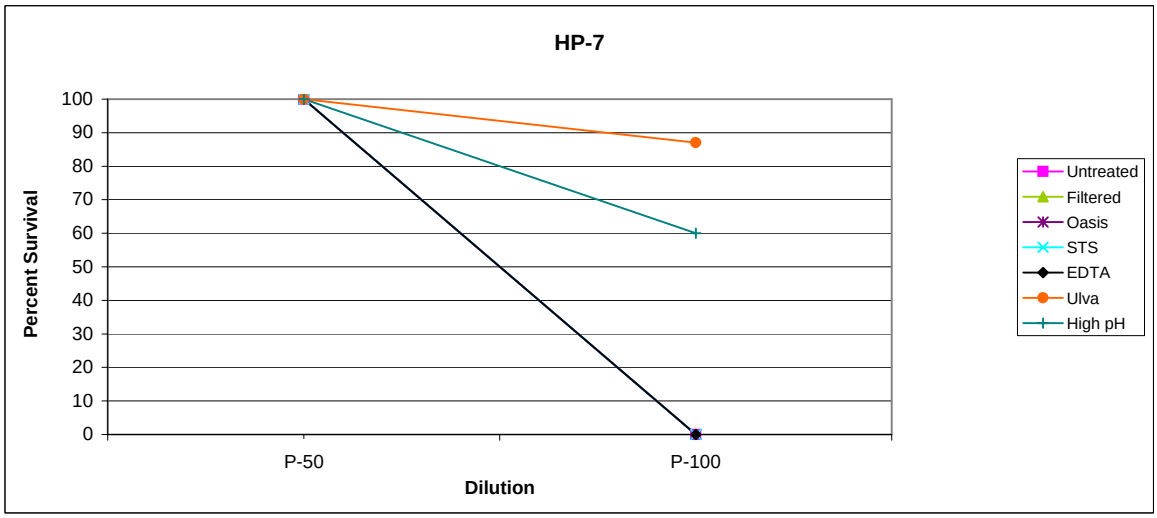


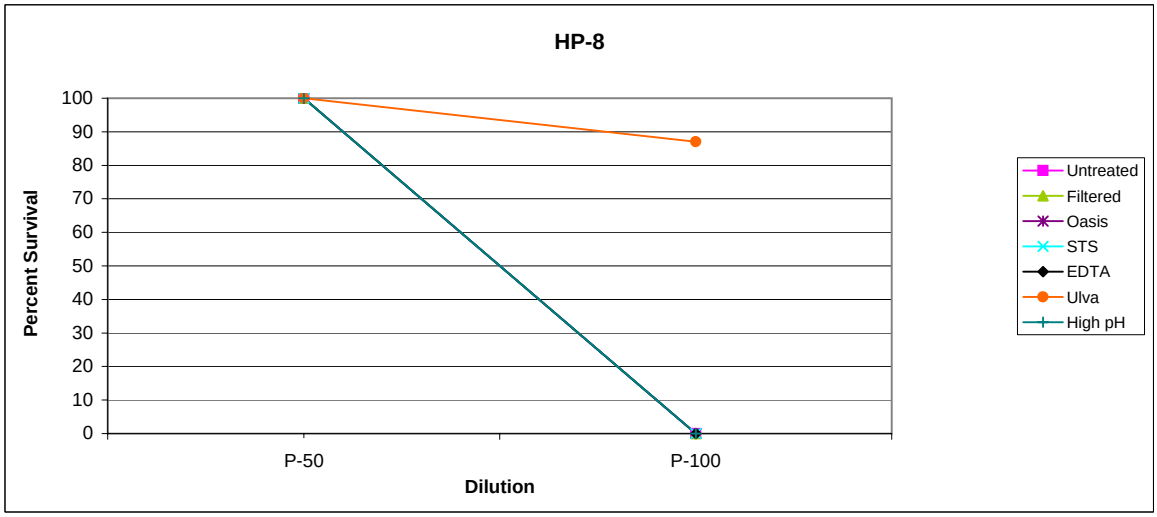

HP-3
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

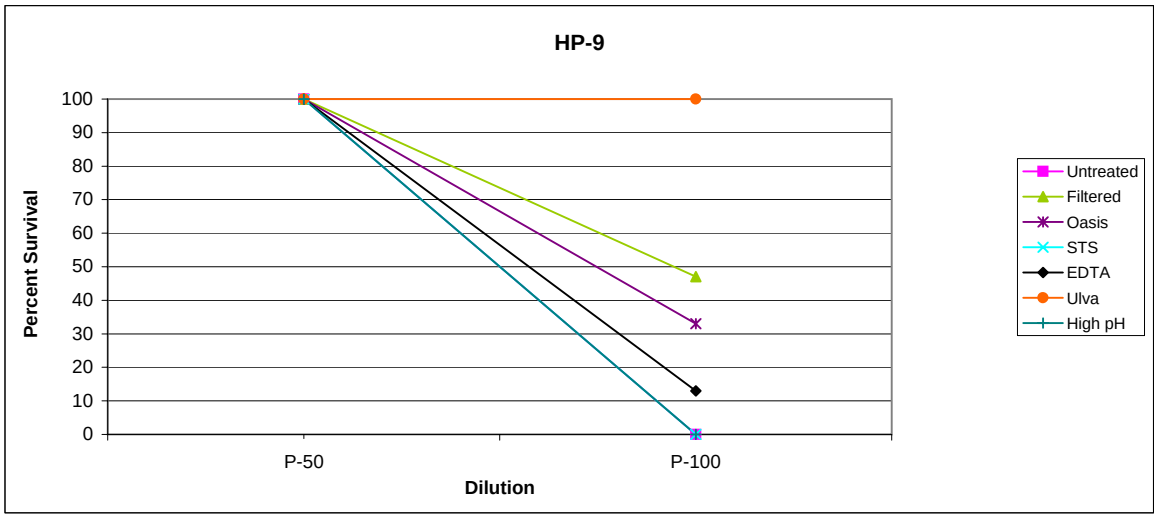

HP-4
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

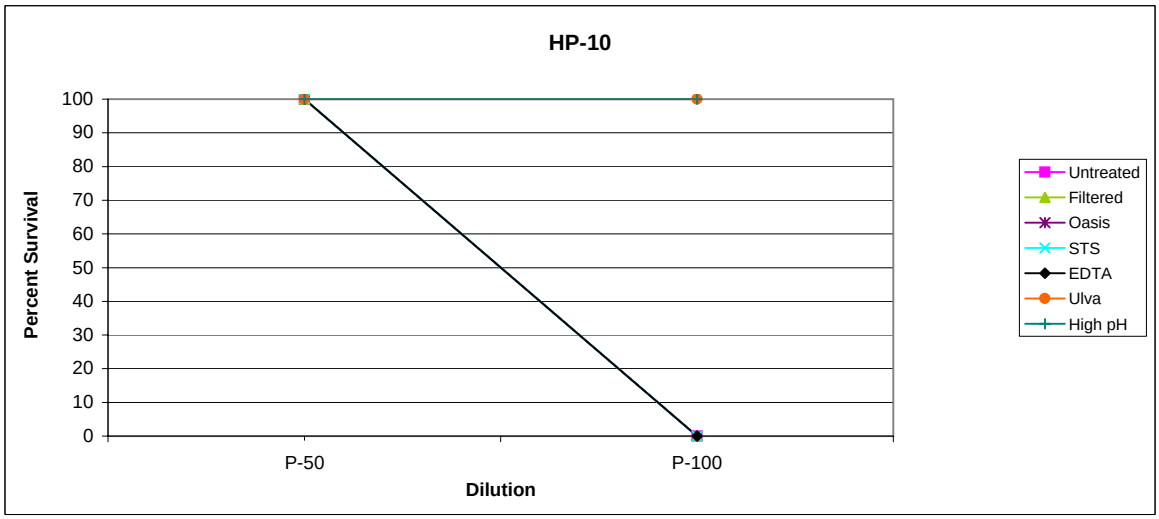

HP-5
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

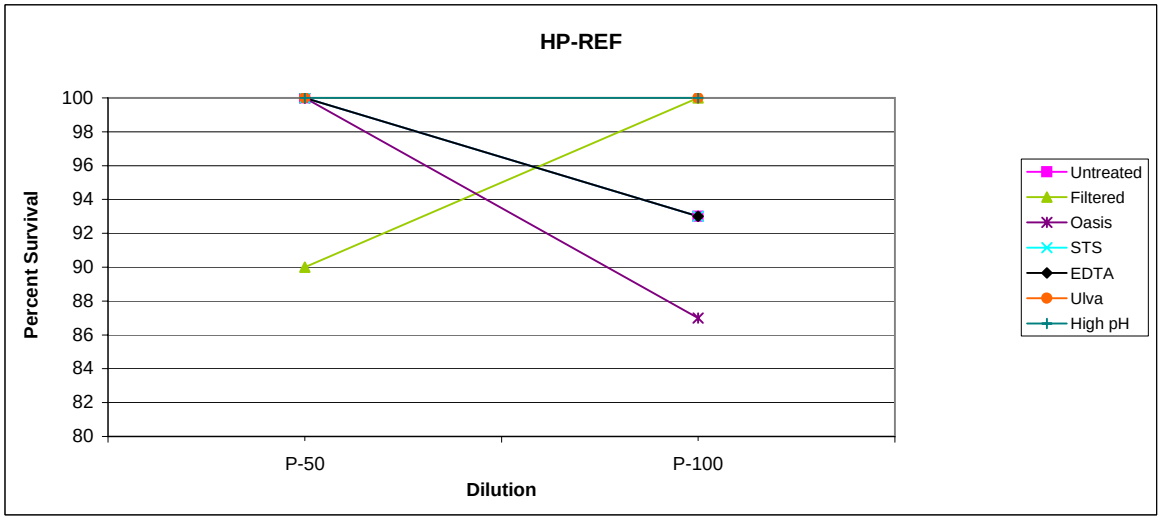

HP-6
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

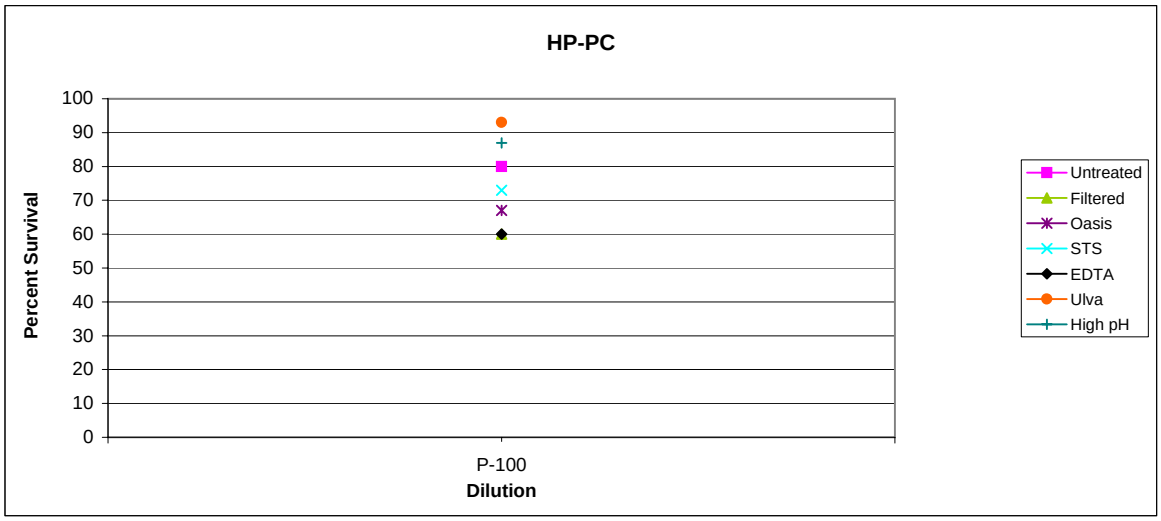

HP-7
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH


HP-8
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

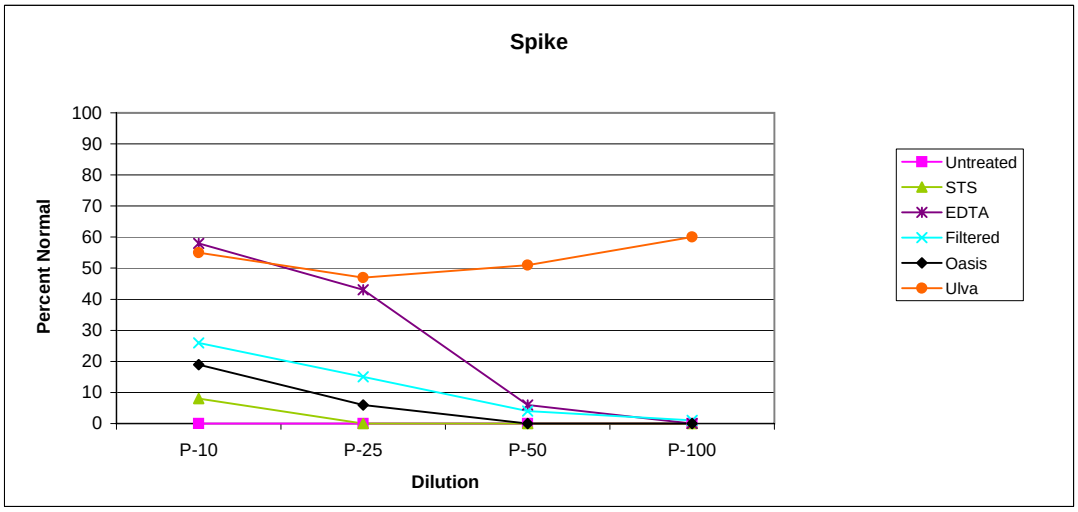

HP-9
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

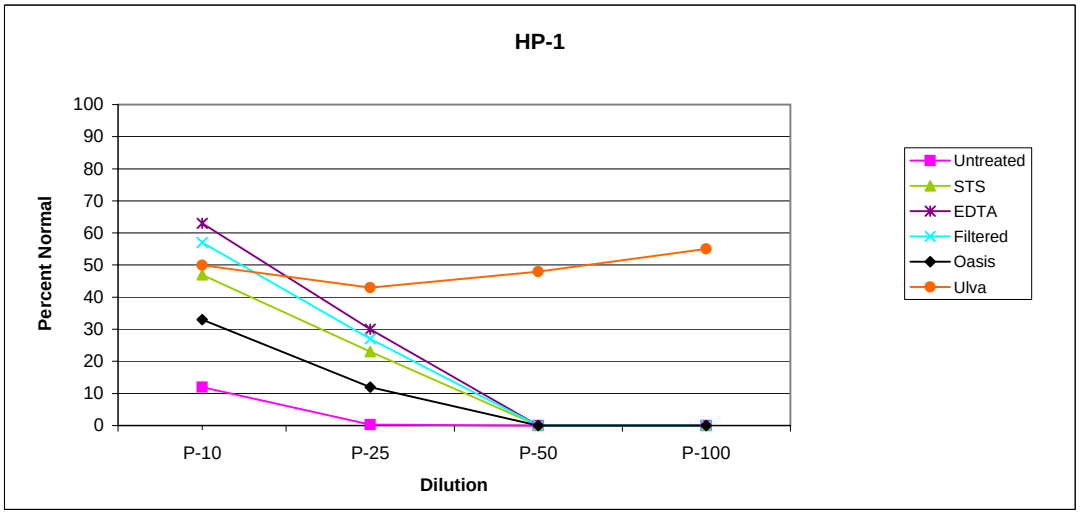

HP-10
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

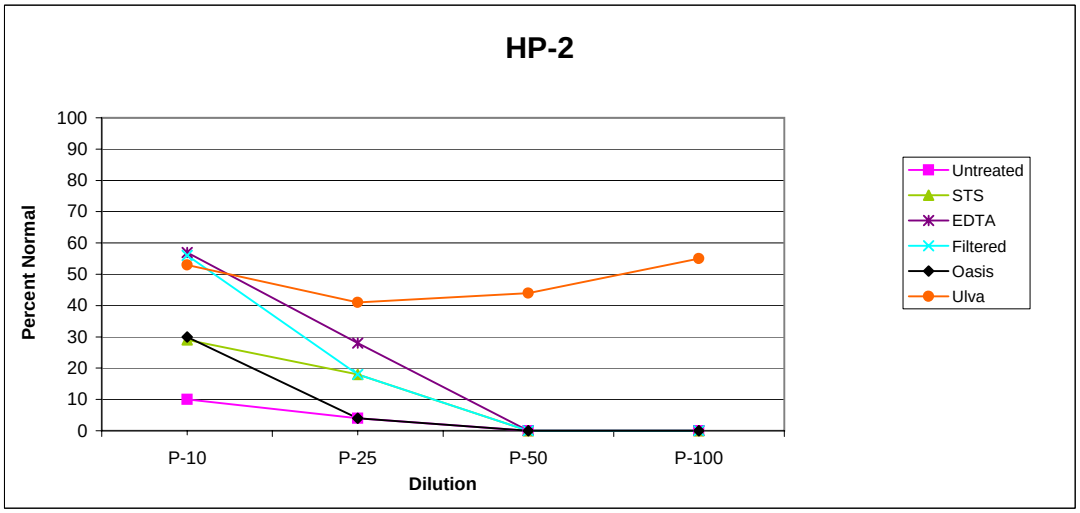

HP-REF
Percent Survival
100
98
96
94
92
90
88
86
84
82
80
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

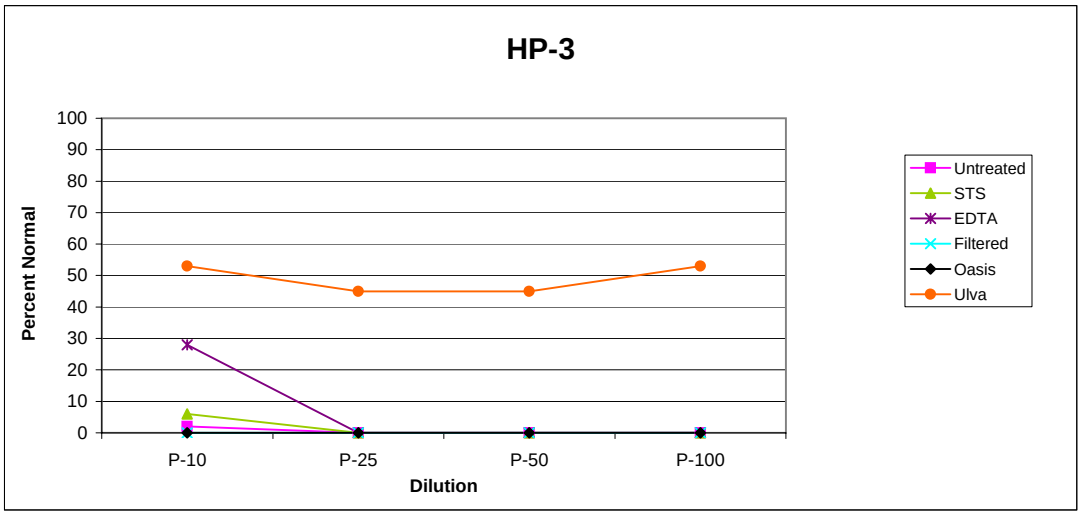

HP-PC
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

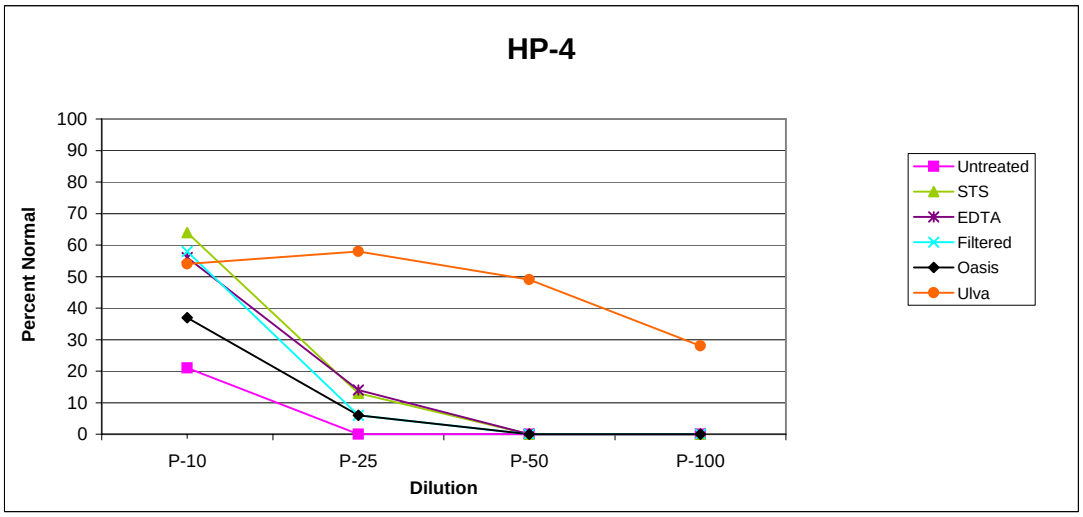
Appendix B-3-2. Plots of percent normal development of *Strongylocentrotus purpuratus* vs. sample dilution by station for the Hunter's Point TIE study.

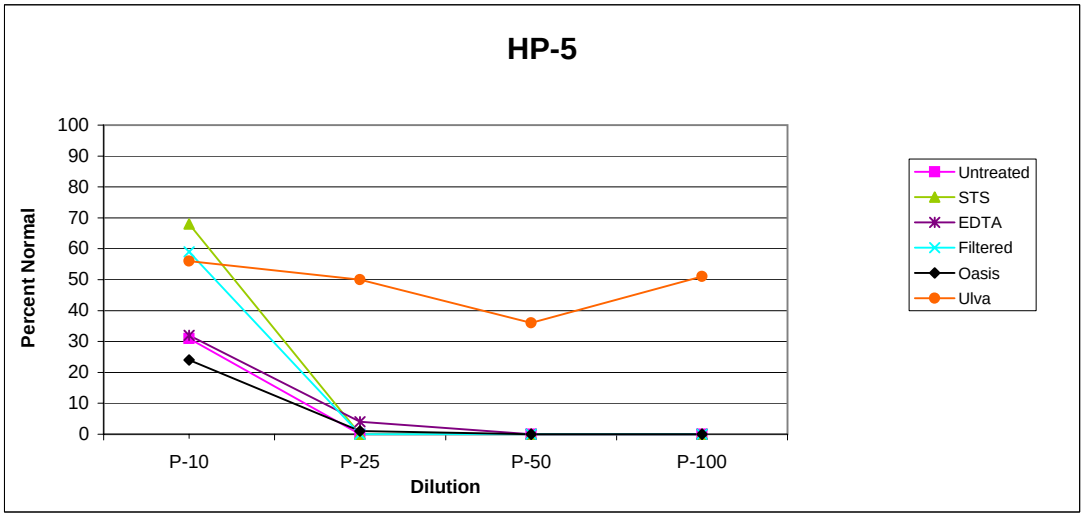


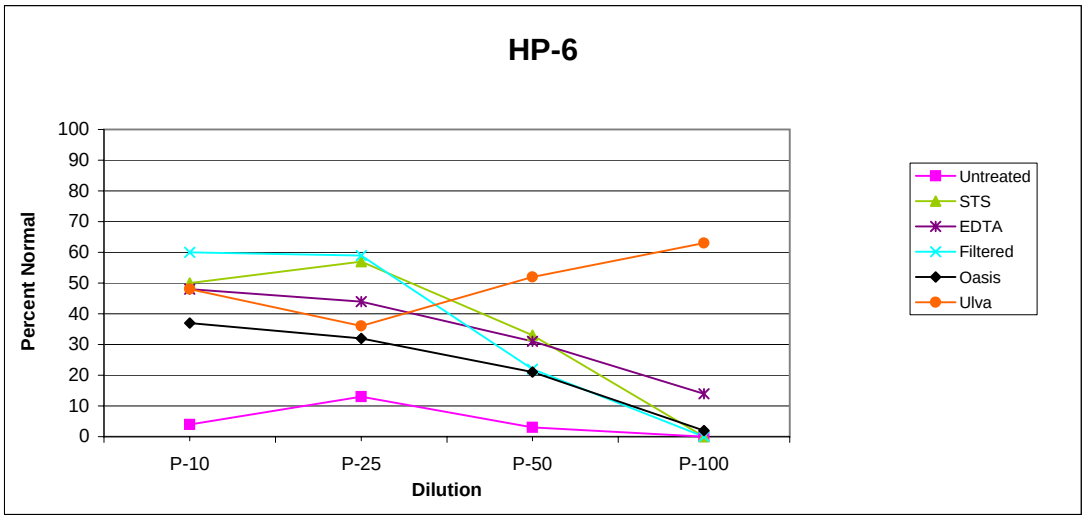


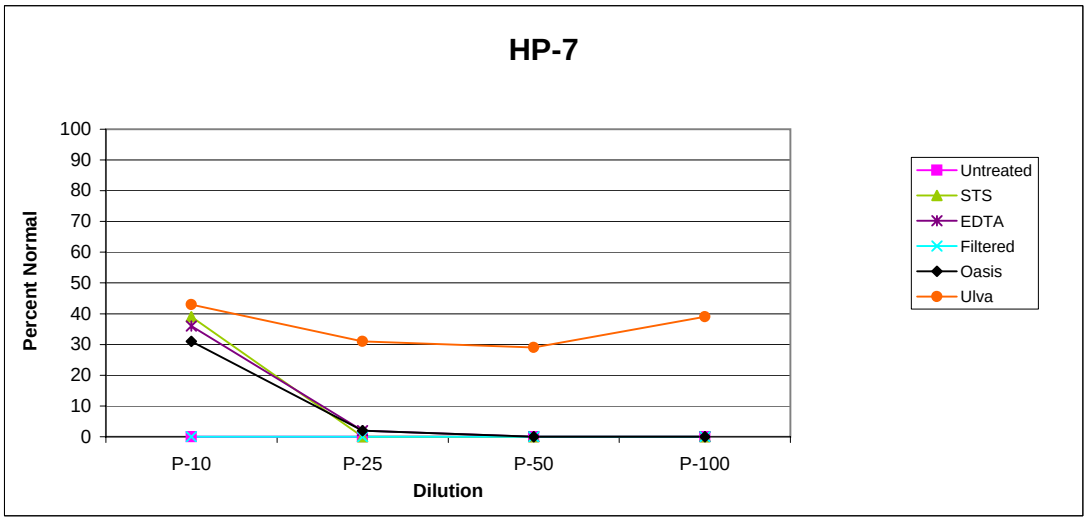


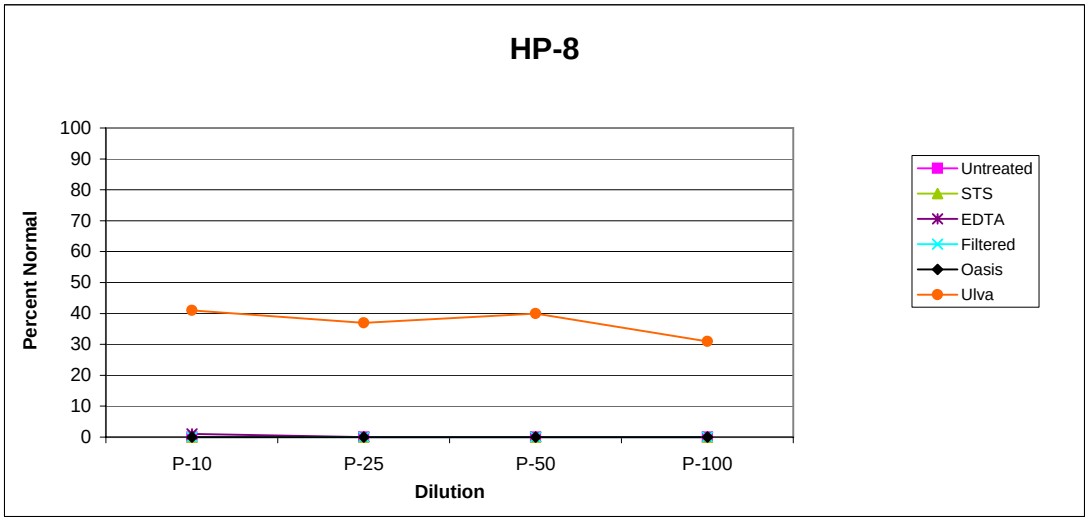

HP-3
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

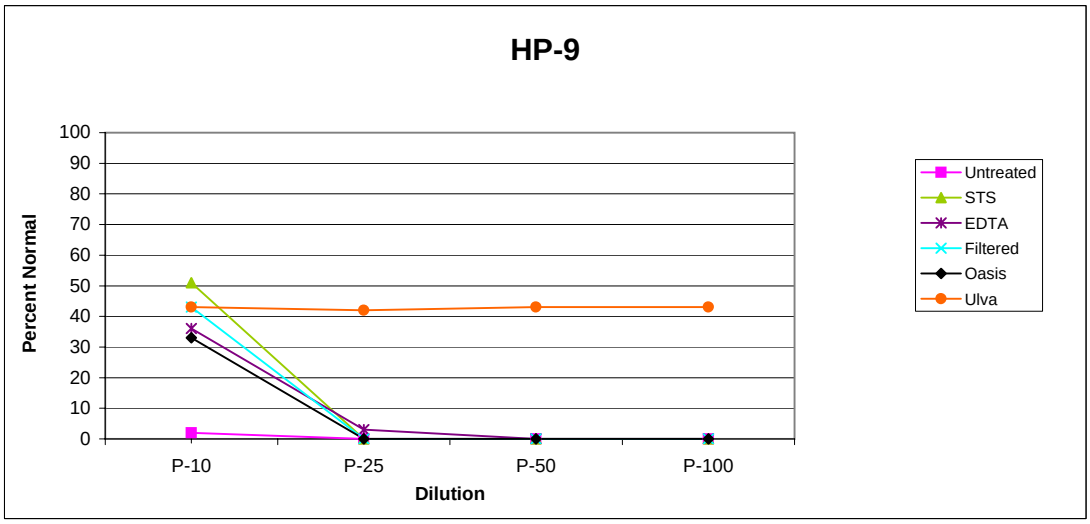

HP-4
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

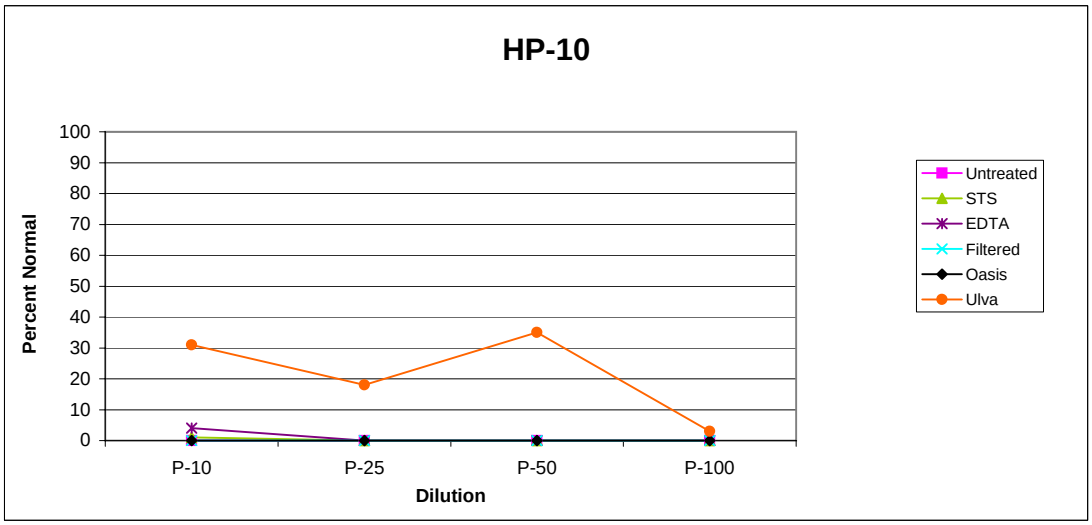

HP-5
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

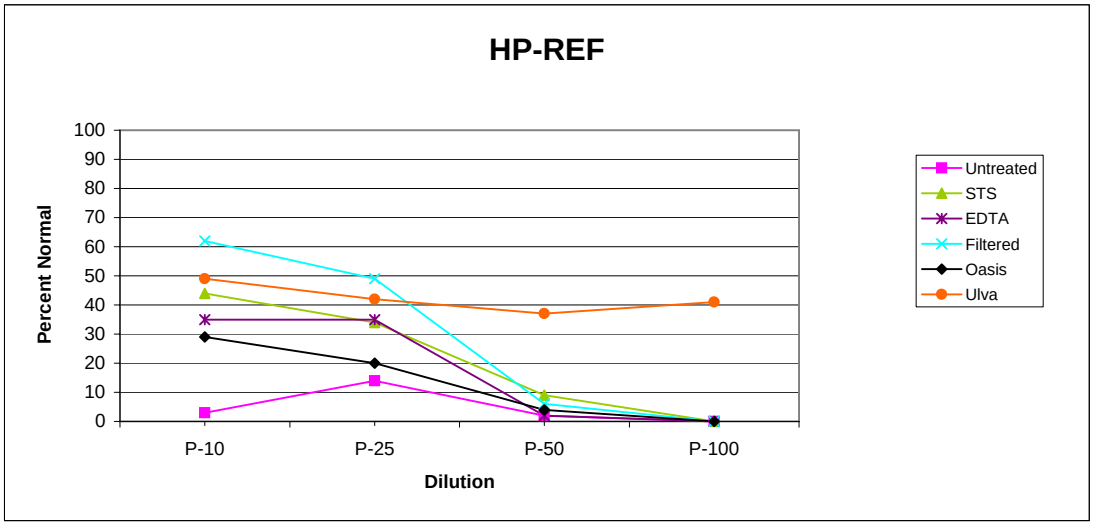

HP-6
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

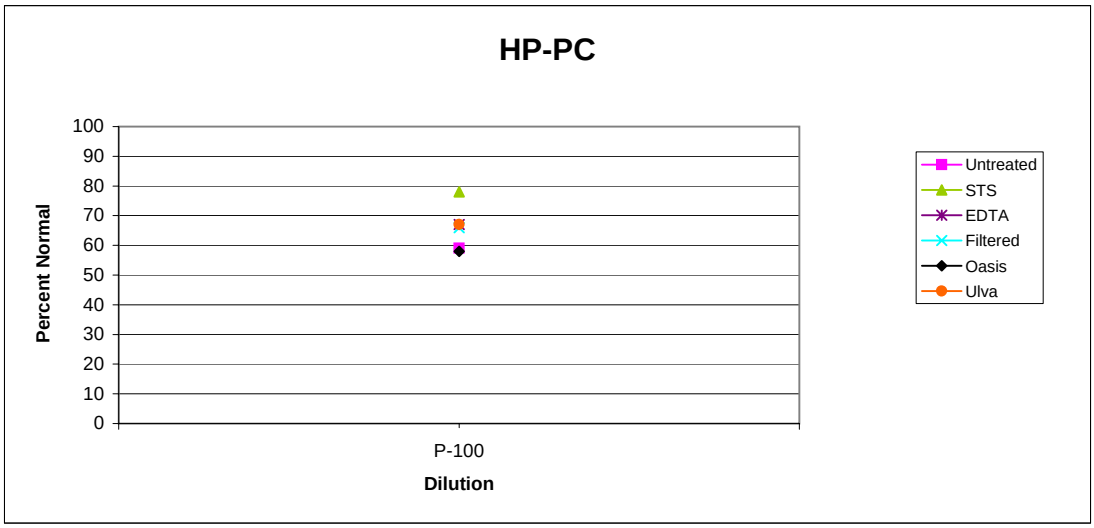

HP-7
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva


HP-8
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

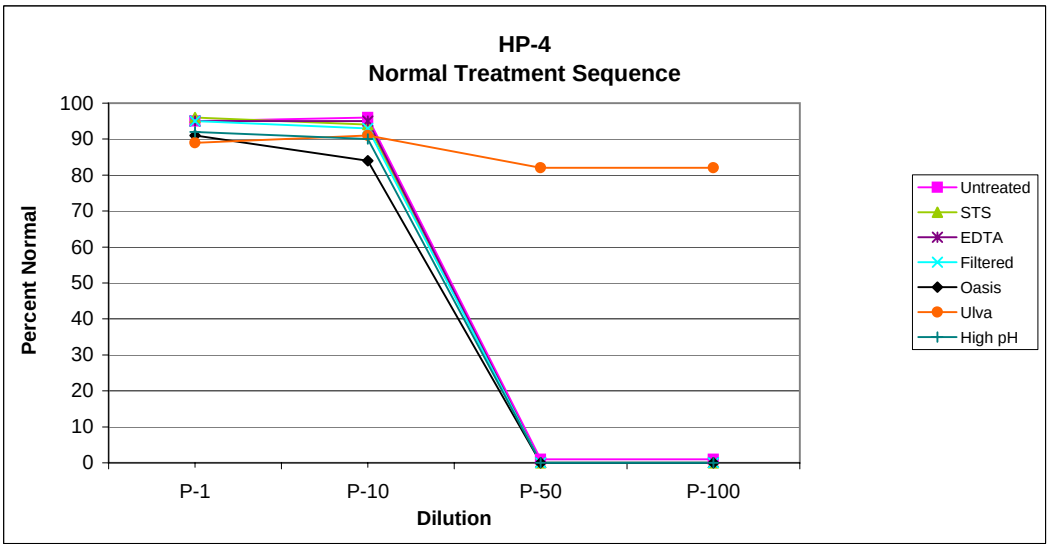

HP-9
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

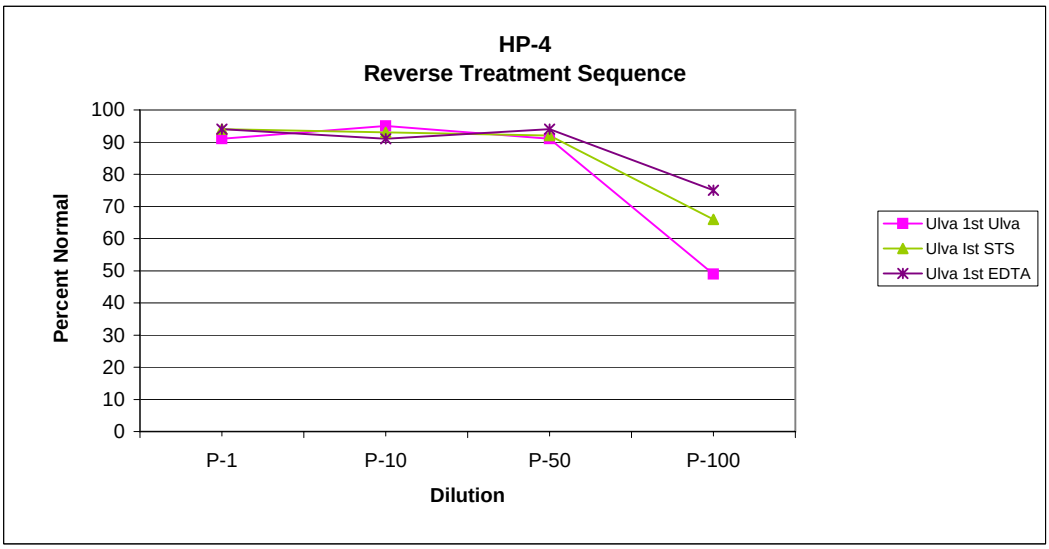

HP-10
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

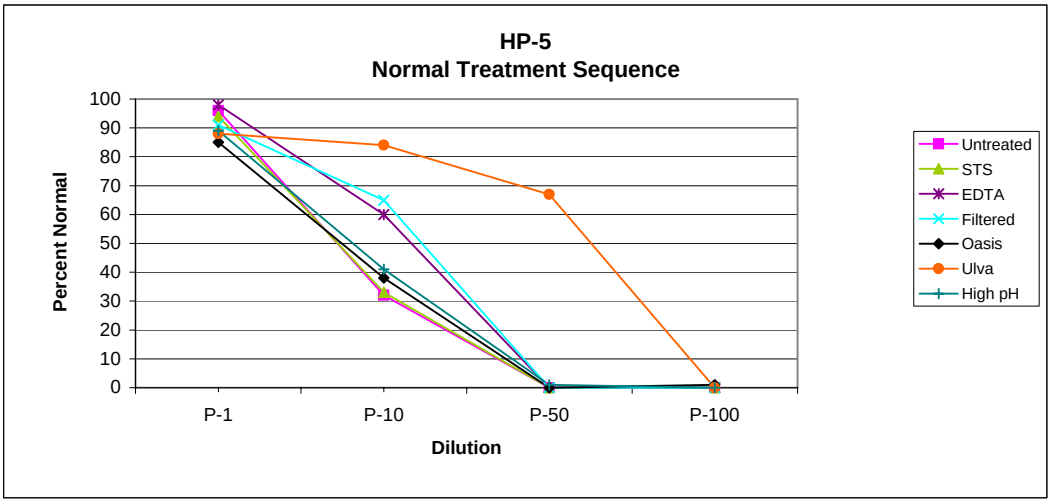

HP-REF
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

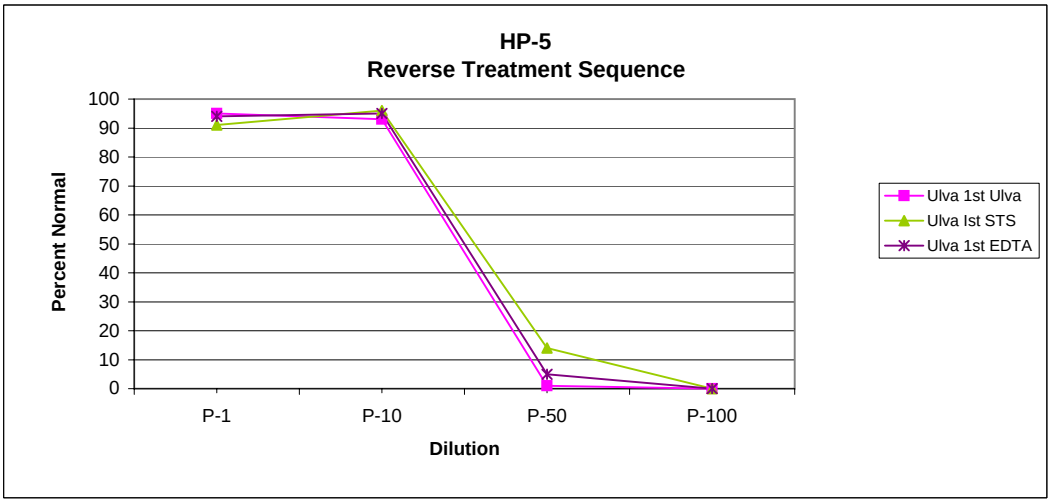

HP-PC
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

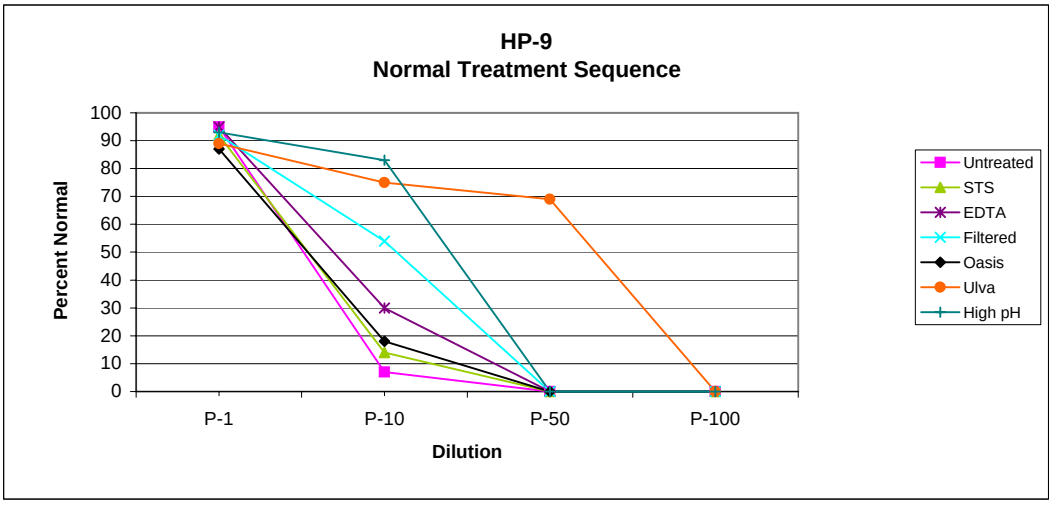
Appendix B-3-3. Plots of percent normal development of *Dendraster excentricus* vs. sample dilution by station for the Hunters Point TIE study.

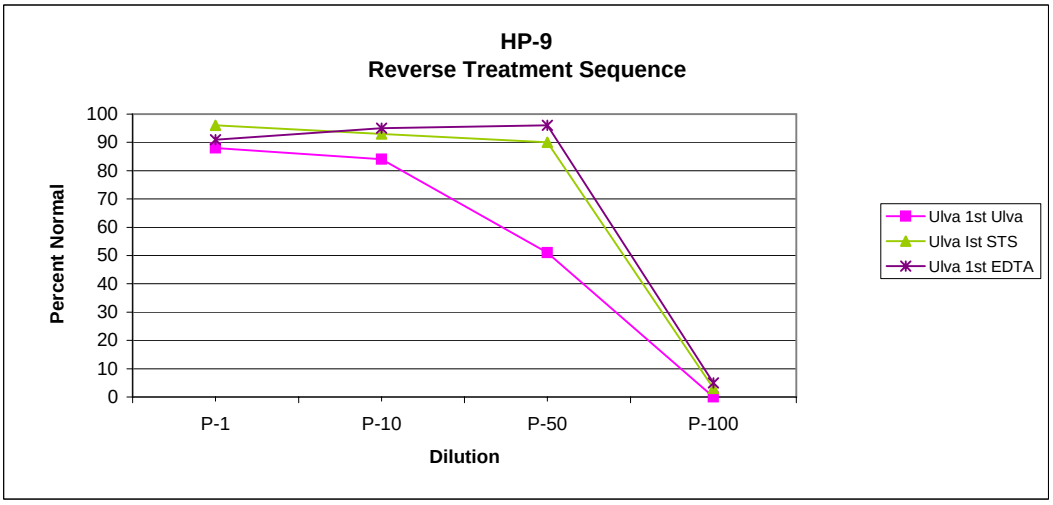


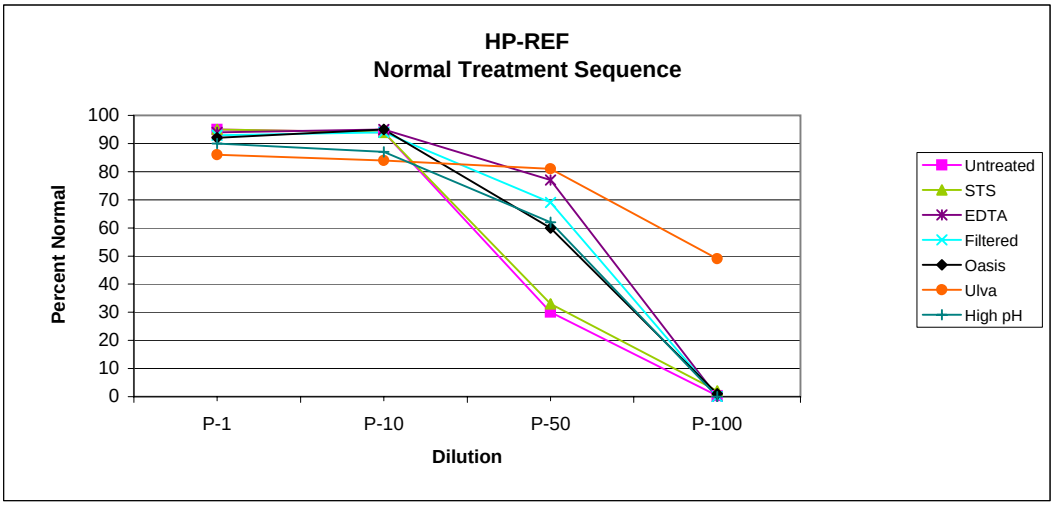


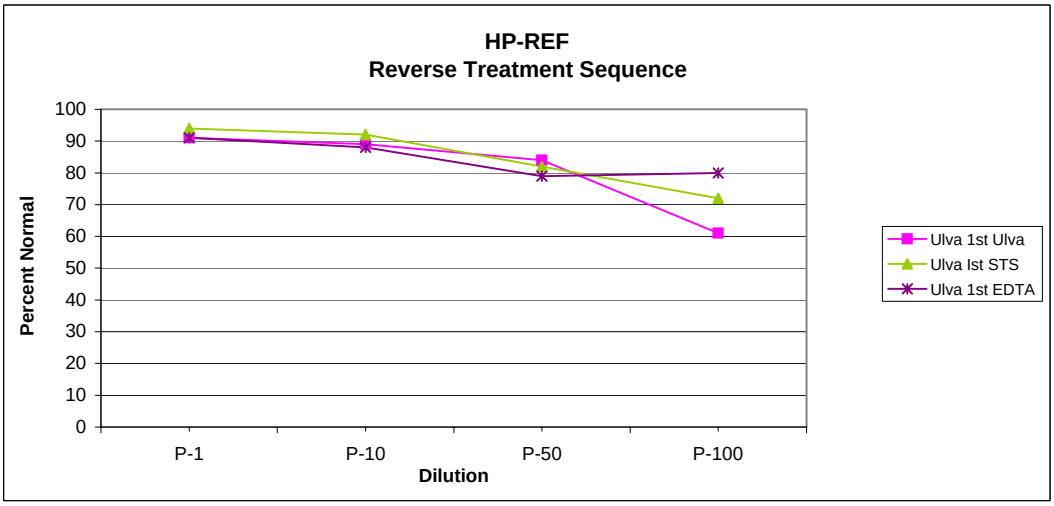

HP-5
Normal Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva
High pH

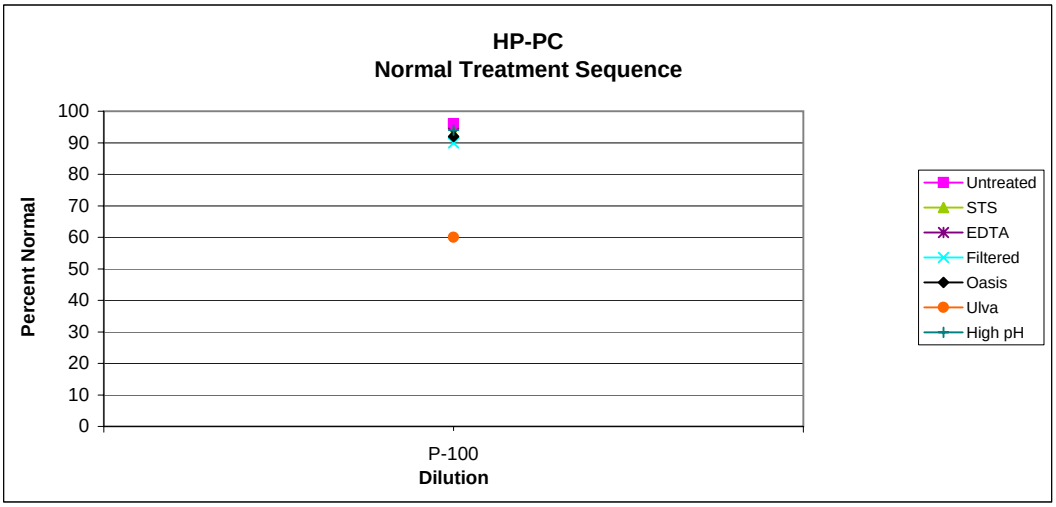

HP-5
Reverse Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Ulva 1st Ulva
Ulva Ist STS
Ulva 1st EDTA

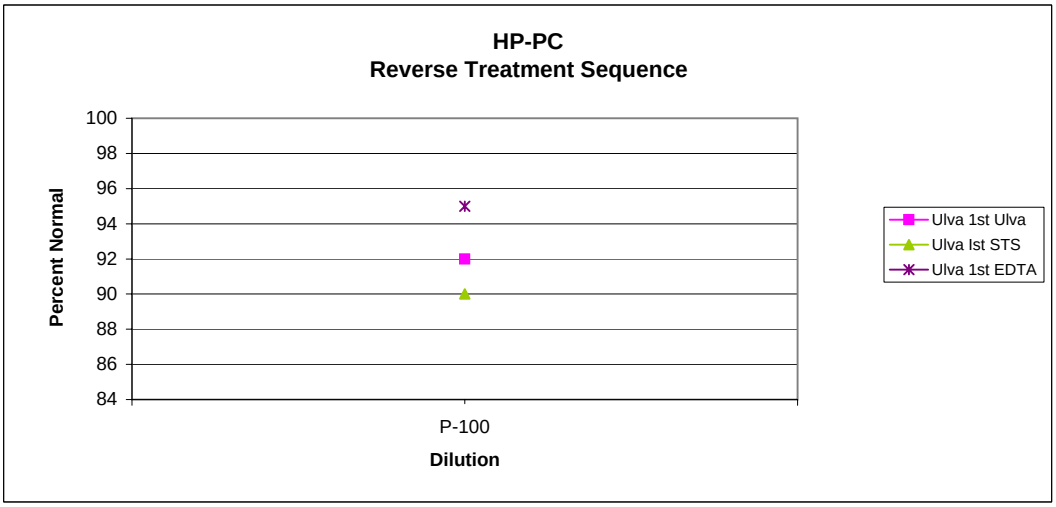

HP-9
Normal Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva
High pH


HP-9
Reverse Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Ulva 1st Ulva
Ulva Ist STS
Ulva 1st EDTA


HP-REF
Normal Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva
High pH


HP-REF
Reverse Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Ulva 1st Ulva
Ulva Ist STS
Ulva 1st EDTA


HP-PC
Normal Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva
High pH


HP-PC
Reverse Treatment Sequence
Percent Normal
100
98
96
94
92
90
88
86
84
P-100
Dilution
Ulva 1st Ulva
Ulva Ist STS
Ulva 1st EDTA

Appendix B-4. Statistical summary of *Menidia menidia* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples[1].

A. LC_{20} values.

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH
HP-1	LC_{20}	>100	>100	>100	>100	>100	>100	>100
	CL							
HP-2	LC_{20}	>100	>100	>100	>100	88.6	>100	>100
	CL					X		
HP-3	LC_{20}	X	X	X	X	X	>100	X
	CL							
HP-4	LC_{20}	60.0	>100	>100	>100	>100	>100	53.8
	CL	(88.2-140.0)						(106.7-158.5)
HP-5	LC_{20}	60.0	60.0	60.0	>100	60.0	>100	92.3
	CL	(60.0-71.4)	(71.4-73.3)	(60.0-75.0)		(60.0-68.1)		X
HP-6	LC_{20}	>100	>100	>100	>100	>100	>100	>100
	CL							
HP-7	LC_{20}	>50	X	X	X	X	>100	73.1
	CL	X						X
HP-8	LC_{20}	X	X	X	X	X	>100	X
	CL							
HP-9	LC_{20}	X	X	60.0	>100	60.0	>100	53.8
	CL			(60.0-83.1)		(72.0-116.9)		(106.7-158.5)
HP-10	LC_{20}	X	X	>100	X	X	>100	X
	CL							
REF	LC_{20}	>100	>100	>100	>100	>100	>100	>100
	CL							
Spike	LC_{20}	60.0	60.0	>100	>100	>100	>100	>100
	CL	(60.0-71.4)	(72.0-162.9)					

B. LC_{50} values

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH
HP-1	LC_{50}	>100	>100	>100	>100	>100	>100	>100
	CL							
HP-2	LC_{50}	>100	>100	>100	>100	>100	>100	>100
	CL							
HP-3	LC_{50}	X	X	X	X	X	>100	X
	CL							
HP-4	LC_{50}	75.0	>100	>100	>100	>100	>100	71.2
	CL	X						X
HP-5	LC_{50}	75.0	75.0	75.0	>100	75.0	>100	>100
	CL	(75.0-103.6)	(103.6-108.3)	(75.0-112.5)		(75.0-95.3)		
HP-6	LC_{50}	>100	>100	>100	>100	>100	>100	>100
	CL							
HP-7	LC_{50}	>50	X	X	X	X	>100	>100
	CL	X						
HP-8	LC_{50}	X	X	X	X	X	>100	X
	CL							
HP-9	LC_{50}	X	X	75.0	>100	75.0	>100	71.2
	CL			X		X		
HP-10	LC_{50}	X	X	>100	X	X	>100	X
	CL							
REF	LC_{50}	>100	>100	>100	>100	>100	>100	>100
	CL							
Spike	LC_{50}	75.0	75.0	>100	>100	>100	>100	>100
	CL	(75.0-103.6)	X					

Note:
1 - Values calculated by linear interpolation, with bootstrapped 95% Confidence Limit (CL).
2 - SPE = Single Phase Extraction.
X: Not enough data available; Toxcalc unable to calculate value.
(Norber-King,1988) using the ToxCalc version 5.0.23 (Tidepool Software).
Concentrations for spiked sample were 200 ug/L fluoranthene (nominal) and 315 ug/L copper (measured);
140 mg/L ammonia was added after the Oasis step.

Appendix B-5. Statistical summary of *Strongylocentrotus purpuratus* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples

A. LC_{20} values.

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva
HP-1	LC_{20}	<10	<10	14.3	12.1	<10	<10
	CL			(11.6-17.2)	(7.5-17.5)		
HP-2	LC_{20}	<10	<10	11.6	11.0	<10	<10
	CL			(6.9-14.6)	(7.4-14.7)		
HP-3	LC_{20}	<10	<10	<10	<10	<10	10.0
	CL						(5.8-23.9)
HP-4	LC_{20}	<10	10.6	10.6	11.3	<10	34.1
	CL		(7.3-13.3)	(9.0-12.7)	(7.9-14.2)		(0.0-79.6)
HP-5	LC_{20}	<10	11.2	<10	11.5	<10	15.8
	CL		(9.7-12.7)		(9.1-14.0)		(4.2-34.8)
HP-6	LC_{20}	<10	<10	<10	28.8	<10	<10
	CL				(22.0-36.3)		
HP-7	LC_{20}	<10	<10	<10	X	<10	<10
	CL						
HP-8	LC_{20}	<10	<10	<10	<10	<10	<10
	CL						
HP-9	LC_{20}	<10	<10	<10	<10	<10	<10
	CL						
HP-10	LC_{20}	<10	<10	<10	<10	<10	<10
	CL						
REF	LC_{20}	<10	<10	<10	19.9	<10	<10
	CL				(10.9-30.6)		
Spike	LC_{20}	<10	<10	14.0	<10	<10	15.0
	CL			(0.0-23.6)			(4.4-73.3)

B. LC_{50} values

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva
HP-1	LC_{50}	<10	15.0	23.5	22.1	12.6	>100
	CL		(3.5-20.3)	(19.5-30.1)	(19.4-25.4)	(6.2-19.1)	
HP-2	LC_{50}	<10	<10	22.2	19.0	10.4	>100
	CL			(19.8-24.7)	(16.9-21.3)	(8.8-12.4)	
HP-3	LC_{50}	<10	<10	<10	<10	<10	>100
	CL						
HP-4	LC_{50}	<10	17.5	17.9	17.2	13.9	86.6
	CL		(15.0-20.4)	(16.6-19.4)	(15.3-19.0)	(7.1-18.2)	(19.6-95.7)
HP-5	LC_{50}	10.6	16.4	<10	16.6	<10	59.3
	CL	(7.9-14.1)	(15.4-17.3)		(15.0-18.1)		X
HP-6	LC_{50}	<10	43.1	44.4	42.2	32.6	81.7
	CL		(36.3-49.9)	(36.2-53.1)	(36.7-50.7)	(16.6-43.0)	X
HP-7	LC_{50}	<10	10.2	11.2	X	10.9	24.8
	CL		(7.7-14.1)	(9.1-13.0)		(9.2-12.8)	X
HP-8	LC_{50}	<10	<10	<10	<10	<10	84.4
	CL						X
HP-9	LC_{50}	<10	13.6	11.2	13.3	11.8	70.3
	CL		(12.2-15.2)	(8.6-13.6)	(10.1-16.3)	(10.0-13.7)	X
HP-10	LC_{50}	<10	<10	<10	<10	<10	<10
	CL						
REF	LC_{50}	<10	17.3	25.8	34.2	10.0	>100
	CL		(7.8-25.4)	(14.6-28.2)	(30.9-37.6)	(8.5-19.7)	
Spike	LC_{50}	<10	<10	31.1	<10	<10	85.3
	CL			(27.4-34.1)			X

Note:
1 - Values calculated by linear interpolation, with bootstrapped 95% Confidence Limit (CL).
2 - SPE = Single Phase Extraction.
X: Not enough data available; Toxcalc unable to calculate value.
(Norber-King,1988) using the ToxCalc version 5.0.23 (Tidepool Software).
Concentrations for spiked sample were 200 ug/L fluoranthene (nominal) and 315 ug/L copper (measured);
140 mg/L ammonia was added after the Oasis step.

Appendix B-6. Statistical summary of *Dendraster excentricus* LC-20 and LC-50 LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples[1].

A. LC_{20} values.

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH	Ulva 1st	Ulva 1st, STS 2nd	Ulva 1st, EDTA
HP-1	LC_{20}										
	CL										
HP-2	LC_{20}										
	CL										
HP-3	LC_{20}										
	CL										
HP-4	LC_{20}	17.9	17.8	18.1	18.1	15.0	>100	16.7	69.8	84.8	96.2
	CL	(16.1-18.4)	(16.7-18.3)	(15.8-18.3)	(16.8-18.5)	(8.1-20.9)		(15.4-18.0)	(63.2-76.7)	(69.9-91.4)	X
HP-5	LC_{20}	<10	<10	<10	<10	<10	53.7	<10	17.8	19.4	18.3
	CL						(47.4-58.4)		(15.9-18.5)	(18.4-20.8)	(15.8-19.3)
HP-6	LC_{20}										
	CL										
HP-7	LC_{20}										
	CL										
HP-8	LC_{20}										
	CL										
HP-9	LC_{20}	<10	<10	<10	<10	<10	56.5	13.6	22.1	58.9	60.1
	CL						(52.8-59.8)	(10.1-15.9)	(10.9-37.4)	(57.0-60.6)	(57.0-61.4)
HP-10	LC_{20}										
	CL										
REF	LC_{20}	20.9	22.2	51.1	41.2	32.3	76.9	28.9	72.4	91.8	>100
	CL	(15.0-23.6)	(17.6-25.7)	(33.0-58.6)	(29.5-64.0)	(19.2-59.5)	(69.7-88.3)	(14.4-50.5)	(58.1-83.9)	X	
Spike	LC_{20}										
	CL										

B. LC_{50} values

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH	Ulva 1st	Ulva 1st, STS 2nd	Ulva 1st, EDTA
HP-1	LC_{50}										
	CL										
HP-2	LC_{50}										
	CL										
HP-3	LC_{50}										
	CL										
HP-4	LC_{50}	30.2	29.9	30.2	30.2	28.1	>100	29.2	>100	>100	>100
	CL	(29.1-30.6)	(29.2-30.2)	(28.6-30.9)	(29.3-31.3)	(23.8-31.8)		(28.4-30.0)			
HP-5	LC_{50}	<10	<10	18.4	22.0	<10	71.0	<10	30.0	33.6	31.1
	CL			(11.4-24.2)	(19.6-24.1)		(67.1-74.0)		(28.7-30.7)	(31.2-36.9)	(28.7-33.1)
HP-6	LC_{50}										
	CL										
HP-7	LC_{50}										
	CL										
HP-8	LC_{50}										
	CL										
HP-9	LC_{50}	<10	<10	<10	16.1	<10	72.8	27.3	55.0	74.9	76.2
	CL				(11.8-19.8)		(70.5-74.9)	(25.0-28.7)	(30.7-71.7)	(73.7-76.0)	(74.1-77.5)
HP-10	LC_{50}										
	CL										
REF	LC_{50}	38.9	40.8	69.5	66.5	61.2	>100	62.2	>100	>100	>100
	CL	(33.0-43.5)	(30.7-49.5)	(64.0-74.1)	(60.8-74.1)	(41.7-75.3)		(41.7-72.0)			
Spike	LC_{50}										
	CL										

Note:
1 - Values calculated by linear interpolation, with bootstrapped 95% Confidence Limit (CL).
2 - SPE = Single Phase Extraction.
X: Not enough data available; Toxcalc unable to calculate value.
(Norber-King,1988) using the ToxCalc version 5.0.23 (Tidepool Software).
Concentrations for spiked sample were 200 ug/L fluoranthene (nominal) and 315 ug/L copper (measured);
140 mg/L ammonia was added after the Oasis step.

Appendix B-7. Interpretive summary of *Menidia menidia* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples.

A. LC_{20} values.

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH
HP-1	*	*	*	*	*	*	*
HP-2	*	*	*	*	*	*	*
HP-3						*	
HP-4	+	v *	*	*	*	*	^ +
HP-5	+	+	+	v *	^ +	v *	*
HP-6	*	*	*	*	*	*	*
HP-7	*					*	^ +
HP-8						*	
HP-9			+	v *	^ +	v *	^ +
HP-10			*			*	
REF	*	*	*	*	*	*	*
Spike	+	+	v *	*	*	*	*

B. LC-50 values

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH
HP-1	*	*	*	*	*	*	*
HP-2	*	*	*	*	*	*	*
HP-3						*	
HP-4	+	v *	*	*	*	*	^ +
HP-5	+	+	+	v *	^ +	v *	*
HP-6	*	*	*	*	*	*	*
HP-7	*					*	*
HP-8						*	
HP-9			+	v *	^ +	v *	^ +
HP-10			*			*	
REF	*	*	*	*	*	*	*
Spike	+	+	v *	*	*	*	*

Toxicity Codes:
If LC20>80 then "*" (not toxic); if 40 < LC20 < 80 then "+" (slightly toxic);
if 10 < LC20 < 40 then "++" (moderately toxic); if LC20 < 10 then "+++" (highly toxic).
Change in Toxicity:
If toxicity (no. of "+"s) reduces or increases by one category, then "v" or "^", respectively.
If toxicity (no. of "+"s) reduces or increases by > one category, then "vv" or "^^", respectively.
2 - SPE = Solid Phase Extraction.

Appendix B-8. Interpretive summary of *Strongylocentrotus purpuratus* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples.

A. LC_{20} values.

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva
HP-1	+++	+++	v ++	++	^ +++	+++
HP-2	+++	+++	v ++	++	^ +++	+++
HP-3	+++	+++	+++	+++	+++	v ++
HP-4	+++	v ++	++	++	^ +++	v ++
HP-5	+++	v ++	^ +++	v ++	^ +++	v ++
HP-6	+++	+++	+++	v ++	^ +++	+++
HP-7	+++	+++	+++		+++	+++
HP-8	+++	+++	+++	+++	+++	+++
HP-9	+++	+++	+++	+++	+++	+++
HP-10	+++	+++	+++	+++	+++	+++
REF	+++	+++	+++	v ++	^ +++	+++
Spike	+++	+++	v ++	^ +++	+++	v ++

B. LC_{50} values

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva
HP-1	+++	v ++	++	++	++	vv *
HP-2	+++	+++	v ++	++	++	vv *
HP-3	+++	+++	+++	+++	+++	vv *
HP-4	+++	v ++	++	++	++	vv *
HP-5	++	++	^ +++	v ++	^ +++	vv +
HP-6	+++	vv +	+	+	^ ++	vv *
HP-7	+++	v ++	++		++	++
HP-8	+++	+++	+++	+++	+++	vv *
HP-9	+++	v ++	++	++	++	v +
HP-10	+++	+++	+++	+++	+++	+++
REF	+++	v ++	++	++	++	vv *
Spike	+++	+++	v ++	^ +++	+++	vv *

Toxicity Codes:

If LC20>80 then "*" (not toxic); if 40 < LC20 < 80 then "+" (slightly toxic);

if 10 < LC20 < 40 then "++" (moderately toxic); if LC20 < 10 then "+++" (highly toxic).

Change in Toxicity:

If toxicity (no. of "+"s) reduces or increases by one category, then "v" or "^", respectively.

If toxicity (no. of "+"s) reduces or increases by > one category, then "vv" or "^^", respectively.

2 - SPE = Solid Phase Extraction.

Appendix B-9. Interpretive summary of *Dendraster excentricus* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples.

A. LC_{20} values.

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH	Ulva 1st	Ulva 1st, STS 2nd	Ulva 1st, EDTA
HP-1										
HP-2										
HP-3										
HP-4	++	++	++	++	++	vv *	^ ++	v +	v *	*
HP-5	+++	+++	+++	+++	+++	vv +	^^ +++	v ++	++	++
HP-6										
HP-7										
HP-8										
HP-9	+++	+++	+++	+++	+++	vv +	^ ++	++	v +	+
HP-10										
REF	++	++	v +	+	^ ++	v +	^ ++	v +	v *	*
Spike										

B. LC_{50} values

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH	Ulva 1st	Ulva 1st, STS 2nd	Ulva 1st, EDTA
HP-1										
HP-2										
HP-3										
HP-4	++	++	++	++	++	vv *	*	*	*	*
HP-5	+++	+++	v ++	++	^ +++	vv +	^^ +++	v ++	++	++
HP-6										
HP-7										
HP-8										
HP-9	+++	+++	+++	v ++	^ +++	vv +	^ ++	v +	+	+
HP-10										
REF	++	v +	+	+	+	v *	^ +	v *	*	*
Spike										

Toxicity Codes:
If LC20>80 then "*" (not toxic); if 40 < LC20 < 80 then "+" (slightly toxic);
if 10 < LC20 < 40 then "++" (moderately toxic); if LC20 < 10 then "+++" (highly toxic).
Change in Toxicity:
If toxicity (no. of "+"s) reduces or increases by one category, then "v" or "^", respectively.
If toxicity (no. of "+"s) reduces or increases by > one category, then "vv" or "^^", respectively.
2 - SPE = Solid Phase Extraction.

Appendix B-10. Dissolved oxygen in TIE samples below critical concentrations measured during TIE toxicity tests conducted for the Hunter's Point TIE investigation[1].

			Dissolved Oxygen (mg/L) in TIE Treatment						
Test species	SAIC TIE Sample ID	Dilution	Untreated	Filtered	Oasis	STS	EDTA	Ulva	High Ph
M. menidia	HP-2	50			0.9				
		100			1.6				
	HP-3	25					1.0		
		50	0.9						1.0
		100		0.7	1.2				0.6
	HP-4	10							1.3
		25							1.0
		50							1.0
		100			2.0				0.9
	HP-5	100							2.8
	HP-6	100						2.9	
	HP-8	100				0.7	0.7		1.4
	HP-9	25							2.0
		50							2.7
		100		0.8					1.1
	HP-10	50		0.6	2.3		3.1		
		100						1.8	
	HP-REF	100			3.1				
S. purpuratus	HP-2	50			0.9				
	HP-3	50	0.9						
		100		0.7					0.6
	HP-4	100							0.9
	HP-8	100				0.7	0.7		
	HP-9	100		0.8					
	HP-10	50		0.6					

1 - Critical concentration of 3.5 mg/L used for *M. menidia* (U.S. EPA, 2000); 1.0 mg/L used for *S. purpuratus* and *D. excentricus* .

Appendix C.
Hunters Point TIE Demonstration Work Plan

WORK PLAN FOR:

CONDUCT OF NAVY SEDIMENT TOXICITY IDENTIFICATION EVALUATION DEMONSTRATION:

HUNTERS POINT SHIPYARD
Parcel F

SUBMITTED TO:

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING SERVICE CENTER
NCBC CODE 27162 BUILDING 41
1000 23RD Avenue
Port Hueneme, CA 93043-4410

SUBMITTED BY:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
221 THIRD STREET
NEWPORT, RI 02840

IN RESPONSE TO:

NAVY BAA N47408-97-D-0410

14 February 2001

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1.0 INTRODUCTION

The Hunters Point Shipyard, Parcel F, was chosen as the second of two sites to be evaluated as part of the Sediment Toxicity Identification Evaluation (TIE) Demonstration project for the Naval Facilities Engineering Service Center. The Technical Proposal for the Demonstration Project was submitted and approved in March 2000. The other site selected for the demonstration is the Naval Surface Warfare Center at Indian Head, a freshwater site in Maryland. Hunters Point was chosen as a Demonstration site because it conforms with the principal site-selection criteria developed for the project designed to resolve ecological risk concerns:

1. An identified need exists for information that may clarify the source of apparent toxicity. One objective of the on-going Feasibility Study (FS) for the site is to determine the chemical characteristics that will guide remedial decisions to treat, depose or investigate reuse options for the contaminated sediments. Thus, results from the TIE should help to resolve regulatory uncertainties and site management decisions.
2. The site presents a unique case study in relation to environmental and contaminant characteristics at the other chosen site. Hunters Point is a saltwater site incorporating numerous habitat types and sources of Contaminants of Potential Concern (CoPCs). Thus, the TIE program should demonstrate applicability in diverse habitat conditions, and serve to address uncertainties with regard to the principal toxic agents that may be found across a wide variety of navy sites.

Existing data supported the need for a Validation Study antecedent to a Feasibility Study (FS) of remedial options (Battelle et al., 1999; Battelle et al., 2000). The Southwest Division (SWDIV) Naval Facilities Engineering Command (NAVFAC) is performing the Validation Study for offshore sediments (Parcel F) at the Hunters Point Shipyard (HPS) in San Francisco Bay to clearly identify areas that require consideration in the FS of remedial alternatives for Parcel F sediments. The Validation Study will focus on areas that have been characterized as the "Low-Volume Footprint", as identified in the Parcel F Feasibility Study Draft Report, Hunters Point Shipyard, San Francisco, California (Tetra Tech EMI and LFR, 1998). The CoPC list includes metals, PAHs, PCB-aroclors, PCB-congeners, pesticides and Total Petroleum Hydrocarbon (TPH). The proposed Phase 1 TIE study will provide data to evaluate degrees of risk associated with CoPCs at the site. It will also characterize the extent to which confounding factors (e.g., ammonia, sulfides) are potentially involved in observed toxicity.

Specific objectives for the Hunters Point TIE are to evaluate:

- The utility of the TIE findings in providing clarification/enhanced certainty with respect to causes of site-related risks;
- Potential cost/benefits resulting from performance of the TIE demonstration; and
- Regulatory acceptance of TIE methodology as a legitimate ERA tool.

A site description and history, as well as a review of the findings from previous studies has been provided in the Hunters Point Shipyard Parcel F Validation Study Work Plan (Battelle et al., 2000a). An advantage in the choice of Hunters Point as a site for the TIE demonstration is that field surveys and toxicity-testing activities will be supported through the Validation Study for the site. The NORTHDIV TIE demonstration to be conducted by SAIC reflects the shared interest of all parties involved to efficiently coordinate a plan that is mutually beneficial. SAIC, Navy and contract personnel involved in the Validation Study are committed to the collaborative effort.

Details regarding the field sampling plan for surface sediment collection as well as additional sampling and data collection associated with the Validation Study (Battelle et al., 2000a) have been reviewed in order to develop a TIE plan that is highly collaborative.

The Program Team involved in addressing remediation at the site includes the primary technical team (SAIC), the Navy Northern Division (NORTHDIV) oversight/liaison team, the Installation Restoration support team (SWDIV IR staff and contractors), and Regulatory Team (Hunters Point Base Closure Team). The Program Team is committed to a close collaboration with the TIE effort to assure successful and efficient study designs and sampling efforts.

2.0 SAMPLING DESIGN FOR THE HUNTERS POINT SHIPYARD SITE

2.1. STRATEGY FOR EVALUATING POTENTIAL TOXICITY OF CONTAMINATED SEDIMENTS

The objectives of the proposed Phase 1 TIE study are to provide data to identify sources and magnitude of toxicity associated with CoPCs at the site. It will also characterize the extent to which confounding factors (e.g., ammonia, sulfides) are potentially involved in the toxic response. The sampling design derived to meet these objectives is discussed in this section and; the technical approaches for field and laboratory analysis procedures are discussed in Section 3.

The choice of sediment sampling locations within Hunters Point Shipyard emphasizes sites with measured CoPCs that exceed NOAA ERM benchmark concentrations. Hazard Quotients (HQs) calculated as the ratio of Sediment Concentrations/ERM, indicate that cationic metals, tributyl tin (TBT) and PCBs apparently represent the greatest risks to aquatic receptors (Battelle et al., 2000b; Poucher and Tracey, 2000). For purposes of the TIE Demonstration, the stations were selected according to the following criteria:

- Bulk sediment concentrations exceed benchmarks for potential/probable effects;
- Mediating factors (e.g., TOC, AVS) that may affect chemical bioavailability;
- Confounding factors (e.g., NH_4) that directly contribute to toxicity;
- Contaminants other than cationic metal CoPCs (e.g., TBT, PCBs, PAHs) may

contribute to toxicity, based on benchmark Hazard Quotients (HQs);

- Spatial distribution that reflects unique contaminant sources and different environmental conditions or CoPC distributions that represent gradients in chemical availability.

The concentration of Acid Volatile Sulfides (AVS) relative to total metal and the amount of dissolved and particulate organic carbon may all mediate the availability of CoPCs. Ammonia and sulfides as well as uptake mechanisms and enzymatic processing within organisms may also influence toxicity. Though progress has been made in sediment toxicology, many of the drivers of toxicity remain unresolved. TIE testing serves to deduce which classes of contaminants and sediment quality characteristics govern sediment toxicity on a site-specific basis.

Simultaneously Extracted Metal (SEM) concentration. Research into the bioavailability and toxicity of metals has found that for some metals, sulfides (measured as Acid Volatile Sulfides, AVS) in sediments can act as an important binding compound that can prevent toxicity as long as the quantity of AVS is in excess of the total amount of metals (measured as SEM). Sulfides are a common constituent of organic-rich sediments that do not have prolonged exposure to oxygen in the water column (e.g., hypoxic).

Confounding factors affecting bioavailability and toxicity. In the historical and recent surveys conducted at Hunters Point, sediment constituents were measured to varying degrees, resulting in uncertainty with regard to the potential for toxicity of CoPCs versus confounding factors. A limited number of samples were analyzed for organic carbon, and ammonia. SEM/AVS and sulfide concentrations have not been measured. Still, the available data indicate that locations generally characterized by lower organic carbon and or alternatively, high ammonia, have the greatest potential for toxicity. In the present study, stations with varying TOC, SEM/AVS, ammonia and/or sulfides will provide data to address site-specific effects on potential COPC toxicity.

Information concerning ammonia toxicity to echinoderms in embryo-larval tests (U.S EPA, 1993; Greenstein, Alzadjali and Bay, 1995) indicates that this group is much more sensitive than other taxa (U.S. EPA, 1988). In tests with *Strongylocentrotus purpuratus* embryos, the LC50 in expressed as total ammonia ranged from 7.2 mg/L at pH 7.7 to 1.4 mg/L at pH 8.4 (Greenstein, Alzadjali and Bay, 1995). Available ammonia data corresponding to observed bulk sediment toxicity of the Hunters Point site sediments ranged from 12 to 100 mg/L in the sediment pore waters. This indicates that ammonia was a probable source of toxicity observed in tests with *S. purpuratus*, however ammonia-only tests should be conducted with this species using ambient water. This would provide results that could be used to derive site specific ammonia HQs.

Spatial distributions. Another important consideration in selecting stations for the TIE Demonstration at Hunters Point Shipyard is the relatively broad area of concern. The TIE stations selected are from four distinct areas within the study area: (1) Point Avisadero; (2) Eastern Wetlands; (3) Oil Reclamation Area; and (4) South Basin (see Appendix A).

Samples for the TIE were chosen to reflect the potential for multiple sources of contamination. Also, the vertical distribution of contaminants at Hunters Point is an important consideration. The depth profile of contaminants must be considered in terms of associated gradients in toxicity and the potential for aquatic organism exposures. The choice of stations for TIE evaluation of subsurface sediment was based on criteria that reflect an emphasis on depositional areas where core sampling is planned, with radioisotopic and/or hazardous waste characterizations. Availability of data from independent chemical characterizations of the stations (other than the FS study) was also considered in narrowing the selection to three subsurface stations (Battelle, 2001).

2.2. RATIONALE FOR SELECTION OF SPECIFIC STATIONS

Table 2-1 describes each of 12 proposed locations in terms of the characteristics that led to its selection, with particular emphasis on factors that may influence toxicity associated with elevated heavy metals. Three additional samples will be taken to determine the depth distribution of contaminants and associated toxicity. They will be collected from the 5-10 cm strata as secondary collections following surface sampling (0-5 cm) at the same station. The stations have been chosen not only to maximize opportunities to observe and characterize potential toxicity from COPC and confounding factors, but also to provide a representation of the varying contaminant signatures and sediment characteristics that occur across the Low-Volume Footprint areas.

The stations for the TIE were selected from the following areas:
Point Avisadero (PA); Stations 38-41, plus 5-10 cm samples at Station 40 and 41
Eastern Wetlands (EW); Station 33
Oil Reclamation Area (OR); Station 24
South Basin (SB); Stations 18-23, plus 5-10 cm samples at Station 20

In the PA area, four stations were chosen to represent the sites where Cu, Zn and Pb all exceeded ERL values. Pore water Cu was also measured at levels that exceeded acute WQC Stations PA 40 and PA 41 were selected for TIE testing on pore waters from subsurface sediments because of the known elevations in CoPCs, as well as expected differences in sediment characteristics with depth (Battelle, 2001)

One station was selected in both the EW and OR areas, mostly in order to represent the potential differences in toxic signatures at the two sites. The EW station represents a single hot spot in the area with four target CoPCs exceeding ERM levels. The OR station has been characterized with Cu, Zn and PB above ERL values.

In the South Basin Area six stations on the eastern bank were selected for the TIE to represent toxic sediment with a mixture of contaminants that exceed ERL values but with consistent ERM exceedences for Zn. The third subsurface sample will be taken from SB 20, because of its proximity to a landfill (Battelle, 2001). The locations of each station are presented in Appendix B.

3.0 TECHNICAL APPROACH

The following sections describe the rationale and methods for TIE testing, chemical analysis of pore waters and data interpretation. Field sampling will be conducted in conjunction with the SWDIV-NAVFAC Hunters Point 'Low Volume Footprint' Validation Study. Sediment samples, prepared as splits of the collected and homogenized bulk sediments, will be provided to SAIC by SWDIV-NAVFAC's contractor (Battelle) for the TIE study. Toxicity characterization, including the bulk sediment tests that normally precede sediment TIE testing, will also be conducted by SWDIV's contractor (see below). As an integral part of the Validation Study, the sediments will also be analyzed for priority contaminants, including all CoPCs. The resulting data, as well as other measurements that are critical in the evaluation of sediment characteristics associated with toxicity, including total organic carbon (TOC), grain size and percent moisture, will be provided to SAIC (Battelle et al., 2000a; Battelle et al. 2001). SAIC will be responsible for the laboratory analyses of porewater metals, as well as TOC, DOC, ammonia, sulfides and standard water quality parameters measured during biological testing (i.e. salinity, pH, D.O.). If SEM and AVS are not measured in sediment samples as part of the Validation Study SAIC will be responsible for these analyses for samples from TIE stations. The technical approach proposed for toxicity and chemical characterizations associated with the TIEs to be conducted on sediment pore waters are described below.

3.1. FIELD SAMPLING

3.1.1. TOXICITY CHARACTERIZATION

TIE sample selection/porewater extraction. Upon completion of toxicity tests conducted for the Validation Study, ten sediment samples will be selected for the porewater TIE. The following information will be reviewed prior to selection of samples for TIE analyses:

- Results from preliminary pore water analyses (salinity, pH, ammonia and sulfides; see below).
- Toxicity test results, including the following, as available;
    - Bulk sediment survival of *Eohaustorius estuaries*
    - SWI echinoderm larval development
    - SPP echinoderm larval development

These data will be used to assure that the pore water TIE is conducted on toxic samples; as non-toxic or marginally toxic samples are unlikely to produce meaningful TIE results. In conjunction with the demonstration of toxicity, the selection will also be based on original study objectives, to characterize the factors that drive observed toxicity. Representation of spatial variability (including vertical profiling) is also a priority.

Pore water screening tests will be conducted on samples from the ten stations chosen for the TIE. For the screening test, 60 ml of pore water will be extracted from homogenized sediments using the syringe extraction method (Winger and Lassier, 1991). This method

will serve as an efficient means to collect the small volume required for the screening test, with minimal disruption of the sediments. The echinoderm larval development test will be performed on 100% pore water, with three replicates per sample. Results from this test will be used to determine the number of dilutions to be used in the TIE for each sample. If the screening test results in ≥ 50% reduction in normal development relative to the control response, a four dilution series (10%, 25%, 50% and 100%) TIE will be conducted. If less than a 50% effect is observed, only the 50% and 100% pore water samples will be tested in the TIE manipulation series. The TIE series will only be performed on samples that are statistically difference from the controls (one tailed T test) in the screening test.

Approximately two liters of pore waters for the TIE will be extracted by centrifugation at 5200 revolutions per minute (RPM). Centrifugation is an efficient method that allows the collection of sufficient pore water in a shorter time frame than would be required using the syringe method (which can require up to three days, depending on the number of syringes applied to each sediment). Water for control exposures and dilution water will be clean saltwater, filtered to 10*u*, in all TIE tests. Also, reference treatments for TIE tests will consist of pore water extracted from the Paradise Cove reference sediment.

TIE procedures. In a TIE investigation, the physical/chemical properties of sediment pore water samples are manipulated in order to alter or render biologically unavailable generic classes of chemicals (U.S. EPA 1991). Because sediments posing potential risks are usually toxic to aquatic organisms, fractions exhibiting toxicity reveal the nature of the toxicant(s). Depending upon the responses, the toxicant(s) can be tentatively categorized as having chemical characteristics of non-polar organics, cationic metals or confounding factors such as ammonia (U.S. EPA 1996).

Procedures for conducting specific TIE steps developed by EPA (1996) describing specific methodologies and QA/QC procedures form the basis for the proposed technical approach. SAIC has improved on the EPA approach by applying sequential testing of fractions and documentation of cumulative removal up to and including the production of completely non-toxic samples (Figure 3.1). Using the sequential approach, absence of residual toxicity provides a clearer demonstration that all the relevant chemical exposures in a sample can be adequately accounted for. SAIC's approach has been successfully demonstrated at the Naval Submarine Base-New London, CT at an IR site (Goss Cove) for Northern Division (Navy RPM News 1999; SAIC 1999). Prior remedial investigation and risk assessment studies for the site have suggested actionable risk although considerable uncertainty existed as to the contaminants responsible for risk. The application of the improved TIE process revealed that ammonia (a ubiquitous non-CoPC sediment constituent) and not the conventional sediment contaminants (e.g., PAHs, metals) was responsible for the risk.

The proposed Phase I TIE characterization will consist of the following recommended characterization steps or tiers: (1) Baseline Toxicity Test; (1a) Filtration; (2) C_{18} column extraction; (3) sodium thiosulfate; (4) Ethylenediamine Tetraacetic Acid (EDTA); and (5)

zeolite. In addition, low/high pH adjustments of the EDTA treated sample are also performed in parallel with the zeolite treatment. Guidelines for TIE data interpretation are presented in U.S. EPA (1991) and are summarized below:

1. **Baseline Toxicity Test**: Toxicity in exposures to whole pore water indicates the presence of bioavailable chemicals or other confounding factors (e.g., ammonia). Good survival in these exposures indicates that toxicity observed in the solid phase test is due to a factor(s) that is solely associated with the particle phase of the sediments. Toxicity due to extremes of sediment grain size (e.g., extremely coarse or fine) is an example of this type of effect.

1a. **Filtration.** Prior to C_{18} extraction, the pore water will be filtered with 0.45µm filter paper to remove particulates that would otherwise consume sites on the extraction column. In addition, toxicity tests conducted on the pre- and post-filtered fraction will allow for expression of any potential toxicity associated with large colloids or particulates trapped on the filter. The filters will be retained in order that chemical analysis may be conducted to quantify potential CoPC losses in this step.

2. **C_{18} column extraction**: Pore water samples will be subjected to C_{18} extraction to remove organic compounds and metals that are relatively non-polar (U.S. EPA 1991). A non-toxic response in these exposures will indicate the potential role of organic compounds as the sole contributor to toxicity of pore waters. A fully toxic response will indicate that organic compounds are not responsible for observed pore water toxicity. A partial reduction in toxicity would define a joint toxic action by organic compounds and other factors.

3. **Sodium thiosulfate**: Sodium thiosulfate ($Na_2S_2O_3$) will be used to reduce oxidants such as chlorine, ozone, chlorine dioxide, mono and dichloramines, bromine, iodine, manganous ions, and some electrophilic organic chemicals and to remove cationic metals including Cd^{2+}, Cu^{2+}, Ag^{1+}, and Hg^{2+} in the pore water samples (U.S. EPA 1991). Reduced toxicity or a non-toxic response will indicate oxidants or cationic metals as contributors to toxicity.

4. **EDTA chelation**: Samples will be subjected to EDTA chelation to remove divalent cationic metals (i.e., Al^{2+}, Ba^{2+}, Fe^{2+}, Mn^{2+}, Sr^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+}, Co^{2+}, and Zn^{2+}) (Schubauer-Berigan et al. 1993a; U.S. EPA 1991). A non-toxic response or a partial reduction in toxicity indicates metals as a toxic component of the pore water. A fully or partially toxic response indicates that something other than divalent cationic metallic compounds is a contributor to sediment toxicity.

5. **Zeolite treatment**: Samples will be manipulated using a zeolite cation exchange resin to remove ammonia (Ankley et al. 1990; Besser et al. 1998; Jop et al. 1991; Van Sprang and Janssen 1997). A non-toxic sample will indicate the presence of ammonia as contributing to pore water toxicity in the precursor sample. A partial toxic response is not expected since organics, metals, oxidants, hydrogen sulfide, pH-

dependent toxicants, and ammonia will have been sequentially removed from the samples.

Graduated pH: In this procedure, sample pH is manipulated to determine if pH dependent toxicants such as speciated metals, ammonia, hydrogen sulfide, cyanide and some ionizable organic compounds (e.g., pentachlorphenol) are responsible for observed toxicity (Schubauer-Berigan et al. 1993a; Schubauer-Berigan et al. 1993b; U.S. EPA, 1993). For instance, if sample toxicity increases with increasing pH, toxicants such as ammonia are suspected. Conversely, if sample toxicity increases with decreasing sample pH, toxicants such as hydrogen sulfide are suspected. Typical pH adjustments include 1.0 pH units above and below ambient pH (e.g., pH 7 and pH 9 for ambient pH 8).

The pore water will be manipulated according to the sequential extraction scheme shown in Figure 3-1. They will be tested with species that are appropriate for the site and are also amenable to TIE testing protocols. In addition to the extracted water from ten site and one reference sediment, water from a performance control (i.e., clean seawater) will be evaluated. Also, a clean seawater sample spiked to produce toxic concentrations of a metal CoPC (e.g. copper), an organic contaminant (e.g. a PCB-aroclor mixture) and ammonia will be included as a positive control. The seawater control will be run in parallel to each manipulation. Thus, 104 toxicity tests (13 samples x 8 treatments) will be performed with two species.

Biological Tests tc "2.4.3. Toxicity Characterization " \l 3 . To assure relevance of the SAIC TIE Program in characterizing the sources of toxicity to aquatic receptors of concern in the Hunter's Point Validation Study, the echinoderm larval development test will be one of the two tests performed. SAIC's analysis of the test results will involve determining the percent normal development of test organisms relative to stocking density, and subsequently, derivation of concentration of pore water that produces a 50% reduction in survival (LC-50) in the untreated and manipulated samples. Other endpoints (e.g., LC-20) may also be derived using the ToxCalc statistical software package (Tidepool Scientific Software, 2000). The source of parent stock for the echinoderm test will be the same as that used in the other planned Validation Study tests.

A second species will also be tested in the pore water TIE series, as differential sensitivity to the classes of contaminants under study can be used to deduce the causes of observed toxicity. For the Hunters Point study, the inland silverside (*Menidia berylinna* embryo-hatch test will be employed because it is allows representation of a vertebrate receptor to compliment the echinoderm, and because susceptibility to many contaminants is particularly well-characterized for this species. Test procedures will generally follow the reduced-volume methodology developed by the EPA for TIEs (EPA/600/R-96-054, 1996).

Test conditions for the echinoderm larval development test and *M. beryllina* are presented in Table 3-1.

3.2. CHEMICAL ANALYSES

Laboratory analysis of metal and organic contaminants in bulk sediments will conform with NOAA's Recommended Target analytes (NOAA 1998), and will be conducted by Battelle for the FS Study. Sediment chemistry analyses will be performed using the methods developed by NOAA for use in the NOAA Status and Trends (NS&T) program because the methods are especially sensitive and appropriate for measurement of trace metal and organic contaminants in marine and estuarine sediment (NOAA, 1998). Battelle's sediment evaluations will also include measurements TOC, moisture content and grain size distributions for each sample. Battelle will also supply other results from sediment and initial pore water analyses, including salinity, pH, ammonia and sulfides, and QA/QC erratum for all analyses, upon availability (Battelle et al., 2000). If SEM and AVS are not measured for the VS, then SAIC will assure that these measurements are made on the TIE sediments. The analytical procedure for SEM/AVS involves an acid digestion and a cold-acid purge and trap technique. AVS is analyzed by titration. The SEM concentration reported is the sum of cadmium, copper, lead, nickel and zinc.

The eleven sediment pore waters plus the spiked seawater sample used in the TIE study will be split for toxicity analysis and laboratory analyses of metals. Like the sediment analysis, pore waters will be measured in accordance with NS&T protocols (NOAA, 1998). Specifically, a radio-frequency inductively coupled plasma (ICP) method will be applied following mineral acid digestion. In order to assess the bioavailability of potential toxicants, DOC (EPA Method 415.1)and TOC (EPA Method 415.1) in the pore waters will also be measured. These measurements, in addition to results from ammonia and sulfide analyses will be provide by SAIC to Battelle upon availability. Table 3-2 summarizes the analytical methods and Minimum Detection Limits (MDLs) that will be applied to the pore water samples.

3.3. DATA ANALYSIS AND REPORTING

For TIE results, survival of each species in each dilution series will be used to generate LC-20 and LC-50 values. These values will be calculated by linear interpolation, and confidence intervals were generated by the bootstrapping technique. ToxCalc software [version 4.0.8] from Tide Pool Scientific Software, 2000) will be used to generate test statistics. To perform hypothesis testing for statistical differences from controls (α = 0.05), results from each dilution will be evaluated by ANOVA followed by Dunnett's test. A test for normality of the distribution of the data (Shapiro-Wilkes test) will also be conducted because Dunnett's test results are most valid with normally distributed data. A report documenting data results and conclusions produced from the TIE investigation will be produced. From this report, SAIC will be prepared to present the results of the site investigation to the Program Team.

4.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

SAIC will be responsible for the overall technical and fiscal management of the TIE Demonstration project including the laboratory analyses activities described below. NFESC personnel will be responsible for the contract management, supportive technical oversight and coordination among federal and state regulatory agencies, if needed. NORTHDIV personnel will be responsible for additional technical oversight and project management dealing with on-site activities and coordination between SAIC, NFESC, and Navy site representatives.

Key Navy personnel for this project are:
Ruth Owens, NFESC Technical Point of Contact (POC)
Jason Speicher, NORTHDIV Technical Point of Contact (POC)
Dave Barclift, NORTHDIV Technical Point of Contact (POC)
Michael Pound, Deputy Chief Environmental Engineer for Restoration (SWDIV)

Key SWDIV contractor (Battelle) POC for coordination of this project is:
Jeff Ward, Senior Research Scientist

Key SAIC personnel supporting the project include:
Gregory Tracey, Program Manager
Sherry Poucher, Lead for Toxicological Analyses
Cornelia Mueller, Quality Assurance Officer

5.0 DELIVERABLE PRODUCTS AND SCHEDULE

A summary of Deliverable Products (DP) and schedule are summarized below. All deliverable products are considered accepted upon delivery. SAIC will prepare all reports and products in a SAIC-specified format. All scheduled delivery dates are contingent on the VS schedule, and therefore, the dates presented below should be considered as estimates.

5.1. LABORATORY ANALYSIS

SAIC will conduct laboratory analyses according to the site-specific work plan. Laboratory analyses as documented in monthly progress reports will be completed approximately 4 weeks after receipt of field sampling and toxicity test results

- Deliverable Product: TIE test results and data report:
  Estimated Due Date: 7/25/01
- Schedule required to meet Estimated Due Date:
  Sediment sampling: Completion by 5/25/01
  Toxicity reports: Delivery to SAIC by 6/27/01

5.2. SITE REPORT PREPARATION

SAIC will prepare a draft and final TIE site report (50-100 pp text). Electronic copies of the report will be sent to all Navy personnel and Navy Contractors involved with THE project, as designated by the SWDIV POC. Up to ten hard copies of the draft and final report, including all appendices, photographs, and graphics will also be distributed. One electronic copy of the final report will be submitted on CD-ROM. Tables will be provided in EXCEL.

- Deliverable Product: Draft Site 2 TIE Report.
  Estimated Due date: 8/27/01.
  Receive review comments: 4 weeks after submission of Draft.
- Deliverable Product: Final Site 2 TIE Report, incorporating comments on Draft.
  Estimated Due date: 10/29/014 (4 weeks after receipt of all comments on Draft).

6.0 TECHNICAL ASSUMPTIONS

6.1. ASSUMPTIONS REGARDING FIELD AND LABORATORY ACTIVITIES

- Field operations at Hunters Point Shipyard will be coordinated and conducted by Battelle for both the SWDIV Validation Study and the NORTHDIV TIE Demonstration project. Sediment samples will be delivered to SAIC following a schedule that complies with sediment holding times, allowing time for pore water extraction and completion of the TIE (i.e., no more than one month from the sample date).
- Battelle will supply data from all laboratory testing, including toxicity tests and chemical analyses, as they become available (i.e. within one week of completion)
- SAIC will subcontract all necessary chemical and toxicity analyses in accordance with the TIE work plan.
- All laboratory porewater metal analyses conducted for SAIC will be performed in accordance with NOAA NS&T (1998) protocols. Laboratory data reports will be included in the TIE report and contain detail sufficient for EPA Reduced Level III data validation.

6.2. ASSUMPTIONS REGARDING DELIVERABLE REPORTS

- Draft and Final Reports will be sent to 1) the facility environmental representative, 2) the Navy's IR RPM for the facility, 3) the NFESC POC, 4) the NORTHDIV POC, and 5) to regulators and trustees as designated by the SWDIV POC. Ten copies of the report are assumed for each deliverable.
- In addition to the hard copy distribution of the final report, a copy of the final report will be provided in PDF format to the Navy IR RPM and NFESC POC.

- The SAIC PM (and supporting personnel as deemed necessary by SAIC) will attend one technical meeting coupled with a Restoration Advisory Board (RAB) meeting to present the results of each investigation and SAIC's recommendations.

7.0 QUALITY ASSURANCE

The letter of transmittal for the report submission will include a certification that it has been subjected to SAIC's own review and coordination procedures to ensure: (a) completeness for each discipline commensurate with the level of effort required for that submission, (b) elimination of conflicts, errors, and omissions, and (c) the overall professional and technical accuracy of the submission.

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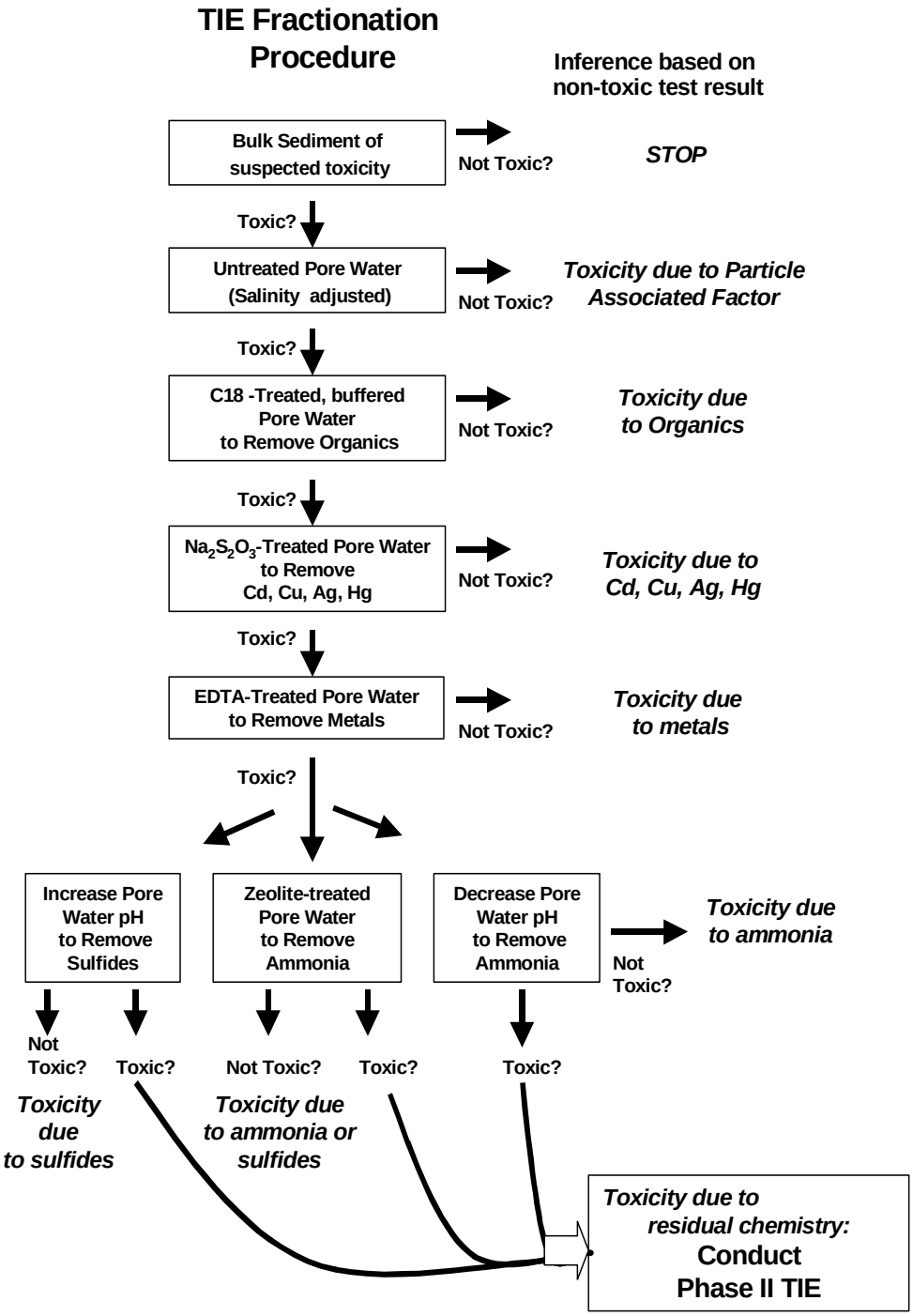


Figure 3-1. Toxicity Identification Evaluation porewater chemical fractionation procedure.

Table 2-1 Selection of Stations for the Hunters Point Shipyard TIE Demonstration.

Previous Toxicity Test Sites Listed By Area	Proposed Valid. Study Station	COCs relative to sediment benchmarks ✔ and porewater HQs ( )				NH4 (mg/L) o.w./ sed	TOC% /Fines	Toxicity Test Results Larval Development PW %LC50	Comments[a]
		Cu	Zn	Pb	PCB				
Area III	PA38 PA39 PA40 PA41	✔	✔	✔	--				PW toxic units >1 for Cu. Other metals not measured
TC 01 TD01 TD03		-- ✔ (1.7) ✔ (1.5)	--	--	--	1.3/24 1.5/28 1.0/22	0.5/64	71.8 -- 70.6	
Area VIII	EW33	✔ ✔	✔ ✔	✔ ✔	✔ ✔				Wetland site Low ammonia, small hot spot, LC50 =70 at one station near hot spot;other three had no toxicity
TV01		✔	✔	✔	--	1.0/12	0.11/17	70	
Area IX	OR24 (near-shore)	✔	✔	✔	✔ ✔				No tox. test sites represented in Verification Plan
TY04 TX05 (not near-shore)		✔ ✔	--	--	NM		1.2/98 0.9/99.4	-- --	
Area X	SB (D) SB02								Large area broadly affected with all 4 CoCs; hot spots on eastern flank Zn>Cu
TX02 TY02 TY03 TZ03 S1S01	(6)	✔ ✔	✔ ✔	✔ ✔	✔ ✔	2/142 3/50 3/63 1/45 3/73	1.3/85 1.3/96.9 1.4/99.5 1.6/75.8 1.5/99.2	71.1 72.9 88.7 71.8 71.1	

✔ = > ERL ✔ ✔ > ERM; Porewater HQs = porewater concentration/WQC Acute Values
For proposed sites, comparisons to NOAA values were made using 0400RSCD Maps (Historical data and RSC Screening values; see Battelle et al., 2000b)
[a] General station characterizations providing either summary or ancillary information used in the station selection process.

Table 3-1. Summary of test conditions for acute water-only toxicity tests with the saltwater fish, *Menidia beryllina*[a] and the saltwaterwater echinoderm, *Strogylocentotus purpuratus*[b]

	M. beryllina	*S. purpuratus*
Test type	Static non-renewal	Static non-renewal
Test Duration	96 hr	72 hr
Number of Replicates per Treatment	3	3
Number of Organisms per Chamber	5	See note
Test Chambers	25 mL vial	25 mL vial
Test Temperature	15°C	15 ^{o}C
Test concentrations	4 (10, 25, 50, 100%)	4 (10, 25, 50, 100%)
Salinity	10-32 ppt	30 ppt
Photoperiod	16:8	16:8
Age/Size of Test Organisms	1 day pre-hatch	
Volume of Overlying Water	20 mL	20 mL
Type of Water	clean seawaterwater	clean seawater
Bay Feeding/Chamber	none	none
Endpoint	time-to-hatch; survival	normal dev't
Physical measurements[1]	Dissolved oxygen, pH ammonia, temperature	Dissolved oxygen, pH ammonia, temperature
Acceptance Criteria	85% survival in control	65% normal dev't in control

[a] U.S. EPA, 1991a. Methods for aquatic toxicity identification evaluations: Phase I toxicity characterization procedures. EPA-600/3-88-034. Environmental Research Laboratory, Duluth, MN.

[b] American Society for Testing and Materials. 1998. Standard Guide for Conducting Static Acute Toxicity Tests Starting with Echinoid Embryos. ASTM E 1563-98. American Society for Testing and Materials, Philadelphia, PA.

1- measured for each treatment prior to addition of test organisms, and as required to monitor stability.

Initial stocking density estimates will be used to determine control development to pluteus stage.

Table 3-2. Analytes measured in pore waters for the Indian Head TIE demonstration program.

Analytes for Sediment Analyses	***Method***	***Description***	***Unit***	***MDL***	***Laboratory RL***
Cadmium	6020	ICP/MS	µg/L	0.19	2.0
Copper	6020	ICP/MS	µg/L	1.4	2.0
Lead	6020	ICP/MS	µg/L	0.22	2.0
Nickel	6020	ICP/MS	µg/L	1.1	2.0
Silver	6020	ICP/MS	µg/L	0.15	2.0
Zinc	6020	ICP/MS	µg/L	4.0	10.0
Arsenic	6020	ICP/MS	µg/L	0.24	2.0
Iron	6020	ICP/MS	µg/L	85	200
Aluminum	6020	ICP/MS	µg/L	17	20
TOC	SW9060	Combustion	mg/L	0.19	1.0
Sulfide	SW9034	Titration	mg/L	0.25	1.0

Appendix A

Hunters Point Areas included in the Validation Study of the 'Low-Volume Footprint'

(from the Hunters Point Validation Study Work Plan, (Draft Final; September, 2000)

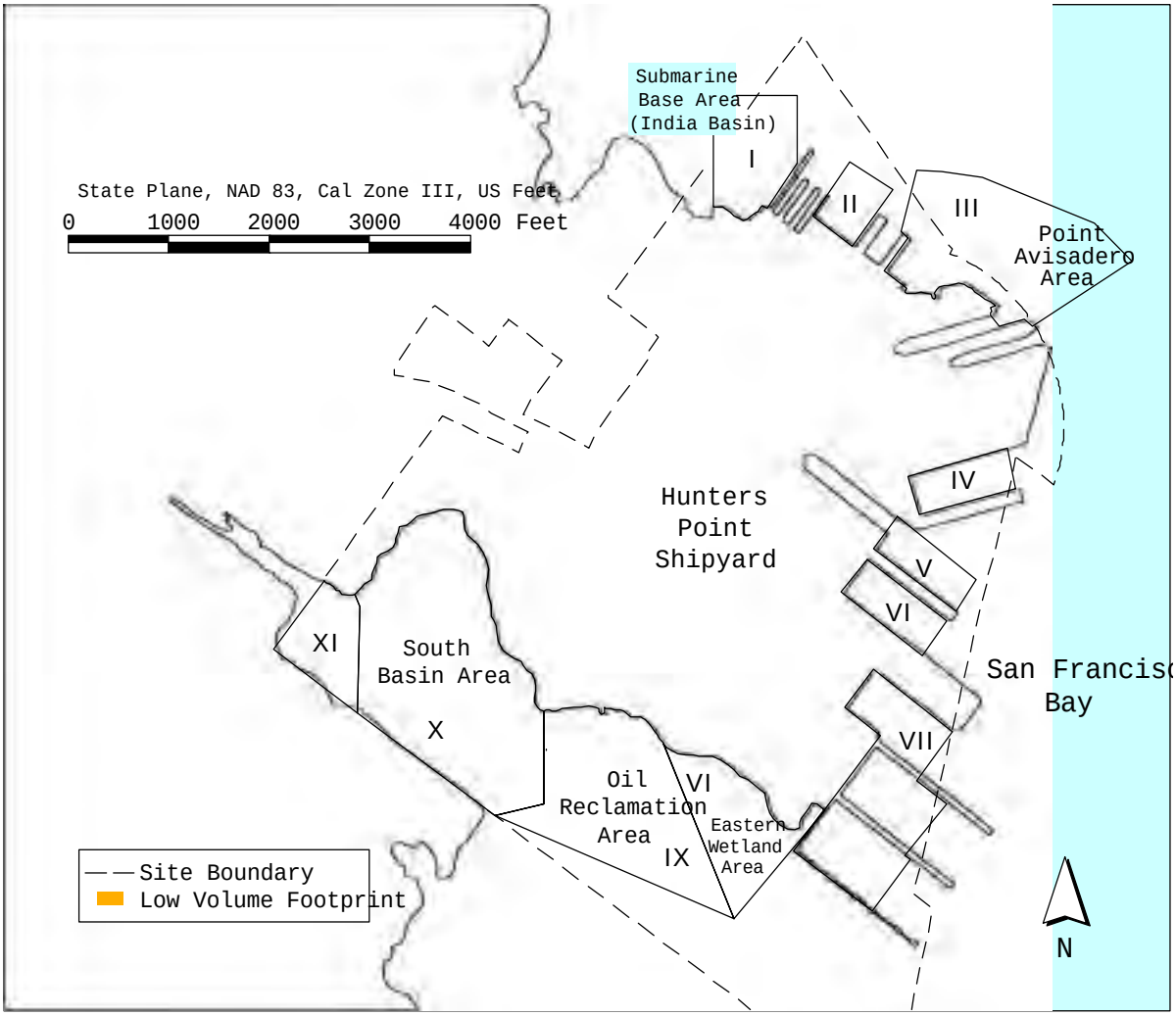


Figure A-1. Hunters Point Sampling Plan for theValidation Study of the 'Low-Volume Footprint'

Appendix B

Hunters Point Sampling Plan for the Validation Study of the 'Low-Volume Footprint'

(from the Hunters Point Validation Study Work Plan, Draft Final; September, 2000)

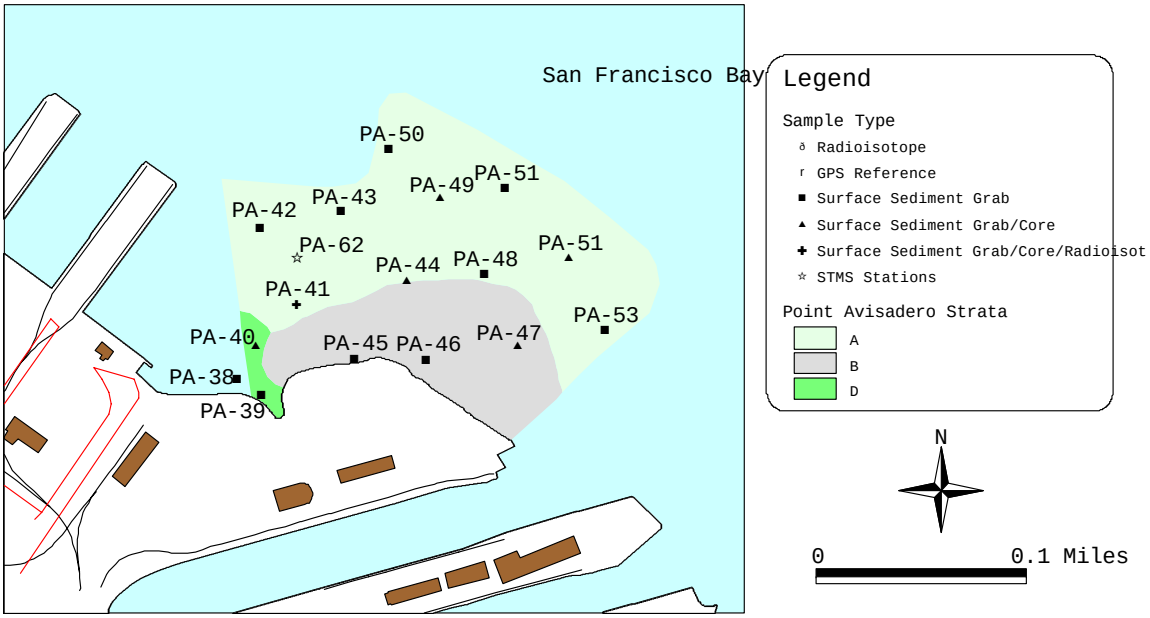


Figure B-1. Sample Locations in Hunters Point Shipyard Area III. (Point Avisadero)

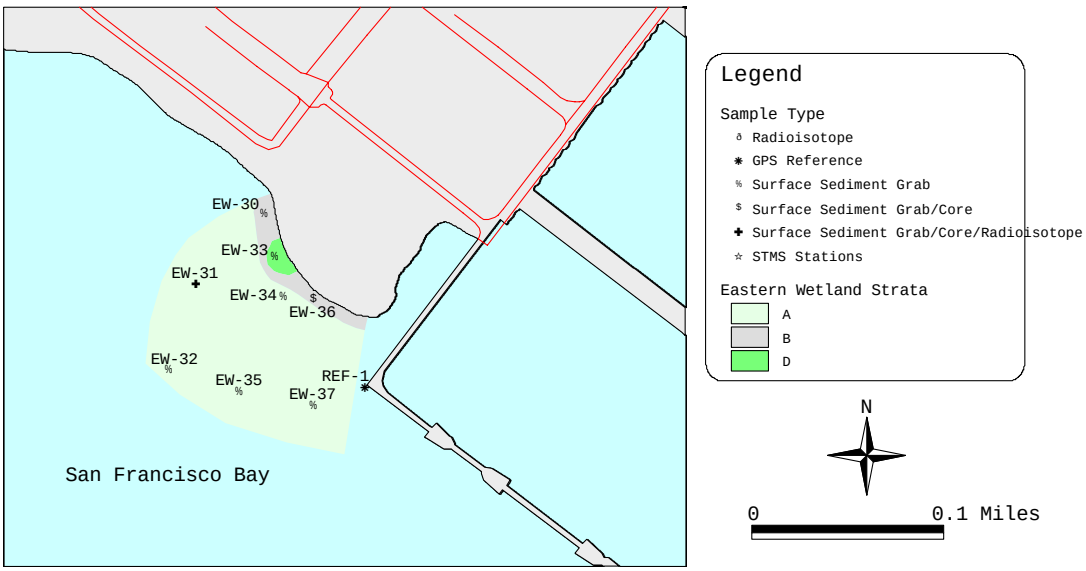


Figure B-2. Sample Locations in Hunters Point Shipyard Area VIII (Eastern Wetland)

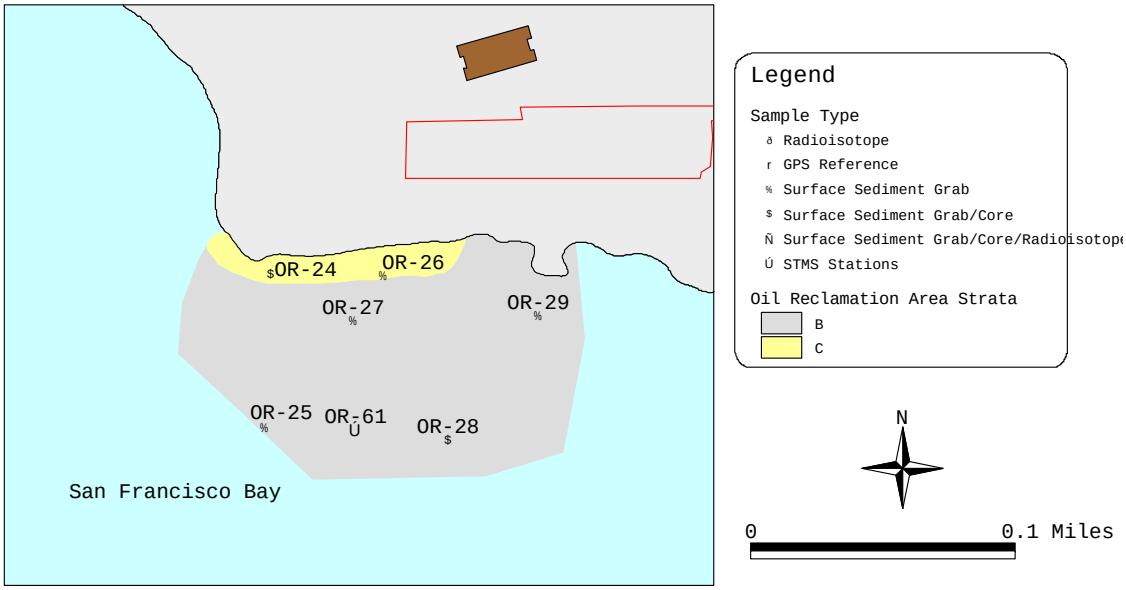


Figure B-3. Sample Locations in Hunters Point Shipyard Area IX (Oil Reclamation Area)

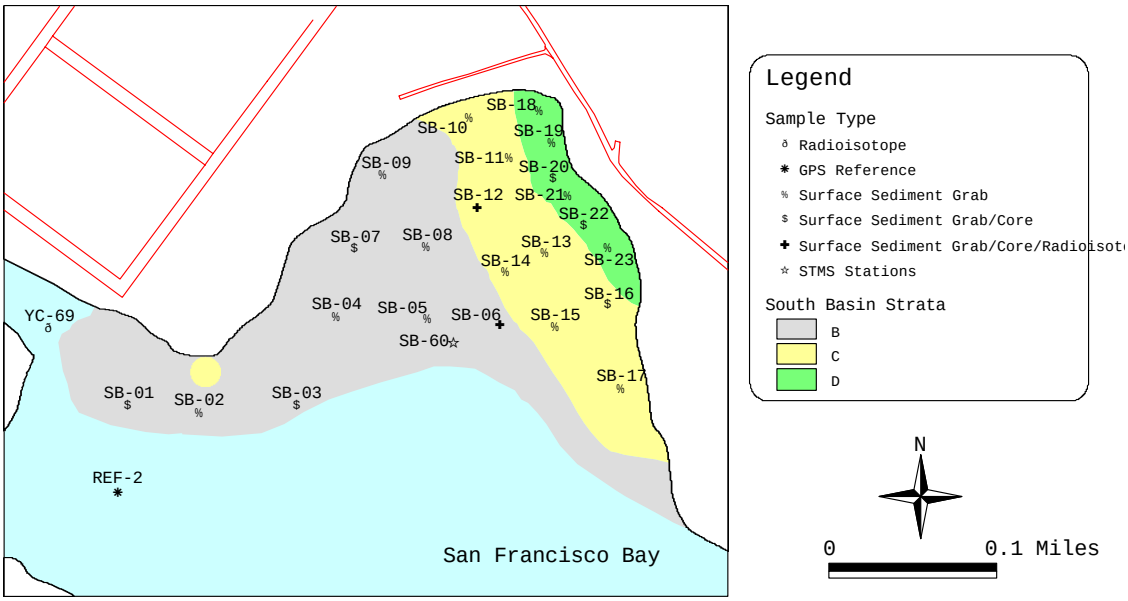


Figure B-4. Sample Locations in Hunters Point Shipyard Area X (South Basin)

ADDENDUM TO THE

WORK PLAN FOR:

CONDUCT OF NAVY SEDIMENT TOXICITY IDENTIFICATION EVALUATION DEMONSTRATION: HUNTERS POINT SHIPYARD (PARCEL F)

SUBMITTED TO:

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING SERVICE CENTER
NCBC CODE 27162 BUILDING 41
1000 23RD Avenue
Port Hueneme, CA 93043-4410

SUBMITTED BY:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
221 THIRD STREET
NEWPORT, RI 02840

NAVY BAA Contract
N47408-97-D-0410

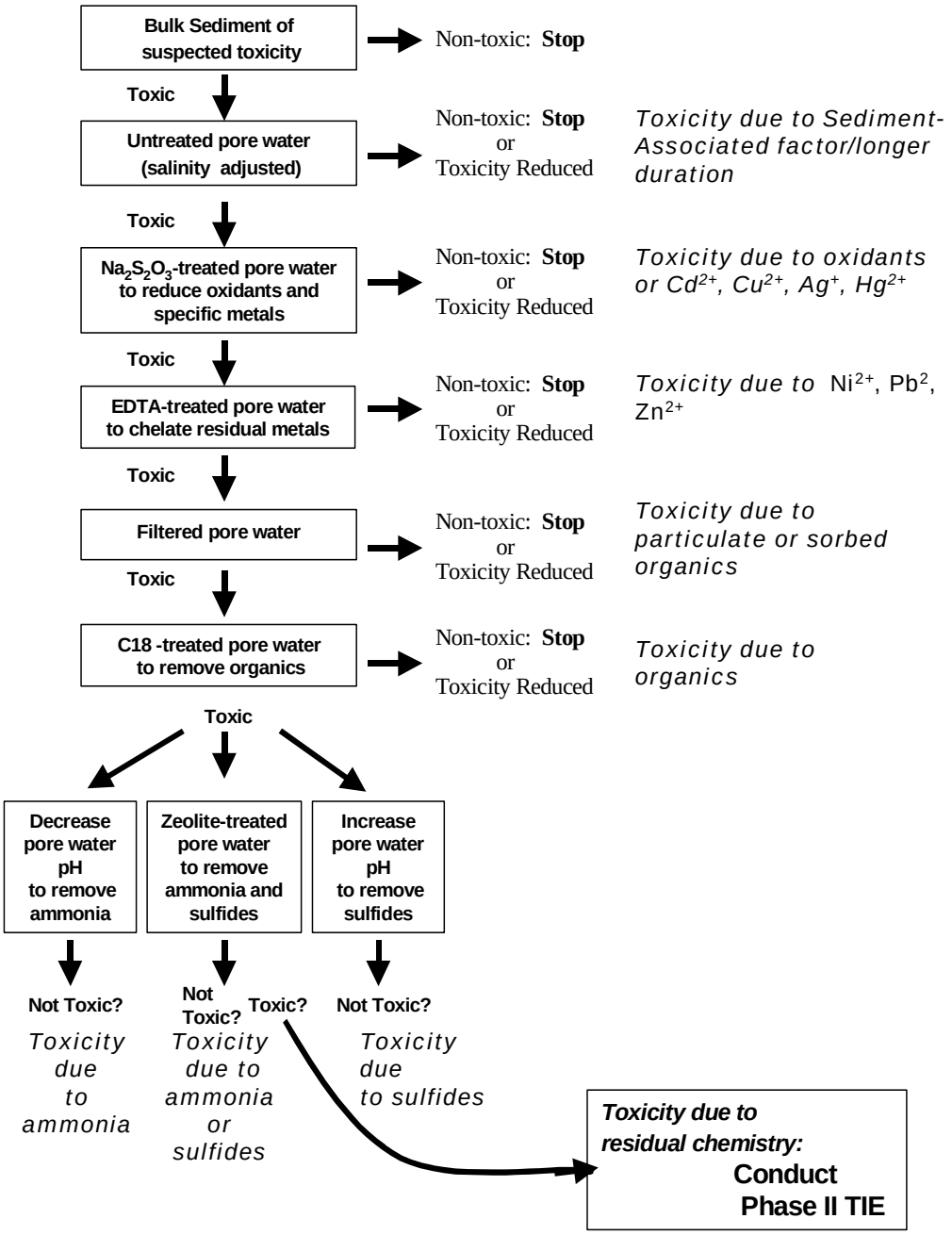
Addendum to the Work Plan For:

Conduct Of Navy Sediment Toxicity Identification Evaluation Demonstration: Hunters Point Shipyard (Parcel F)

Revised Sequence for Sediment Pore Water Toxicity Identification Evaluation

The sequential scheme for pore water manipulations will be modified for the Hunters Point TIE in order to minimize uncertainties associated with filtration of the samples. Figure 3-1 has been revised to reflect the new proposed sequence for the TIE. The filtration step has been shifted to occur after the treatments that eliminate toxicity of metals (Na_2 S_2O_3 and EDTA). Following EDTA treatment, the only expected sources of toxicity will be from organics or confounding factors (ammonia and/or sulfides). Because filtration may remove metals and organics, the placement of the filtration step after the treatments for metals reduces ambiguity of interpretations associated with filtration effects. Filtration has not been found to affect confounding factors. Hence, effects that may occur immediately following metals treatments and prior to the C-18 treatment can be expected to be associated with the organic fraction.

Figure 3-1. TIE Fractionation Procedure



APPENDIX Q

Responses to Comments on
Draft and Draft Final
HPS Parcel F Validation Study Reports

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California Regional Water Quality Control Board San Francisco Bay Region
Response to July 26, 2002 Comments and Supplemental Comments from N. Feger Q-40

U.S. Department of the Interior, Fish and Wildlife Service
Response to July 23, 2002 Comments Q-51

San Francisco Redevelopment Agency
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DRAFT HUNTERS POINT SHIPYARD PARCEL F VALIDATION STUDY REPORT RESPONSE TO COMMENTS

U.S. Environmental Protection Agency, Region IX Response to June 24, 2002 Comments

General ERA Comment

1. **I have reviewed this document and discussed it extensively with my retired senior colleague, Dr. Clarence Callahan, who participated in the development of this study. As a result of my own review and my discussions with Dr. Callahan and other Federal and State of California regulatory and trustee biologists on the Region 9 Biological Technical Support Group, I can not accept all of the conclusions in this report. Specifically, I do not agree that polychlorinated biphenyls (PCBs) are the only risk driver which must be addressed via a preliminary remediation goal or that the only area which requires remedial action is Area X. I appreciate the effort the Navy and my colleagues on the BTAG put into the development of this report. Sadly, the Navy has chosen to produce a study from that effort which is little more than an elaborate but poor excuse to avoid the Navy's responsibility as a trustee and under CERCLA to protect the environment on and adjacent to Navy property. I understand from discussions with my BTAG colleagues that they share my view in general. A full analysis of all the lines of evidence clearly shows unacceptable risk in Areas I, III, IX and X of the original low volume footprint. In addition, mercury contamination at a location (Station TB-SS02, 1.4 ppm Hg) between Areas VIII and IX, as determined in earlier sampling efforts, warrants inclusion of this area in the feasibility study footprint.**

   Response: Two of the primary concerns raised by USEPA and other agencies and stakeholders in comments on the Draft Validation Study (VS) Report were 1) the identification of only one contaminant of potential ecological concern (COPEC) (PCBs) for which a PRG was developed, and 2) the inclusion of only Area X (South Basin) in the FS footprint. Additionally, many of the reviewers commented that the field-collected tissue data had not been used in the dose assessment calculations. Based on the Draft VS Report review comments and subsequent discussions with agency and stakeholder representatives, the approach for identifying areas for evaluation in the Parcel F FS has been revised. The overall approach is summarized below. Details are explained more fully in the responses to specific comments in this document.

   As shown in the Draft VS Report, the WOE evaluation did not clearly identify areas for consideration in the Parcel F FS. In the Draft Final VS Report, the WOE evaluation is still presented in accordance with the VS Work Plan; however, the results are not used directly to identify areas for the FS. Instead, the individual lines of evidence and ancillary data were used to identify the pathways and contaminants driving risk in each area. As shown in the Draft VS Report, the pathway driving ecological risk at the site is the consumption of contaminated prey by upper trophic level receptors. The dose assessments presented in Sections 6 and 7 of Draft Final VS Report have been revised based on review comments, and Section 7 includes dose modeling based on field-collected tissue data. In Section 10 of the Draft Final VS Report, ranges of PRGs have been developed for the COPECs that are driving risk at Point Avisadero (mercury and copper) and South Basin (Areas IX/X) (PCBs). Ranges of PRGs were developed for a range of site use factors (SUFs) based on protection of the surf scoter and double-crested cormorant. Potential source control issues were also taken into consideration when identifying areas for evaluation in the FS.

In October 2003, additional contaminant distribution data were collected from Point Avisadero and South Basin as part of a FS Data Gaps investigation (other data were collected as well, including methylmercury and sulfide data from Point Avisadero and FS-related data in South Basin). These data have been combined with other existing data for the site as appropriate, and are provided as an addendum to the Draft Final VS Report. PRGs and contaminant distribution data will be evaluated in consultation with the BCT to identify the areas to be evaluated in the Parcel F FS (i.e., the FS footprint). The FS footprint, PRGs, and agreed-upon sediment cleanup levels will be documented in Parcel F FS Report.

Details regarding the inclusion of various areas in the Parcel F FS are provided in the response to DTSC Specific Comment #45. Briefly, Point Avisadero (Area III) and South Basin (Areas IX/X) will be evaluated in the FS because of potential risk to ecological receptors. Human health risk is also a concern in South Basin (Areas IX and X). The VS results did not indicate unacceptable risk from exposure to soft sediments in Areas I and VIII; however, the shoreline areas adjacent to these areas will be evaluated in the Parcel F FS as potential sources of contamination to Parcel F.

Additional sampling to characterize mercury concentrations in sediment between Areas VIII and IX was conducted as part of the FS Data Gaps investigation in October 2003. Sample results are provided in the addendum to the Draft Final VS Report. Briefly, all samples had mercury concentrations in the range of 0.3 – 0.4 mg/kg except for one sample with a concentration of 1.2 mg/kg.

Specific Comments

1. ***Section 4, Sediment Chemistry.*** **The presentation of sediment chemistry data is not straightforward. The figures provided in this section and in Appendix F are scatter plots of the data, but there are no simple data summary tables listing the number of samples, maximum and minimum detected concentrations, standard deviation, and location of maximum detection for each area. Only small portions of the data are presented in the body of the report, and the presentation of the data relies heavily on the appendices; however, the appendices are difficult to use because they provide only raw printouts of the lab reports for each sample, but do not provide summary statistics. The Navy should provide data summary tables for sediment chemistry data in the main body of the report. The high levels of copper (Area III), chromium (all Areas), mercury (Areas III and X), PCBs (Areas III, IX and X) and tributyltin (Areas III, IX, and X) indicate that many contaminants are risk drivers throughout the low volume footprint.**

   Response: The sediment chemistry data summary tables have been added to Appendix F of the Draft Final VS Report as requested. The box and whisker plots provided in Appendix F of the VS Report provide information on the number of samples collected in each area, the concentrations observed in each area, the 25th and 75% quartiles, and the median concentration. The plots facilitate rapid comparisons between the five Parcel F study areas, and ambient or reference data. The plots also indicate the ambient upper threshold limit (UTL) reported by the Regional Monitoring Program (for 100% fines) as well as the Effects Range-Median (ER-M) and the Effects Range-Low (ER-L) values where available. These plots allow a rapid determination of whether samples at a given Parcel F area exceed reference/ambient concentrations, the ER-L, or the ER-M.

   It should be noted that the elevated chemical concentrations in sediment do not necessarily indicate unacceptable ecological risk. Bulk chemistry values do not account for many factors that control the availability and toxicity of constituents in sediment. Risk drivers in Parcel F were identified based on

the results of the dose assessment presented in Sections 6 and 7. Elevated chemical concentrations in sediment did not correlate with evidence of toxicity to the amphipods or echinoderms.

2. ***Section 5, Toxicity.*** **The text states that no correlations between toxicity test effects and chemical concentrations were established. However, the effort to identify relationships between sediment chemistry and toxicity is minimal compared to the analyses performed to identify factors other than sediment chemistry that may have impacted the results of the toxicity tests. The text on page 94 (Section 5.3, paragraph 2) states, "larval toxicity did not appear to be related to elevated sediment COPEC concentrations, even at stations where metals rather than PCBs drove the ERM-Q". This has not been demonstrated in the report based on the information presented in this section.**

   Response: Section 5 of the Draft Final VSR has been revised to include plots of selected metals versus sediment-water interface (SWI) toxicity (no significant toxicity to the amphipod *Eohaustorius estuarius* was observed in the direct sediment exposure despite a large range of sediment COPEC concentrations). In most cases, correlations between SWI toxicity test effects and chemical concentrations were not apparent. Stations with elevated COPEC concentrations generally had low toxicity (70%-100% normal development) while stations with greater toxic effects had lower COPEC concentrations. Because of the lack of observed correlation and the strong evidence for confounding factor influence, relationships between SWI toxicity and sediment chemistry were not examined further.

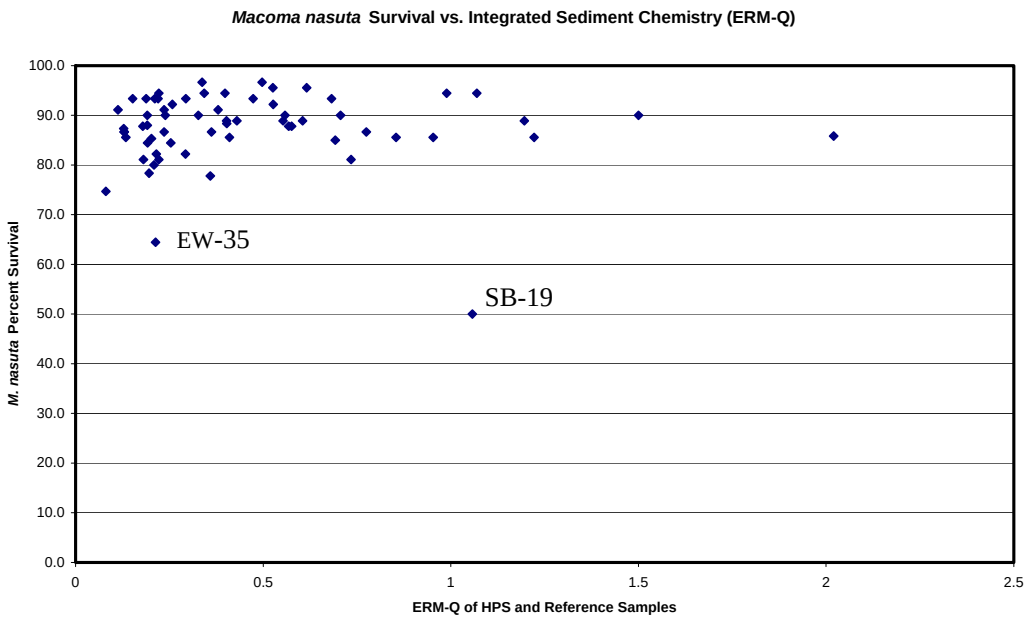
3. ***Section 5, Toxicity (cont.).*** **The results of the Toxicity Identification Evaluation (TIE) test discussed in Section 7 suggest that metals contribute to toxicity at several sample locations, yet these metals (cadmium, copper, zinc) are not discussed in Section 5 relative to the results of the toxicity tests. For example, according to Table 7-3, it appears that metals were associated with dose-response at location EW-33 in Area VIII, where there was only 53% survival in the *Strongylocentrotus* test. Please provide a discussion of the TIE results in Section 5 relative to *Eohaustorius* and *Strongylocentrotus* toxicity test results.**

   Response: Plots of cadmium, copper and zinc in sediment vs. SWI test results have been added to Section 5 and SWI results for the stations tested in the TIE have been added to Table 7-3 in Section 7. It is not possible or relevant to compare the results of the *S. purpuratus* TIE to amphipod survival for three reasons: 1) acute toxicity was not observed in any HPS station for *E. estuarius*, 2) the test species were different, and 3) the exposure media were different (suspended particulate phase vs. sediment porewater vs. bulk sediment). SWI toxicity relative to COPEC concentrations is also addressed as part of the response to DTSC Comment # 22.

4. ***Section 5, Toxicity (cont.) and Section 6.1, Laboratory Bioaccumulation Test Results, Page 96.*** **The Navy evaluated survival rates of *M. nasuta* used in the bioaccumulation test. The text on page 96 states, "the lowest survival was associated with stations EW-35 (64.4%)...SB-19 (50% survival)...These observations do not correlate with survival or development results for the amphipod bioassay and SWI test, and the reason for the reduced survival is not known." However, according to Table 4-7, station SB-19 has one of the highest ER-M quotients of all surface sediment samples (ER-M quotient (ERM-Q) = 1.057). Although the *M. nasuta* results are considered ancillary data in the report, they do appear to correspond with other lines of evidence indicating the potential for risk. Although the *M. nasuta* bioaccumulation test is of course not a measure of acute toxicity, the low survival should be used as a line of evidence. This is another indication that the results of toxicity tests have not been fully interpreted. The report should provide further discussion of toxicity test results and should address the potential that chemical concentrations in sediment may have caused adverse effects.**

Response: As noted above, Station SB-19 had one of the higher sediment ERM-Qs and also the lowest *M. nasuta* survival. However, the following plot of *M. nasuta* survival against ERM-Q shows that there is no trend of increasing toxicity with increasing concentrations of chemicals in sediment, and that a number of stations with higher ERM-Qs did not exhibit low *M. nasuta* survival. The two samples with *M. nasuta* survival <70% (SB-19 and EW-35) were identified as outliers in a standard nonparametric test [less than 3x (median – interquartile difference)]; hence the conclusion that the reason for toxicity at these stations is not known.

M. nasuta survival was below 80% at only four stations: IB-56 (78.3%), SB-04 (77.8%), EW-35 (64.4%), and SB-19 (50.0%). Sensitive bioassays using the amphipod *E. estuarius* and purple urchin larvae *S. purpuratus* conducted on the same sediment samples did not produce a toxic response. Therefore, the survival of *M. nasuta* in those exposures does not appear to be directly related to sediment contaminants.



5. ***Section 6, Bioaccumulation and Section 7.2.2, Field Collected Invertebrate and Fish Tissue Data.*** **The bioaccumulation line of evidence should evaluate all dose estimates and emphasize the results from the highest sources, regardless of whether these were field collected tissues or laboratory study results. All three categories of field tissues should have been evaluated directly in the bioaccumulation modeling. Relegating the field tissue data to ancillary status in the analysis of the lines of evidence, while consistent with the Navy's strict protocol for a quantitative weight of evidence, allows the Navy to ignore some of the most damning evidence at Hunters Point Shipyard.**

Response: The bioaccumulation data supported three different evaluations in the VS: 1) the dose assessment (Sections 6 and 7), 2) the formal WOE (Section 8), and 3) the development of BAFs and PRGs (Section 10). Although these evaluations are linked, each has different data requirements. The fact that a given evaluation focused on some aspects of the data and not others does not mean that the data were ignored, only that they weren't appropriate for that particular evaluation. Additionally, it should be noted that the term ancillary data was not meant to imply that they were not important, only that they were not formally evaluated within the WOE construct. The issues raised in the comment above are discussed further below for each evaluation.

Evaluation 1- Dose assessment: In the Draft VS Report, the evaluation of potential risk to upper trophic level receptors consisted of screening-level and refined dose assessments using laboratory *M. nasuta* data (Section 6). In Section 7, the field-collected hard-bodied invertebrate (HBI) and soft-bodied invertebrate (SBI) tissue data were compared to the depurated laboratory *M. nasuta* tissue data to evaluate the relevance of using the laboratory data as prey concentrations in the WOE. Additionally, bioaccumulation risk to the double-crested cormorant was modeled using the field-collected forage fish tissue data. In Section 7 of the Draft Final VS Report, dose modeling to the scoter using the field-collected hard-bodied invertebrate (HBI) and soft-bodied invertebrate (SBI) data has been added to address concerns regarding potential risk to benthic invertebrate-foraging birds (such as the scoter) that may forage on soft-bodied as well as hard-bodied invertebrates.

Evaluation 2 – Bioaccumulation line of evidence in the WOE: The integration of the bioaccumulation line of evidence into the WOE is provided in Section 8 of the VS Report. Because the WOE is based on a station-by-station evaluation, only the depurated *M. nasuta* data can be used formally in the evaluation (i.e., field-collected tissue data are not available for every station). However, the effect of using the laboratory *M. nasuta* data in the WOE rather than field-collected invertebrate data can be assessed by comparing the results of dose assessments using the field-collected tissue data and laboratory *M. nasuta* data from adjacent stations (Tables A-1 through A-5, Attachment A). In these tables, highlighted cells indicate results that would have changed the WOE score (e.g. HQs<1, HQs>1 and HQs>10) at matching stations. In all five areas, HQs for only a few COPECs did not match. No consistent trend is apparent; in some cases the HQs based on laboratory *M. nasuta* were higher, while in others the HQs based on SBI data were higher. Based on this evaluation, it is believed that the laboratory depurated *M. nasuta* data adequately represent invertebrate prey found in the field, and that evaluations based on laboratory data and field-collected data would lead to similar conclusions.

Evaluation 3 –Footprint Development: As discussed in Section 10 of the Draft VSR, the WOE could not be used directly to identify the feasibility study (FS) footprint in South Basin because the majority of the stations were in the "gray" zone. Therefore, as indicated in the VS Work Plan, the ancillary data and results for the individual lines of evidence were used to identify the primary risk drivers and develop PRGs. Thus, although the ancillary data were not used in the formal WOE evaluation, they were critical in the development of BAFs and PRGs. The data needs specific to the development of BAFs and PRGs and use of field-collected data in this process are discussed in detail in the response to DTSC Specific Comment #56.

In summary, Section 7 of the Draft Final VS Report has been revised to include a dose assessment based on the field-collected invertebrate data. However, the field-collected tissue data cannot be used in the WOE because it does not meet the data requirements of the WOE model. A comparison of HQ results based on field-collected invertebrate tissue data and laboratory *M. nasuta* data from adjacent stations indicates that the outcome of the WOE evaluation is not likely to be significantly different if it were based on invertebrate tissue collected from the field.

6. ***Section 6.2, Evaluation of Upper Trophic Level Risk, Page 97.*** **These comments are within the context of the bioacummulation analysis performed with the Navy's focus on the laboratory *Macoma* tests. It is unclear whether the *Macoma* tissue reference threshold values (Table 6-3) were used to calculate the reference exposures presented in Tables 6-12 through 6-15, or if they were only used to determine whether food chain modeling should be conducted for a given chemical. It is also unclear why upper trophic level risk (i.e., food chain modeling) was not evaluated for all chemicals of concern listed in Table 6-3. The text states that if tissue COPECs exceeded the reference values, the station was evaluated. However, chemical concentrations measured in depurated *Macoma* tissue samples are not predictive of effects to upper trophic**

level receptors. As demonstrated in Section 6.3.2.1, reference concentrations can result in Hazard Quotients (HQs) greater than 1 for avian receptors. Food chain modeling should be conducted for all chemicals of concern. If this was done, the text in Section 6.2 should be revised to more clearly explain how upper trophic level risk was evaluated.

Response: Section 6.2 of the Draft Final VS Report has been revised to more clearly explain how upper trophic level risk was evaluated. The focus of Section 6 is on COPECs with tissue concentrations that exceed *M. nasuta* tissue reference threshold values. Reference threshold values were used to represent ambient conditions, and were used to identify stations where tissue concentrations exceeded ambient levels. Only chemicals that exceeded the tissue reference threshold values were considered in the food chain model.

Tissue reference threshold values were not used to develop exposure point concentrations (EPCs) for the reference stations. To develop reference station EPCs, *M. nasuta* tissue from reference stations were used to estimate the 95% UCL of the dataset (see Eq. 6-5 in the Draft Final VS Report).

Appendix H of the VS Report presents the calculated risk associated with exposure to all COPECs, regardless of whether or not they exceed tissue reference threshold values. Doses to the scoter were modeled for all detected COPECs, and HQs were developed for all COPECs with toxicity reference values (TRVs). These results were not discussed in Section 6 because the bioaccumulation evaluation focused on evaluating risk associated with contamination exceeding ambient levels.

7. ***Section 6.2.1.3, Risk Characterization.*** **Tables 6-6 through 6-10 are helpful qualitative summaries. However, the presentation of hazard quotients in this section should also include summary tables which list the actual values, as is done in Table 6-11 in Section 6.3.**

   Response: HQ values for all stations and chemicals are presented in Appendix H of the VS Report. Because Tables 6-6 through 6-10 present summaries for each area, the HQ values cannot be summarized readily in the same manner as the site-wide HQs presented in Table 6-11.

   Section 6.3.1, Exposure Point Concentration Refinement. **The report states the arithmetic mean provided a more relevant estimate of central tendency exposure than the 95% upper confidence level of the mean because of the small sample size for each area. However, hazard quotients calculated from the 95% UCL were either fractionally elevated or equal compared to hazard quotients based on the mean. I view this as evidence that the 95% UCL values were not unrealistic estimates of exposure, and hazard quotients based on the 95% UCLs should be evaluated in the weight of evidence.**

   Response: For the dose assessment, HQs based on the 95% UCL as well as the arithmetic mean were calculated and presented in Appendix H of the Draft VSR (Tables H-60 through H-71). The dose assessment refinements presented in Sections 6 and 7 focused on the arithmetic mean because they were meant to provide an estimate of central tendency exposure integrated over an area. Sections 6 and 7 of the Draft Final VSR have been revised to present HQ results based on the 95% UCL. It is not possible to evaluate the 95% UCLs in the WOE because the WOE is based on a station-by-station evaluation (i.e., it is based on point estimates).

8. ***Section 6.3.2, Refinement of SUF*****. In order to adjust risk estimates using site use factors (SUF) at a small spatial scale, the appropriate comparison is to contamination in adjacent sites. Thus, for the SUF analysis for each Area, the comparison should have been to other Areas of Hunters Point. Since all Areas of the low volume footprint but XIII have significant sediment contamination, I do not see the point of evaluating site use factors on an Area by Area basis.**

Furthermore, it is not appropriate to use a site use factor to minimize the sitewide risk characterization from bioaccumulative contaminants which are spread over such a large area, as they are at Hunters Point.

Response: Available data support the assumption that bird species of interest at HPS have foraging ranges that are larger than the low-volume footprint (see Appendix G-2 of the VS Report). Therefore, while it is appropriate to estimate exposure from adjacent contaminated areas, the sizes of those areas are so small compared to the foraging range outside of the low-volume footprint that their integration would have a *de minimus* impact on the risk estimate. For example, based on the best available data, the foraging range of the scoter is believed to be about 7 km^2. The area of the entire low volume footprint is about 0.17 km^2, resulting in a SUF for the entire low volume footprint of approximately 0.02. Area I is about 15% of the low volume footprint, and Areas III, VIII, IX and X are 21%, 10%, 12% and 42%, respectively. Thus, even the largest subarea (Area X) is only about one half of one percent of the size of the scoter's foraging range.

In order to evaluate exposure to areas outside of the location of interest, information about contaminant concentrations in other areas of the foraging range is required. In most instances, this information is lacking and assumptions must be made. In the case of the VS, the entire low-volume footprint was assumed to be the area of the site, and this area was divided into the foraging area to estimate a SUF. Thus, the SUF was not modified for the size of each of the five subareas at HPS. This resulted in larger SUFs for each subarea, but was assumed to be a reasonably conservative estimate (see the response to SFRA Comment #5).

The refinement of risk estimates based on an evaluation of site utilization was not intended to minimize site-wide risk. Instead, it allows the risk managers to see a range of potential exposures from the most conservative (SUF = 1) to those that are more consistent with the foraging ecology of the animals evaluated.

9. ***Section 7.2.2, Field Collected Invertebrate and Fish Tissue Data, pg.143.*** **Avians do not pick the guts out of polychaetes before consuming them.**

Response: Section 7.2.2 of the Draft Final VS Report has been revised to explain that it is not clear whether SBI tissue sample data solely represent tissue concentrations, or are a combined measure of chemical concentrations in tissue and sediment present in the gut.

10. ***Section 12.1.6.2, Radioisotope Data.*** **Where is the ecological risk assessment for exposure to radioisotopes?**

Response: At the time of the VS Work Plan development, radionuclides had not been identified as COPECs for Parcel F. Therefore, they were not included on the COPEC list and were not assessed in the VS. Additional investigation of radionuclides in Parcel F will be conducted following the recommendations in the Draft Final Historical Radiological Assessment (Navy Radiological Affairs Support Office, 2004).

The data quality objectives for the collection of ^{210}Pb and ^{137}Cs data are provided in Table 2-13 of the Draft Final VS Report. These data were collected to estimate sediment accumulation rates at various locations around HPS, and not to evaluate potential ecological risk from exposure to these radioisotopes.

General HHRA Comments

1. ***General HHRA Comment #1.*** **Some of the terminology used within the Human Health Evaluation (HHE) is inconsistent with EPA guidance and should not be used. Specifically, the reasonable maximum exposure (RME) is not meant to represent the "worst case" scenario as often stated in the text. RME is considered the highest exposure that is reasonably expected to occur at a site. The exposure parameter values used to estimate RME should represent a combination of mean or median and upper bound estimates such that the RME represents a conservative estimate above the average case, but is specifically not representative of "worst case" conditions. Likewise, the goal of any HHE conducted under the auspices of EPA, including this document, is not to "overestimat[e] rather than underestimat[e] potential exposures (and hence risks)" (see Page 9-1, paragraph 1). The goal of the HHE is to provide risk managers with, at a minimum, conservative estimates of risk and hazard attributable to known or potential receptor populations in consideration of associated uncertainty. Please revise the text to correctly describe RME and the goal of the HHE.**

   Response: Section 9 of the Draft Final VS Report has been clarified to refer to 'reasonable maximum exposures' rather than 'worst case exposures.' In addition, the stated goal of the HHE has been modified to indicate that due to the uncertainty associated with calculating risks, conservative exposure parameters were selected to ensure that risks were not underestimated.

2. ***General HHRA Comment #2.*** **The statements in Section 9.1.2.2 that the RME evaluation consists of the most conservative exposure factors to estimate worst-case conditions, and in the conclusion section, Section 9.1.4.1 the text states that "actual" risks at HPS would not be greater than the risks estimated in the HHE; these statements are inaccurate and contrary to EPA guidance. EPA defines RME as the highest exposure that is reasonably expected to occur at a site (EPA, 1992). It is intended to represent a plausible estimate for individuals at the upper end (i.e., above the 90th percentile) of the risk distribution that focuses on the actual population. The intent of an RME evaluation is to avoid estimates that are beyond the true distribution. The Hunters Point HHE data are limited and potentially complete pathways have not been quantified within this assessment (see specific comments below). In addition, the level of uncertainty in this type of assessment is significant. The RME evaluation may tend toward conservatism: however, statements that it is overly conservative and that the CTE evaluation represents a "more reasonable" or "accurate" (Section 11.2) estimate are more opinion than fact. It is important to note here that for the purpose of decision-making in the Superfund program, RME is used to estimate risk (EPA, 1992). Please revise the text in these sections to correctly describe the RME approach.**

   Response: Section 9 of the Draft Final VS Report has been clarified to define the CTE exposure as the more typical or "average" exposure, and the sentence in Section 9.1.4.1 stating that actual risks at HPS would be lower than those estimated in the assessment has been removed. The text has been revised to more clearly explain that the assumptions used in the assessment were intended to provide a conservative estimate of actual risks, as stated in the response to USEPA General Comment #1.

3. ***General HHRA Comment #3.*** **We do not agree with the Navy's position presented in Section 11.2 that risk estimates predicated on central tendency exposures represent a more "reasonable" basis for assessing risk. Estimates based on these exposures more closely approximate mean or median exposures, but are not more accurate than other potential conditions such as the RME. The Navy should revise the stated objective of the HHE and all references to the RME condition**

appropriately, providing risk managers with a better understanding of this evaluation, it's descriptors and relevance to remedial decisions.

Response: Please see the response to USEPA General Comment #1 and #2.

4. ***General HHRA Comment #4.*** **Taken together, the questions raised in this review call into question whether the authors of the subject document have an adequate understanding of current EPA CERCLA guidance and protocol for conducting human health risk assessments. The numerous deficiencies outlined here must be addressed before the Validation Study Report can be considered for approval.**

Response: The responses to the comments below address the specific issues raised by USEPA.

Specific HHRA Comments

1. ***Table 9-1, Page 169:*** **The basis for using Toxic Equivalency Factors (TEFs) proposed by Van den Berg, et al., 1998 is unclear. EPA-approved TEFs for evaluating human exposure to various dioxin and furan congeners have been available since 1987, and have been recently updated in *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds*, (EPA, 2000). The risk estimates should be revised using EPA-approved TEFs.**

Response: Use of the Van den Berg et al. (1998) TEFs was described in the Human Health Evaluation Work Plan (May 2, 2001), which was reviewed by USEPA. The TEFs used in the risk assessment are identical to those proposed by USEPA (2000) with the exception of two congeners (i.e., 1,2,3,7,8-PeCDD and 1,2,3,4,6,7,8,9-OCDF). The values proposed by USEPA (2000) for these congeners are actually less conservative than those used in the Draft VS Report, with the TEF value for 1,2,3,7,9-PeCDD decreasing from 1 to 0.5 and the TEF for 1,2,3,4,6,7,8,9-OCDF decreasing from 0.01 to 0.001. The following table presents a comparison of the risks for both the RME and CTE scenarios when the USEPA (2000) TEFs are applied (all other exposure factors were kept consistent with the VS Report):

	Risks from Dioxin Based on RME Scenario		Risks from Dioxin Based on CTE Scenario	
Area	VS Report	USEPA (2000) TEFs	VS Report	USEPA (2000) TEFs
Eastern Wetland Area	1.7E-02	1.5E-02	5.5E-04	4.8E-04
Oil Reclamation	3.3E-02	3.1E-02	7.8E-04	7.1E-04
South Basin Area X	3.7E-02	3.5E-02	8.9E-04	8.4E-04
Reference	2.8E-02	2.5E-02	8.6E-04	1.3E-04

As illustrated in the table, the use of USEPA-recommended TEFs decreases the risk estimates for both the RME and CTE scenarios. Consequently, the Draft Final VS Report has not been revised to reflect the USEPA (2000) TEFs. It should also be noted that that regardless of the TEF values used, concentrations of dioxin (and thus associated risks) at HPS are consistent with those associated with the reference areas, indicating that it is not a primary site-related risk driver.

2. ***Section 9.1.2.1, Exposure Pathways and Populations, Page 169:*** **This section describes the complete and potentially complete exposure pathways associated with environmental contamination at HPS. Exposure was stated to be limited to ingestion of contaminated edible fish tissue and**

shellfish. Direct contact with contaminated sediments via incidental ingestion and dermal contact by recreational users or future residents via wading or swimming was considered minimal given the disrepair of current on-site boat ramps and the accessibility of other functional docks along the San Francisco Bay. The Navy also maintains that the water is too cold and the water depth along the shoreline too shallow to engage in active water sports. However, no explanation is provided to explain how the shellfish will be harvested without direct contact with contaminated sediments and surface water. Additional explanation and/or justification is required in this section to support the conclusion that these pathways are incomplete or inconsequential.

Response: Risk estimates associated with direct contact with sediment while harvesting shellfish have been added to Section 9.1.2.1 of the Draft Final VS Report based on the following exposure assumptions:

a. Exposure frequency: One day per week for six months of the year (RME = 26 days per year) or one day every two weeks for six months of the year (CTE = 13 days per year);
b. Sediment ingestion rate of 100 mg/day for RME and 50 mg/day for the CTE;
c. Skin surface area: Assumed that individuals wear short-sleeved shirt and shorts, exposing hands, forearms, lower legs, and feet (i.e., 5,700 cm^2/day);
d. Dermal absorption factors based on data reported by U.S.EPA Region 9 in the development of PRGs (EPA, 2002). In the absence of dermal absorption factors, default values of 0.1 for organic chemicals and 0.001 for metals were assumed; and
e. Adherence factor assumed to be 0.07 mg/cm^2.

In addition to these parameters, the exposure point concentrations for the CTE scenario are now based on either the maximum measured concentration or the 95 percent UCL, whichever is lower, in response to USEPA Specific Comment #3. Toxicity values have also been updated in response to USEPA HHRA Specific Comment #5 and RWQCB comment #27. Applying these assumptions, the risks for the RME and CTE scenarios based on exposure through direct contact with sediment were estimated as follows:

Area	RME Risk and Hazards through Direct Contact with Sediment		CTE Risk and Hazards through Direct Contact with Sediment	
	Risk	Hazard	Risk	Hazard
Eastern Wetland Area	3.6E-06	0.01	1.4E-07	0.002
India Basin Area I	3.4E-06	0.02	1.4E-07	0.002
Oil Reclamation Area	4.9E-06	0.02	1.9E-07	0.003
Point Avisadero Area	3.6E-06	0.02	1.5E-07	0.002
South Basin Area X	3.6E-06	0.02	1.5E-07	0.002
Reference	2.6E-06	0.01	1.0E-07	0.002

RME risks estimated for this pathway are within USEPA's risk management range of 10^{-4} to 10^{-6} and the CTE risks are all below 1×10^{-6}. Hazard quotients estimated for all areas are below the USEPA benchmark of 1.0. Based on these assumptions, risks associated with direct contact with sediment are anticipated to contribute less than 5 percent of the total cumulative human health risk at HPS.

The second issue associated with this section is that future potential construction worker exposure (direct contact via incidental ingestion and dermal contact with sediments and dermal contact with pore water) be managed via an approved Health and Safety Plan. This type of management (requiring PPE, etc.) would be tantamount to an institutional control. The Navy's contention that construction worker exposures are likely to be of short duration is specious. Perhaps this type of exposure is of a more limited duration than the exposure of potential future

residents, but construction worker exposures should be quantitatively evaluated, particularly if exposure for all other receptors is limited only to fish and shellfish ingestion. EPA and other risk managers should be provided with an understanding of the potential risks associated with direct contact with these sediments.

Response: As discussed above, direct contact with sediments during recreational activities (e.g., while harvesting shellfish) contributes less than 5 percent of the total cumulative risk at the site. In comparison, occupational exposures are likely to be of short duration and result in less direct skin contact with sediments than these recreational exposures, resulting in lower risks. To illustrate this point, risks associated with direct contact to sediment by construction workers were evaluated using the following exposure assumptions:

f. Exposure frequency: 5 days per week for six months of the year (RME and CTE = 120 days per year);
g. Sediment ingestion rate of 100 mg/day for RME and 50 mg/day for the CTE;
h. Skin surface area: Assumed that individuals wear short-sleeved shirt, exposing hands, and forearms (i.e., 3,300 cm^2/day);
i. Dermal absorption factors based on data reported by U.S.EPA Region 9 in the development of PRGs (EPA, 2002). In the absence of dermal absorption factors, default values of 0.1 for organic chemicals and 0.001 for metals were assumed; and
j. Adherence factor assumed to be 0.20 mg/cm^2.

All of these exposure factors were taken from USEPA Region 9 PRG Table (2002). The exposure point concentrations for both the RME and CTE scenarios were either the maximum measured concentration or the 95 percent UCL (whichever was lower). Because the exposure duration is less than 7 years, subchronic reference doses were used for anthracene (3 mg/kg-day), fluoranthene (0.4 mg/kg-day), fluorene (0.4 mg/kg-day), and pyrene (0.30 mg/kg-day). Chronic toxicity values were applied for all other compounds. Applying these exposure assumptions and toxicity values, the risks to RME and CTE scenarios based on exposure through direct contact with sediment to construction workers were estimated as follows:

Area	RME Risk and Hazards through Direct Contact with Sediment		CTE Risk and Hazards through Direct Contact with Sediment	
	Risk	Hazard	Risk	Hazard
Eastern Wetland Area	5.2E-07	0.07	1.4E-07	0.02
India Basin Area I	5.3E-07	0.07	1.4E-07	0.02
Oil Reclamation Area	7.6E-07	0.10	2.0E-07	0.03
Point Avisadero Area	6.0E-07	0.08	1.7E-07	0.02
South Basin Area X	5.8E-07	0.08	1.7E-07	0.02
Reference	4.1E-07	0.06	1.1E-07	0.02

The risks from both the RME and CTE scenarios for construction workers are below USEPA's risk management range of 10^{-4} to 10^{-6}, and hazards estimated for all areas are below the USEPA benchmark of 1.0. Based on these results, it was concluded that risks to future potential construction workers through direct contact with sediment is *de minimis*. Section 9.1.2.1 of the Draft Final VS Report has been revised accordingly, and references to managing risks via Health and Safety Plans have been removed.

3. ***Section 9.1.2.2, Exposure Point Concentrations:*** **The HHE utilizes the simple arithmetic mean as the exposure point concentration for CTE estimates, and the text on page 170 states that "it is not reasonable to assume long-term contact with the maximum concentration or the 95%**

(percent) UCL of a constituent." This methodology contradicts EPA risk assessment guidance. According to *EPA, 1992*, the contaminant concentration should be an estimate of the arithmetic average. However, because of the uncertainty associated with estimating the true average concentration, the 95 percent UCL of the arithmetic mean should be used in *both* RME and CTE evaluations to provide reasonable assurance that the true site average will not be under-estimated. Accordingly, the CTE evaluations should be recalculated using the 95 percent UCL as the exposure point concentration. Alternately, the CTE evaluations may be deleted from the Draft Final version of the report.

Response: The risk estimates for the CTE in Section 9.1.2.2 have been revised using either the maximum measured concentration or the 95 percent UCL (whichever was lower) as the exposure point concentration instead of the arithmetic mean. The results based on this change, as well as an update of the fish consumption rate per the data presented by SFEI (2001) in response to RWQCB Comment #23, are included in the Draft Final VS Report. However, this revision does not change the conclusion of the evaluation, which is that risks associated with exposure to sediments at HPS are above 1×10^{-6}, but are comparable to those associated with the reference area. Similarly, the non-carcinogenic hazards at HPS are consistent with those estimated at reference areas. The primary human health risk drivers at HPS include arsenic and chromium, which are consistent with the reference locations, implying that they are attributable to natural or ambient sources rather than site-specific sources. Because both arsenic and chromium were present at levels comparable to or less than those found at reference locations, they were eliminated as potential risk drivers in the assessment. The only risk driver that is elevated above ambient conditions is PCBs.

4. ***Section 9.1.2.3, Estimation of Chemical Intake, Page 171:*** **Children are assumed to be part of the potentially exposed future residential receptor population. The Navy has not addressed children's exposure on the basis that "adults typically consume the majority of shellfish harvested within the bay, SFEI, 2000." According to this study, only 13 percent of the SFEI study participants reported that children under the age of six eat locally caught seafood. EPA's Exposure Factors Handbook indicates that the mean fish and shellfish ingestion rate for children under the age of nine is 6.2 g/day, which is approximately 44 percent of the average adult rate of 12 g/day (and also notes that the average ingestion rate is 21 g/day for Asian races). When normalized for body weight, this children's ingestion rate is approximately 200 percent higher than the corresponding adult ingestion rate, which could put children at a significantly higher risk level. Further justification is needed before concluding that children do not represent a significant at-risk population that should be evaluated in the HHE.**

Response: Risks associated with exposures to children were calculated for dermal contact to sediments and for ingestion of sportfish and included in the Draft Final VS Report. Risks to children associated with consumption of shellfish were not calculated because as observed by SFEI (2002), children under the age of 6 years are unlikely to consume shellfish. In addition, Wong (1997) estimates that shellfish consumption typically comprises less than five percent of total seafood consumption among San Francisco anglers. Risks associated with consumption of sportfish were only calculated for those chemicals found to be statistically different from reference (i.e., copper, 4,4′-DDD, a-chlordane, g-chlordane, tributyltin, and PCBs in jacksmelt). Ingestion rates of fish by children who reside in households that consume recreational fish were taken from USEPA Exposure Factors Handbook (1997; Table 10-61), which estimates a total fish consumption rate for children under the age of six of 11.4 g/day and a recreational fish intake of 5.6 g/day. By applying these ingestion rates for children in conjunction with the adult fish ingestion rates estimated from SFEI's study (see response to RWQCB Comment #23), it was found that risks and hazards to children were only slightly higher than those calculated for adult only exposures, which were comparable to risks

calculated for the reference area. The hazards associated with direct contact with sediment and ingestion of jacksmelt were below USEPA's benchmark of 1.0 while hazards from arsenic were above 1.0 at both the site and reference stations. Consistent with the findings of the VS report, the results of this evaluation support the overall conclusion that PCBs are the primary human health risk driver at HPS.

5. ***Table 9-3, Page 173:*** **The toxicity criteria used in the presented in this table should be verified, and the source for each value should be provided. In cases where the Navy has preferentially selected a Cal EPA OEHHA toxicity criterion, the Navy needs to ensure that this criterion does not represent a less conservative approach than that recommended by EPA. For example, the slope factor for dibenz(a,h)anthracene given in Table 9-3 is 4.1E+00. Use of the slope factor for benzo(a)pyrene provided in EPA's Integrated Risk Information System (IRIS) database (and using a relative potency factor of 1.0) gives this value as 7.3E+00. In addition, based on a cursory review of the polynuclear aromatic hydrocarbons (PAH) toxicity criteria, it appears that the Navy may be using a set of relative potency factors other than those approved by EPA in their 1992 *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*, based on the relative toxicity of other PAHs to benzo(a)pyrene. Please use the most conservative approach, specify the source for each value and justify the use of any non-EPA approved values.**

   Response: Table 9-3 of the Draft Final VS Report has been updated to include the source of each of the toxicity criteria used. The toxicity values used in the assessment of PAHs were taken from DTSC OEHHA guidance and represent the more conservative criteria in comparison to the IRIS database. The text has been revised to apply the oral RfD for methylmercury of 1×10^{-4} mg/kg-day for mercury as requested by RWQCB (see response to RWQCB Comment #27); otherwise, all other toxicity criteria are the same as those previously used in the VS report.

6. ***Section 9.1.6, Human Health Risk Assessment Summary, Page 181:*** **Please explain why the first complete paragraph on this page indicates that consumption of shellfish poses only a low additional excess cancer risk to human health as compared to the reference stations, when the previous paragraph states total PCBs were found to be significantly above concentrations measured at the reference locations in both Areas IX and X. The following sentences temper this position somewhat with regard to the drivers of risk (TCDD); however there appears to be some inconsistency. After reviewing Table 9-4, it appears that risks due solely to PCBs at these areas are significantly greater than 10 times those associated with reference locations.**

   Response: As shown on Table 9-4 of the VS Report, total cumulative risks from each of the areas at HPS were comparable to reference. For example, cumulative risks from Areas IX and X were consistent with reference, while risks from Areas I, III, and VIII had lower risks than those found at the reference area. In general, risks associated with arsenic and dioxin account for more than 95% of the total risk associated with Area X. Concentrations of these chemicals are comparable to reference concentrations; therefore, the cumulative risk at reference is similar to that at HPS. By evaluating risks from individual stations in Area X, it was found that stations with elevated PCB concentrations had risks elevated compared to reference. Closer examination indicated that at those stations where the total cumulative risk was elevated above reference, elevated concentrations of PCBs were the distinguishing factor. However, although PCBs specifically in these stations may be elevated relative to reference, the actual contribution of total PCBs to the total cumulative risk is minimal (about 1 percent) due to the presence of other chemicals (e.g., arsenic, dioxin) that are comparable to ambient conditions.

7. ***Section 9.1.6, Human Health Risk Assessment Summary:*** **According to the conclusions presented on page 181, cumulative risks were elevated at Stations IX and X compared to reference areas due to PCB contamination. The risk assessment goes on to conclude that because 99 percent of the risk was due to COPCs for which estimated concentrations are within reference levels, "remediation of the remaining 1 percent will not be effective in reducing human risk." This represents a risk management decision, and for it to be made within the risk assessment is a violation of EPA's Policy for Risk Characterization (1995), which states that risk assessors "do not make decisions on the acceptability of any risk level for protecting public health or selecting procedures for reducing risks." In addition, such a decision without conducting a Feasibility Study effectively represents a circumvention of the CERCLA process and represents a unilateral decision by the Navy without consideration of input from all stakeholders. Accordingly, the conclusions of the risk assessment should be revised such that they are limited to an objective analysis of the potential risk levels posed by site contamination.**

   Response: Section 9.1.6 of the Draft Final VS Report has been revised to remove risk management language.

8. ***Section 11.2, Uncertainty Associated with Human Health Risk Assessment, Page 223:*** **The statement in the bulleted text on page 223 that because "arsenic skin cancers from ingestion which are not usually fatal and are amenable to treatment are included with more potent cancers in the total cancer risk estimates...may result in an overestimate of the cumulative risk" represents a lack understanding of carcinogenic risk assessment in Superfund. Whether or not a cancer is fatal is irrelevant to the "risk" of developing cancer. Accordingly, this conclusion should be deleted from the discussion of uncertainties.**

   Response: This statement has been deleted from the Draft Final VS Report.

California Department of Toxic Substances Control
Response to July 1, 2002 Comments

General Comments

1. ***General Comment #1.*** **This report is well written and presents the data analysis with very instructive graphic methods. However, HERD does not agree with some of the areas excluded and some of the contaminants which appear to be excluded. Specifically the proposed Remedial Action Objective (RAO) for polychlorinated biphenyls (PCBs) in the South Basin excludes mercury, copper and other contaminants.**

   Response: Please refer to the response to USEPA General Comment #1 regarding contaminants and areas that will be considered in the Parcel F FS. In South Basin, the highest concentrations of PCBs co-occur with the highest concentrations of mercury and copper, and sediment remediation based on PCB contamination should effectively remove the highest concentrations of these other constituents. It should be noted that PRGs for PCBs, mercury and copper have been developed in Section 10 of the Draft Final VS Report.

2. ***General Comment #2.*** **In addition, the Draft Validation Study Report for Parcel F concentrates on polychlorinated biphenyls (PCBs) in Area X, to the exclusion of other contaminants in Area X or other Areas of Parcel F. HERD considers additional Areas of Parcel F to pose an ecological hazard. Those areas are outlined below.**

   Response: Please refer to the response to USEPA General Comment #1 regarding contaminants and areas that will be considered in the Parcel F FS.

Specific Comments

1. ***Comment #1.*** **HERD does not agree with the statement that 'However, uncertainty associated with the previous data prevented clear definition of the extent of Parcel F sediments that posed unacceptable risk' (Section 1.0, page 1). All regulatory agencies and resource trustees considered areas in the Low Volume Footprint (LVF) and some areas in the High Volume Footprint (HVF) outlined in the previous Draft Feasibility Study (FS) (TtEMI and Levine-Fricke-Recon, Inc., 1998) to pose some hazard to ecological receptors. The regulatory agencies and resource trustees, however, agreed to allow the Navy to address the LVF as those areas of highest ecological hazard. Please amend the text to indicate that the agreement to investigate the LVF sediments addresses those areas considered to have the greatest risk based on the previous studies and analysis.**

   Response: Section 1 of the Draft Final VS Report has been revised to indicate that the low-volume footprint was identified as the area of greatest ecological risk based on previous data. However, it should be noted that the low-volume and high-volume footprints were based primarily on Effects Range-Median (ER-M) and Effects Range-Low (ER-L) values, which are not intended to represent unacceptable risk levels or to be used as cleanup goals.

2. ***Comment #2.*** **Please amend the text to indicate that not all the extensions of sampling beyond the LVF (Section 1.1.3, page 3) proposed by the regulatory agencies and resource trustees were included in this Validation Study (VS).**

Response: Section 1 of the Draft Final VS Report has been revised to indicate that some of the extensions proposed by the regulatory agencies and resource trustees were not included in the VS.

3. *Comment #3.* **The six to eight foot diameter drainage tunnel from Dry Dock 3, which leads to an outfall on the north side of Point Avisadero (Figure 1-4, page 6) should be investigated. Any contained sediments determined to be a source of continuing contamination of offshore sediments in this area should be remediated.**

   Response: A steel door currently blocks access a short distance into the tunnel, precluding sediment transport from the former dry dock. Alternatives for decommissioning this tunnel are currently under consideration.

4. *Comment #4.* **The metal debris and slag-like material in Area VIII (Section 1.2.3, page 7) should be removed as a source of future contamination of offshore sediments. This area could not be sampled using standard sediment sampling procedures and the Navy was notified that HERD considered this a potential future source area.**

   Response: The Navy is currently developing a plan for removing this material as part of Parcel E shoreline activities.

5. *Comment #5.* **The sampling of the Parcel E shoreline area, scheduled for the spring of 2002 (Section 1.2.3, page 7), should include mercury as a Contaminant of Concern (COC) for evaluation. This is the area where mercury concentration in offshore sediments approached the elevated mercury sediment concentration in Area III. Sampling should not terminate at the boundaries of Area VIII and Area IX, but cover the portion of Parcel E between these two areas. The Navy document states (Table 2-6, page 21) that the location of sediments in Areas VIII and IX, in addition to other areas are '…not clearly defined.'**

   Response: Mercury was included as a COPEC in the Parcel E shoreline sampling conducted in 2002. Mercury data for samples collected in 1996 between Areas VIII and IX indicate one sample with an elevated mercury concentration (i.e., >1 ppm) surrounded by samples with low concentrations. Additional samples were collected in this vicinity as part of the FS Data Gaps investigation conducted in October 2003. The results are presented in an addendum to the Draft Final VS Report. One sample had a mercury concentration exceeding 1 ppm.

6. *Comment #6.* **Please identify the Parcel F areas where the shoreline and intertidal areas are covered with riprap or disposal debris (Section 1.3.1, page 10) which will be managed as part of the upland parcels.**

   Response: The attached maps (Attachment B) of Areas III and X show the extent of shoreline rip rap and disposal debris. These areas are being addressed as part of the Parcel B and Parcel E investigations, respectively. The nature and extent of subtidal rip-rap and disposal debris in Area III were further characterized as part of the FS Data Gaps investigation conducted in October 2003.

7. *Comment #7.* **HERD does not consider the 'ancillary data' (Section 2.1, page 13) as of lower status than the three lines of evidence (i.e., sediment chemistry, toxicity and bioaccumulation). HERD views the 'ancillary data' as verification data for these three lines of evidence. This comment is included for consistency with the many discussions which led to the VS. No response is required for this comment.**

Response: The term 'ancillary' was not meant to imply that the data were less important, but rather that they were not formally evaluated within the WOE construct.

8. *Comment #8.* **HERD did not agree, during development of the VS work plan, that the proposed Weight of Evidence (WOE) approach (Figure, 2-1, page 14) would limit HERD interpretation of the results of the VS. The Navy was made aware of this reservation during development of the VS technical documents and work plan. This comment is included for consistency with the many discussions which led to the VS. No response is required for this comment.**

   Response: The Navy acknowledges that during VS Work Plan development, HERD reserved the right to independently evaluate the VS data.

9. *Comment #9.* **Step 5 of the Data Quality Objective table (Table 2-4, page 18) indicates a P=10 for an α=0.05. This is most probably a typographic error which should indicate β=0.10. If not please explain the P parameter.**

   Response: The SWRCB (1998) states that the reference envelope tolerance limits were "based on an alpha value of 0.05 and a 'p' value of 10," hence the abbreviations in the DQO table. The 'P' in the DQO table should be lower case. Hunt and others (1998), as referenced in SWRCB (1998), define the reference envelope 'p' value as "the percentile of the reference distribution that is designated as unacceptably toxic. A 'p' value of 10 establishes the tolerance limit such that there is a 95% certainty that a value lower than the tolerance limit would be in (or below) the most toxic 10% of samples collected from the water body that was characterized by the reference sites."

   References:

   Hunt, J. W., B. S. Anderson, B.M Phillips, J. Newman, R. Tjeerdema, M. Stephenson, M. Puckett, R. Fairey, R.W. Smith, and K. Taberski. 1998. *The Evaluation and Use of Sediment Reference Sites and Toxicity Tests in San Francisco Bay.* April 1998. California State Water Resources Control Board, Sacramento, CA.

   SWRCB (California State Water Resources Control Board). 1998. *Sediment Quality and Biological Effects in San Francisco Bay Protection and Toxic Cleanup Program Final Technical Report.* California State Water Resources Control Board Division of Water Quality. Sam Francisco Bay Regional Water Quality Control Board, California Department of Fish and Game Marine Pollution Studies Laboratory, California State University Moss Landing Marine Laboratories, University of California Santa Cruz Institute of Marine Sciences. August 1998.

10. *Comment #10.* **The No Observable Effect Concentration (NOEC) for ammonia (Section 2.1.3.1, page 18) equates a total ammonia concentration of 60 mg/l with an unionized ammonia concentration of 0.8 mg/l. The equilibrium between total ammonia and unionized ammonia is determined by many factors including water ion content and salinity. Please describe in the text how this relationship was developed and the limitations of the stated relationship.**

    Response: Both the total and unionized ammonia NOEC values were taken directly from the referenced U.S. EPA document (*Methods for Assessing the Toxicity of Sediment-Associated Contaminants with Marine and Estuarine Amphipods*, EPA Office of Research & Development, 1994). U.S. EPA does not provide a reference therein for the NOEC values. Therefore, it is unclear whether the unionized value was calculated with actual laboratory data for pH, temperature, and salinity, or with values representing the average of those parameters during the test (i.e., pH=7.8,

T=15ºC, S=28-30‰). The unionized ammonia calculation is most sensitive to pH, and the greatest limitation is an accurate pH measurement along with an accurate total ammonia measurement. The commenter is correct that the ionic strength and salinity also need to be taken into account when calculating unionized ammonia concentrations in seawater. Battelle Sequim Laboratory conducted baseline amphipod ammonia sensitivity research in the early 1990s, in which unionized ammonia concentrations were calculated from measured sample pH, temperature, salinity, and total ammonia concentration, using an equation derived from Whitfield's theoretical models to determine the dissociation constant of ammonium in seawater. Battelle's *E. estuarius* NOEC was 67.1 mg/L total ammonia (1.298 mg/L unionized ammonia). Several unionized ammonia conversion programs are in circulation; the main difference between them is probably in derivation of the pK_as (acid hydrolysis constant in saline water).

11. ***Comment #11.*** **HERD disagrees that the benthic invertebrate and forage fish collected in Areas I, III, VIIII, IX and X could not be used in the evaluation (Section 2.1.5.2, page 22). The regulatory agencies and resource trustees stated specifically during development of the VS work plan that if the field collected tissue samples were significantly elevated above the laboratory *Macoma nasuta* tissue concentrations, then the field tissue concentrations should be used to evaluate hazard to upper trophic levels. Tissue concentrations of soft bodied invertebrates (SBI) for inorganic elements and some organic compounds are consistently elevated above tissue concentrations for *Macoma nasuta* (Figures 7-10 through 7-15). The hazard to the surf scoter, one of the representative species, should be assessed using the SBI tissue concentrations. The Navy may include the assessment of the surf scoter based on *Macoma nasuta* tissue concentrations at their discretion.**

    Response: Dose assessment results based on the field-collected tissue data have been added to Section 7 in the Draft Final VS Report. The issues raised in this comment are discussed in greater detail in the response to USEPA Specific Comment #5. Briefly, the SBI and HBI tissue data were included in the VS to support the evaluation of the bioaccumulation line of evidence. Data from field-collected tissues were not used directly in the WOE evaluation because only one composite sample of each tissue type was available from each area, and the WOE was conducted on a station-by-station basis.

12. ***Comment #12.*** **HERD has a basic disagreement with the WOE methodology (Section 2.1.6, page 24). A station where benthic toxicity is demonstrated but bioaccumulation does not significantly exceed reference, or the converse, does not mean that station has no hazard. Such a result means that the ecological hazard is to different representative components of the biological community. HERD agreed that the WOE approach could be presented, but that HERD would provide independent analysis of the data collected. The HERD analysis is contained in Specific Comment number 45. The Navy was made aware of that position during development of the VS work plan.**

    Response: The Navy was aware that HERD would provide an independent analysis of the data collected in the VS. The integration of endpoints in Step 4 of the WOE process was not meant to cancel out results from individual endpoints. "Bright-line criteria" were set in a conservative fashion so that significant concordance among the endpoints at a particular station was required before a finding of no further evaluation was given. Most of the WOE scores fell into the "gray" area, and therefore required further evaluation outside the context of the WOE. Because all data were taken into consideration when identifying the exposure pathways and chemicals that were driving risk (as described in Section 10 of the VS Report), the Navy does not believe that differences in opinion related to the WOE methodology impact the overall findings and recommendations of the VS Report.

13. ***Comment #13.*** **The DQO process indicates that benthic fauna composition and abundance will be considered (Table 2-13, page 32). HERD could find no benthic community analysis in the results of the VS. Please indicate which Appendix, on CD-ROM, contains that analysis.**

    Response: The evaluation of benthic fauna composition and abundance described in Table 2-13 was inadvertently omitted from the Draft VS Report and has been added to Appendix M of the Draft Final VS Report. However, it should be noted that the inclusion of this information in Step 3 of the DQOs for Radioisotope Profiling (Table 2-13) was intended primarily to provide information on bioturbation as it relates to FS-related work (i.e., it was not intended to support the assessment of ecological risk).

14. ***Comment #14.*** **The Red Rock and Alcatraz Environs reference stations should not be considered in the evaluation of reference stations for the Sediment Water Interface Cores (SWICs) because they were sampled by drag sampler and homogenized prior to placement in the SWIC tubes (Section 3.1.1.3, page 40).**

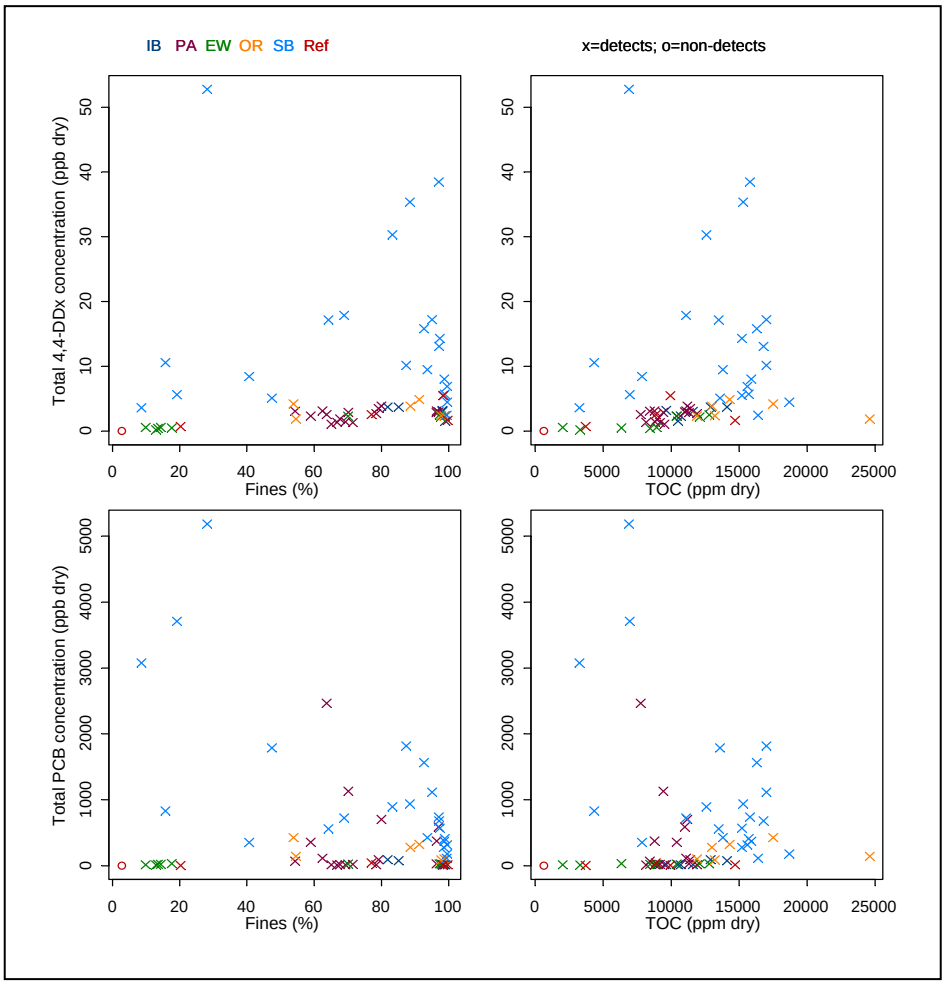
    Response: The Red Rock and Alcatraz Environs reference station SWIC data are provided for informational purposes only and were not included the evaluation of SWIC test results. Instead, SWIC results for cores from HPS stations were compared only to the SWRCB reference envelope. All sediment chemistry and bioassay analyses were performed on reference stations to determine whether the results were consistent with existing SWRCB reference data and, thereby, to evaluate the suitability of the reference sites.

15. ***Comment #15.*** **The fish tissue sample summary lists black surfperch and walleye surfperch (Table 3-4, page 54). However, the appendices do not seem to list these composite samples. Please specify the appropriate location.**

    Response: The black surfperch and walleye surfperch samples listed in Table 3-4 are archived tissue samples that were not analyzed. Upon completion of the sampling effort, the fish collected were separated by species and location into 2 composites per area (e.g., north, east, and south) according to an agency-approved compositing scheme. The few remaining fish not included in the compositing scheme were separated by species and archived. Therefore, these samples have been removed from Table 3-4 in the Draft Final VS Report.

16. ***Comment #16.*** **Total Organic Carbon (TOC) ranged from 650 mg/kg at Alcatraz Environs to 14,700 mg/kg at Bay Farm (Section 4.1.1.2, page 57). Please provide a bicoordinate plot of PCB and DDx concentration versus TOC.**

Response: This plot is provided below.



Total DDx and Total PCBs versus TOC and Percent Fines. Colors are associated with the five HPS areas and Navy reference locations.

17. ***Comment #17*****. The maximum sediment mercury of 7.47 mg/kg is omitted from the box and whisker plots, but indicated in Area III by the triangle (Figure 4-2, page 61). This is in the same area where former sampling showed sediment mercury concentrations in excess of approximately 12 mg/kg. HERD recommends this area be included for consideration of remedial alternatives.**

Response: Point Avisadero (Area III) will be included in the Parcel F FS. Additional sampling was conducted as part of the FS Data Gaps evaluation in October 2003 to better delineate the horizontal and vertical distribution of copper, mercury and PCBs in Area III. These data are provided as an addendum to the Draft Final VS Report.

18. *Comment #18.* **Please explain the different labeling of the last group on the right of the box and whisker plot in Figure 4-7. The majority of the box and whisker plots label this group as 'Ambient Stations' (e.g., Figure 4-1 and 4-3). The box and whisker plot for chromium labels the last group on the right (4-7) as 'BPTCP Stations'.**

    Response: Section F.2.2, page F-4 of the VS Report provides a detailed explanation of the box and whisker plots presented in the document. Ambient data for most inorganic constituents represent a combination of Regional Monitoring Program (RMP) and Bay Protection and Toxic Cleanup Program (BPTCP) reference site data form 1993 to 1997. The only exceptions are antimony, aluminum and chromium. For antimony, BPTCP reference site data is presented alone because this constituent was not reported by the RMP. For aluminum and chromium, BPTCP data prepared by total dissolution (in hydrofluoric acid) was presented to maximize comparability with the 2001 fixed lab Navy data that used a more complete digestion technique (includes hydrofluoric acid) to prepare samples, thereby pulling aluminum and chromium out of the sediment matrix. For a more complete discussion, and the comparison of data generated by different analytical methods, please see Appendix F of the VS Report.

19. *Comment #19.* **The concentration of contaminants in the upper 5 centimeters (cm) appears elevated in Area III and Area X, to a somewhat lesser degree in Area VIII and IX, with a small number of high concentrations in Area I. These concentrations occur despite the Navy finding that the sedimentation rate in the South Basin is 1 cm/year. Given this estimate, samples from the upper 5 cm of sediment would then represent the period from 1997 to 2001, well past the major Navy activities at HPSY. The distribution of PCB concentrations with depth (Figure 4-13, page 77) and ER-M Hazard Quotients (ERM-Qs) (Figure 4-16, page 81) clearly indicate the depth interval of concern in Area X and other HPSY areas. Samples at depth are, therefore, more indicative of Navy releases at HPSY. Sampling locations which exceed the National Oceanic and Atmospheric Administration (NOAA) Exposure Range-Median (ER-M) (e.g., PA-41 and PA-44, Section 4.2.2, page 74 and PA-40, PA-41, PA-44, PA-47, Section 4.2.3, page 74) are candidates for consideration of remedial alternatives attributable to Navy activities at HPSY. Please see Specific Comment number 45.**

    Response: Please refer to the response to DTSC Comment #45 for a discussion of the rationale for including various areas in the Parcel F FS. It should be noted that post depositional processes (e.g. bioturbation) can mix sediments and disrupt the sediment profile, despite the fact that the radioisotope dating method assumes that the sediment column is undisturbed. The average sedimentation rates estimated for South Basin based on radioisotope data should not be applied to other areas of HPS because the radioisotope profiles from the other areas showed evidence of post-depositional disturbance. Therefore the 1cm/yr deposition rate observed in Area X likely does not apply to Area III, where the sediment dynamics study (Appendix M of the VS Report) indicated that sediments are subjected to periodic resuspension and erosion. Conceptual site models (CSMs) for Areas III and X will be refined based on the data collected in the FS Data Gaps investigation. Detailed CSMs will be provided in the FS Report.

20. *Comment #20.* **HERD has several requests regarding the Principal Components Analysis (PCA) provided for the distribution of PCBs (Section 4.3.3, page 82 and Figure 4-17):**

    Please provide the percent of variation attributable to each PCA component.

    Response: The data exploration software that was used to perform the PCA does not provide information about the percent variation attributable to each PCA component.

Please attempt a discriminant analysis with the groupings set according to the hypothesis that there is an eastern South Basin, middle South Basin and Yosemite Creek signature of PCBs. Report the variable loadings for this analysis along with the figure of the first two discriminant axes.

Response: The PCA analysis presented in the VS Report was performed using the PCB congener data that were deemed to be reliable (e.g., congeners that were infrequently detected and/or at concentrations near the limit of detection were removed from the analysis). This exclusion was performed to obtain a more robust dataset for PCA purposes, and was performed with no bias and without regard to any pre-established hypothesis. The site groupings in Figure 4-17 of the Draft VS Report suggested PCB signature differences among the eastern South Basin, the middle South Basin, and the Yosemite Creek area. An alternative approach of selecting the data and the analysis in a more targeted manner (i.e., following a review of a PCA loadings plot) to evaluate a specific hypothesis was considered to be inappropriate and would have lent less credibility to the conclusions. Nevertheless, the PCA has been repeated using just 9 PCB congeners: the 4-5 congeners with a composition that is most unique to Yosemite Creek, and the 4-5 congeners most unique to the west side of South Basin. The resulting PCA plot is presented below as Figure 1. The sample groupings and separations are similar to those shown in Figure 4-17, and even with a location-targeted selection of the congeners, the resolution did not increase notably. This confirms the findings that there are only slight differences in the composition of the PCBs in the sediments, with a composition that is similar to Aroclor 1260 along the eastern shore, and compositions ranging between Aroclor 1260 and a combination of Aroclors 1260/1254 in other areas.

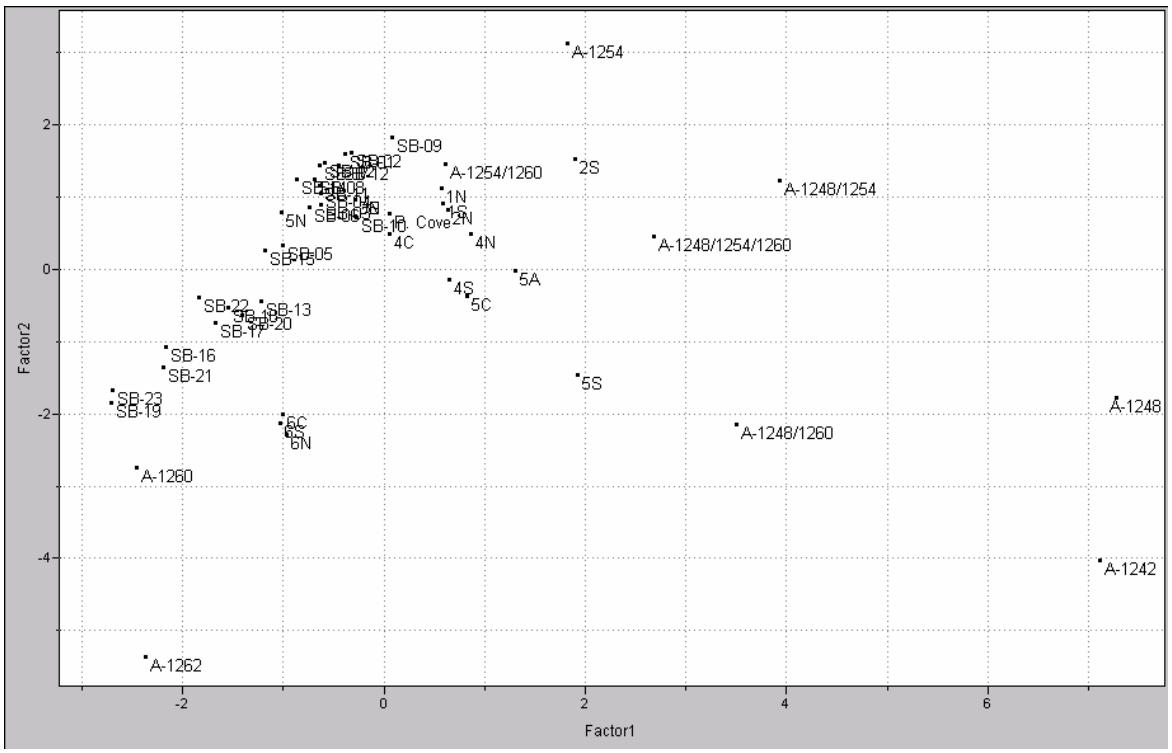


Figure 1. PCA of dataset using 9 of the 18 PCB congeners –the 4-5 congeners that are most specific to the Yosemite Creek and the 4-5 most specific to the west side of South Basin.

Figure 2, below, is the loadings plot that is associated with Figure 4-17 of the Draft VS Report, showing the relative influence of different PCB congeners in the separation of samples in Figure 4-17. This loadings plot displays the same two loadings factors that were used in Figure 4-17 for direct comparison of compounds that influence the separation in the x-axis direction (Factor 1) and the y-axis direction (Factor 2). This plot is provided for informational purposes to address the second request in the comment above.

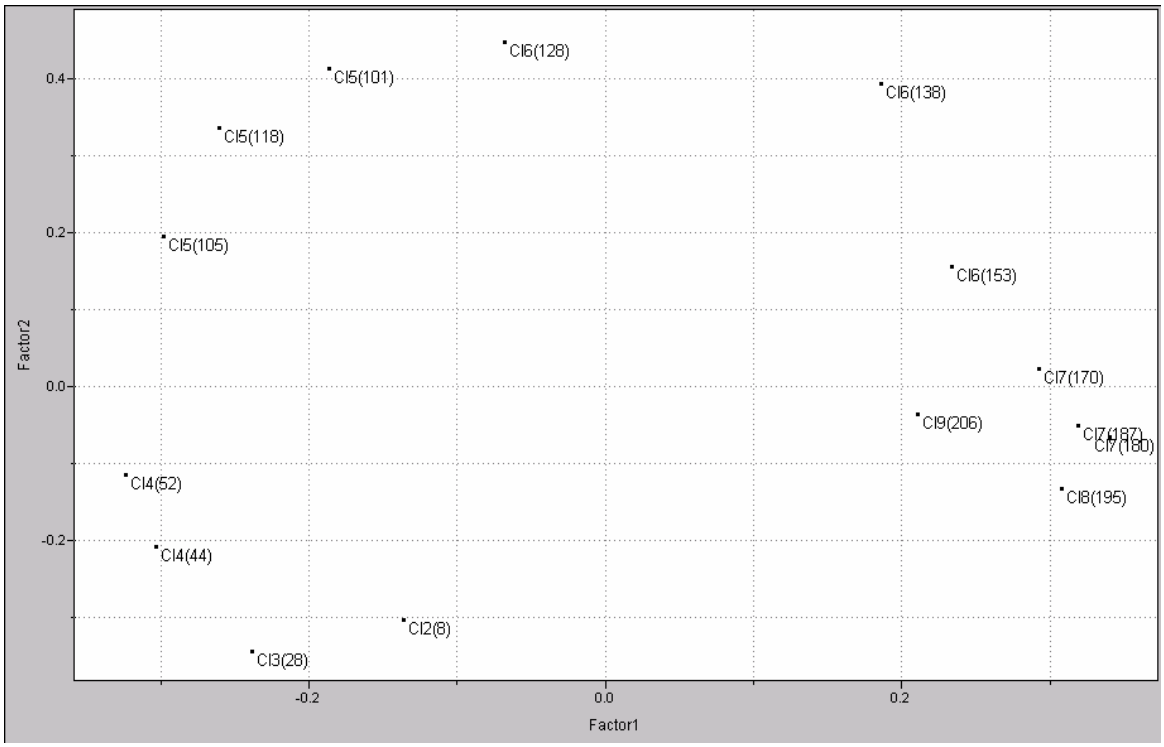


Figure 2. Loadings plot for the PCA shown in Figure 4-17 of the Draft VS Report

21. ***Comment #21.*** **HERD agrees that the apparent differences in Aroclor distribution may be due to environmental dechlorination of Aroclor 1260 (Section 4.3.3, page 84) as opposed to differing sources. Please provide a listing the recorded use of specific Aroclors and volume purchased during Navy activities at HPSY to aid in review of the Parcel F sediments.**

    Response: Inventories or other records of specific Aroclors used and volume purchased during Navy activities at HPS are not available. The existing PCB congener data for sediment samples are not sufficient to definitively determine the reason for the apparent compositional differences between PCBs on the east side of South Basin and those in Yosemite Creek.

22. ***Comment #22.*** **Thirteen of 59 SWICs had less than 60 percent normal development (Section 5.2, page 85). These sampling Areas (Table 5-4) are in the same Areas identified above based on increased concentration at depth and some sample locations are the same.**

    Response: The relationship between stations with <60% normal development and chemical concentrations in sediment, including increasing concentrations with depth, is very difficult to establish. COPECs were not elevated at IB-54, -58, and –59, and were lower at OR-25 than at neighboring stations, yet SWI toxicity was observed. Cores were collected at, or adjacent to, most of those stations, but these cores did not consistently show increased COPEC concentrations with depth (except in

Area X). The table below provides an evaluation of the thirteen SWICs with <60% normal development relative to available information on COPEC concentrations with depth. Six of the thirteen had evidence for significant ammonia contributions to toxicity, and some also had possible low DO effects.

Station PA-50 actually had the greatest decrease in normal development (1.4% larvae normally developed, but also evidence of ammonia and possible anoxia contributions to toxicity). Stations PA-41 and PA-47 had 93.2% and 97.0% normal development, respectively. Larval development ranged from 41.6% normal at PA-49 to 90.4-97.7% at the other stations in Area III where cores were collected (PA-40, PA-44, PA-52). Cores were not collected at the other stations in Area III where SWI toxicity occurred (PA-42, PA-50, PA-51); however, the position of these stations along the outer edge of Area III suggests that the contaminant profile would be similar to that in cores from PA-44, -49 and –52, in which COPEC concentrations did not increase with depth. Therefore, the decreased mean percent normal development associated with cores from Areas I, III, VIII and IX, does not appear to indicate COPEC-related toxicity. This issue is also addressed as part of the response to USEPA Specific Comment #1.

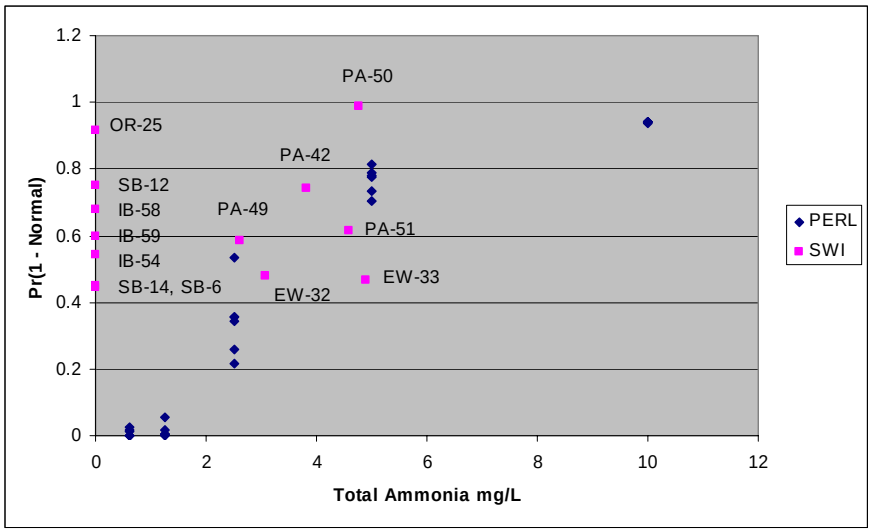
Station	Mean % Normal	Increasing Concentration at Depth?	Comments
IB-54	45.9	No core (COPECs in adjacent core IB-56 were not more elevated at depth)	
IB-58	32.3	No core (COPECs in adjacent cores IB-56 and IB-59 were not more elevated at depth)	
IB-59	40.1	No: Surface ERM-Q > 0-2 ft ERM-Q	
PA-42	25.9	No core (COPECs adjacent cores PA-40 and PA-41 were more elevated at depth)	probable ammonia toxicity; also potential low DO effect
PA-49	41.6	No: Surface ERM-Q = 0-2 ft ERM-Q	probable ammonia contribution to toxicity
PA-50	1.4	No core (COPECs in adjacent core PA-49 were not more elevated at depth)	probable ammonia contribution to toxicity; also potential low DO effect
PA-51	38.7	No core (COPECs in adjacent core PA-52 were not more elevated at depth)	probable ammonia contribution to toxicity; also potential low DO effect
EW-32	52.1	No core (COPECs in adjacent core EW-31 were not more elevated with depth)	probable ammonia toxicity
EW-33	53.3	No core (COPECs in adjacent core EW-31 were not more elevated with depth)	probable ammonia toxicity
OR-25	8.5	No core (COPECs in adjacent cores OR-24 and OR-28 were not more elevated at depth)	
SB-06	55.4	Yes	
SB-12	25.1	Yes	
SB-14	55.2	No core (but COPECs in adjacent cores SB-06 and SB-12 were more elevated at depth)	

23. *Comment #23.* **It is not unusual for sediment samples with high inorganic element concentrations, such as copper (Section 5.2, page 92), to display relatively low benthic invertebrate toxicity at shipyards or former shipyards. The elevated concentration is most probably due to the metallic waste from ship construction and reconditioning. HERD considers these areas sources for future impacts and injury as the metallic components transition to more soluble forms in the marine/estuarine environment. HERD has informed the Navy that this material should be removed.**

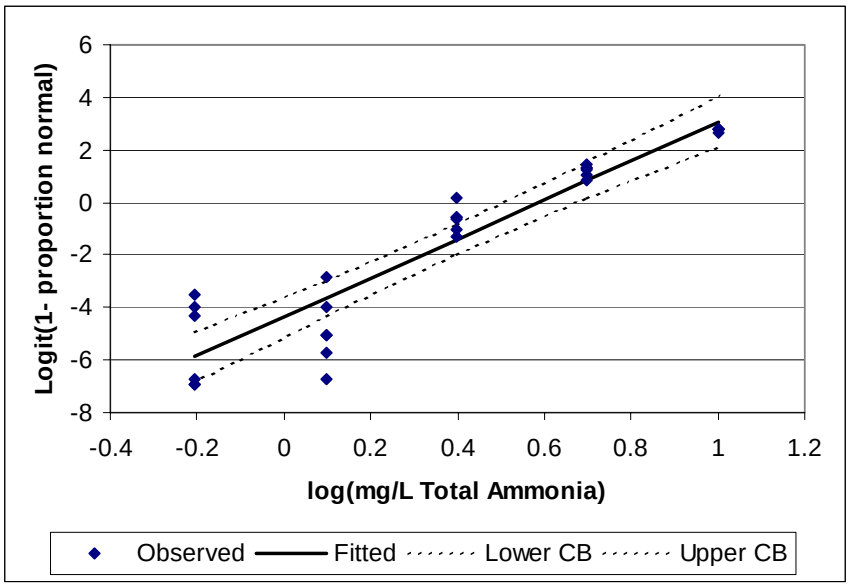
Response: The method used to analyze metals does not distinguish between forms of metals or the matrices in which they are contained (i.e., sediment grains, metal debris particles, or paint chips). Metals such as copper and mercury buried at depth in anoxic sediments likely exist as insoluble sulfides, while those in oxygenated surface sediment are more likely to be insoluble oxides. Mercury and copper were identified in the Draft Final VS Report as the primary risk drivers in Area III, and PRGs for these metals have been developed in Section 10. These PRGs will be used in conjunction with contaminant distribution maps to define the area to be considered in the FS.

24. ***Comment #24.*** **Ammonia in Sediment Water Interface Column (SWIC) toxicity tests is proposed as the rationale for some urchin larvae toxicity (Section 5.2, page 92) with reference to the figure on the following page (Figure 5-2, page 93). Please explain this figure more fully in comparison to the statements made in the text. The numbers do not appear to agree. Thirteen SWIC samples had less than 60 percent normal development. Six stations with the 'solid' diamond symbol are listed and three with an 'open' diamond are listed. Even these total up to 9 out of thirteen with normal development less than 60 percent. Please explain the significance of what appear to be 'solid' circular symbols on the y-axis of the graph. Please provide an explanation for the fact that only three samples appear to lie within the 95 percent confidence limit of the dose-response curve. Please provide the statistical method used to derive the dose-response curve. HERD agrees that the composite ammonia sample analyzed during this test removes the ability to determine the actual ammonia concentration for any individual replicate. The ammonia discussion may, therefore, be of relatively little interpretive value.**

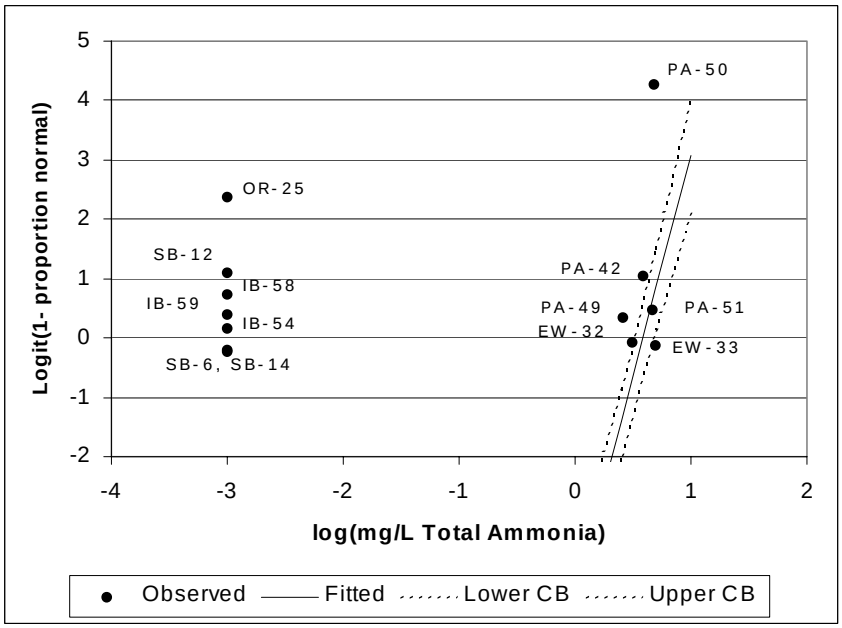
Response: Section 5.2 and Figure 5-3 have been revised in the Draft Final VS Report. In summary, the intent of the original graphic is maintained, which was to identify stations where some or all toxicity (low normal development) can be attributed to ammonia, versus where toxicity is clearly *not* attributable to ammonia. Plot 1 below shows the thirteen HPS SWI stations with normal development <60% overlaid on the ammonia-only dose response (Pacific Ecorisk Laboratory [PERL]). In Plot 2, the ammonia-only dose-response data were transformed to linear and the regression and confidence limits were recalculated and plotted correctly. Finally, all thirteen of the stations with normal development <60% were overlaid on the corrected regression plot to create the revised Figure 5-2 below.



Plot 1. HPS SWI stations with <60% normal development (SWI) overlaid on ammonia-only dose-response (PERL)



Plot 2. Dose-response and 95% confidence bands about the mean response of logit(1-proportion normal) *S. purpuratus* larval development obtained from six reference toxicant tests conducted by PERL.



Revised Figure 5-3. SWI larval responses with less than 60% normal development overlaid on the PERL reference toxicity data dose-response relationship between the logit(1-proportion normal) corrected for the control against the log10 of total ammonia concentration + 0.001 (mg/L).

The text in Section 5.2 of the Draft Final VS Report has been revised to explain the revised figure shown above.

25. ***Comment #25.*** **Any ecological hazard indicated in the SWIC tests is not indicative of hazard only to echinoderms (Section 5.3, page 94). Adverse effects are indicative of hazard to open water invertebrate larvae in general and to the survival of the adult populations of those larvae. Please amend the text to indicate that the urchin larvae is representative of a group of broadcast-spawning invertebrate species.**

    Response: Section 5.3 of the Draft Final VS Report text has been amended as requested.

26. ***Comment #26.*** **HERD does not agree that the consideration of the bioaccumulation assessment for the surf scoter (Section 6.0, page 95) is complete. The stated position of the regulatory agencies and trustees was that, in the event the field collected invertebrate tissues had a higher concentration than the *Macoma nasuta* tissues, the field collected tissue concentrations would be used in the assessment of upper trophic levels. Please provide the assessment of the hazard to invertebrate feeding avian receptors using the most protective tissue concentrations.**

    Response: Section 7 of the Draft Final VS Report has been revised to include a dose assessment based on field-collected tissue data.

27. ***Comment #27.*** **The *Macoma nasuta* survival exceeded the test criterion of 80 percent survival except for five stations (EW-35, IB-56, SB-04, and SB-19 (Section 6.1, page 96). Please provide the specific location of these sampling locations related to elevated contaminants and ERMQs to determine whether the survival levels are related to the ERMQ patterns.**

    Response: Please refer to the response to USEPA Specific Comment #4 for a discussion of the *M. nasuta* survival. Briefly, percent survival for *M. nasuta* was plotted against ERM-Q values to evaluate whether elevated ERM-Qs were related to survival rates. This plot revealed no apparent association between ERM-Q and survival of *M. nasuta.*

28. ***Comment #28.*** **The hazard of selenium intake to invertebrate-feeding birds (e.g., the surf scoter) should be incorporated into the evaluation of the upper trophic levels as the 90th percentile selenium concentration for the *Macoma nasuta* tissue is 5.34 mg/kg (Table 6-3, page 97). Except for sampling locations near oil refineries, this tissue concentration is certainly at the upper extreme of mussel tissue concentrations in San Francisco Bay determined by the California Department of Fish and Game State Mussel Watch Program.**

    Response: Selenium was evaluated in the dose assessment and results of this evaluation are presented in Appendix H of the VS Report. While Appendix H provided the results of a dose assessment for all COPECs detected in tissue, the text in Section 6 focused on COPECs with tissue concentrations that exceeded tissue reference threshold concentrations. The tissue reference threshold value for selenium is assumed to be representative of reference conditions for *M. nasuta* in San Francisco Bay because there is no evidence that selenium in sediments is elevated above ambient sediment conditions at the VS reference sampling locations (see Appendix G-1 of the VS Report).

29. ***Comment #29.*** **Ecological Risk Assessment (ERA) focuses on threshold toxicants, as ERAs do not generally deal with carcinogenic toxic end points. Use of any Site Use Factor (SUF) (Section 6.2.1.1, page 98) for site specific intake must also incorporate offsite intake to determine the total hazard. The dose equation appears to be missing an addition sign between the two components surrounded by the '{ }' brackets (Section 6.3.2, page 111, equation 6-5) making it difficult to determine whether the offsite intake is added to the total dose. It appears that this is the case,**

as relative site-specific and reference intakes are presented (e.g., Figure 6-9). The equation would appear to need modification given the figures presented.

Response: A typographical error in the equation has been corrected. As noted, the typographical error had no impact on the figures or calculations, as the actual working equation was correct.

30. *Comment #30.* **HERD commented during the development of this work plan that the maximum of the depurated *Macoma nasuta*, non-depurated *Macoma nasuta* and field-collected invertebrate tissue concentration would be used in the evaluation of upper trophic level effects. Contrary to this agreement, the depurated *Macoma nasuta* tissue concentrations are used in the assessment of the hazard to the surf scoter (Section 6.3.2, page 111). This is unacceptable to HERD. The tissue concentration for Soft Bodied Invertebrates (SBI) is significantly higher than other tissue concentrations (Figures 7-10 through 7-15) for many elements and some organic compounds. As the surf scoter eats SBI, please recalculate the hazard to the surf scoter using the SBI tissue concentrations.**

Response: Please refer to the response to USEPA Specific Comment #5 for a detailed discussion of the bioaccumulation evaluation using field-collected tissue data. Briefly, tissue concentrations for both HBI and SBI have been evaluated in a dose assessment and the results have been included in Section 7 of the Draft Final VS Report. Although there are some differences in chemical concentrations between the tissue types, these differences are not significant enough to result in different conclusions from those drawn from the analysis based on laboratory *M. nasuta* data. Based on the comparison of HQ results from stations adjacent to where invertebrates were collected in the field (Tables A-1 through A-5, Attachment A), the evaluation based on laboratory *M. nasuta* data is considered to adequately represent exposure to field-collected invertebrate tissue.

31. *Comment #31.* **HERD does not agree that a Hazard Quotient based on the Low TRVs (HQ_{low}) greater than 10 is a criterion for evaluating food web transfers to the surf scoter (Table 6-6, page 101, and subsequent tables for each Area).**

Response: As explained in the Final VS Work Plan, an $HQ_{low} > 10$ was not a criterion for deciding whether further evaluation of bioaccumulation was necessary. Rather, an HQ>1 was the main decision criterion. As such, the categories presented in Tables 6-6 through 6-10 are simply groupings that were selected because they correspond to the major WOE categories in the WOE. They are presented in Section 6 of the Draft VS Report for informational purposes only.

32. *Comment #32.* **Toxicity Reference Values (TRVs) for the scoter assessment (Table 6-5, page 100) were checked at random and found to agree with the Navy/BTAG (Biological Technical Assistance Group) values published in draft form.**

Response: No response required.

33. *Comment #33.* **HERD does not agree with any all encompassing statement regarding the potential impact of bioavailability (Section 6.3, page 109) without site-specific testing of the bioavailability of the Contaminant of Concern (COC) and information from the toxicity test used to set the TRV regarding the bioavailability of the compound used to set the TRV. In the example cited (e.g., lead), the absolute bioavailability of lead carbonate, which can occur as a lead compound in the environment, is fairly comparable to the absolute bioavailability of lead acetate used in the toxicity test which is the basis for the lead TRV. Please see HERD EcoNOTE number four for methods of evaluating the bioavailability of lead.**

Response: Although lead carbonate may be present in site sediments, the great majority of lead (and other metals) is likely to be in less soluble forms, such as lead sulfides. Predictions regarding the bioavailability of lead (and other inorganic constituents) are difficult, particularly when a number of different forms of the metal occur simultaneously. However, because the majority of lead in sediments is in less soluble forms, the statement that TRVs based on more soluble forms may overestimate actual risk is believed to be valid.

34. *Comment #34.* **The text refers to an Area-wide ERA. Please present figures and tables similar to those provided for each Area (Section 6.3) for the area-wide assessment mentioned in the text (Section 6.4, page 120). There is a three-paragraph discussion of this analysis, but no figures or tables are presented.**

Response: Figures and tables of the Area-wide ERA were provided as Table 6-12 and Figures 6-9 through 6-11 of the Draft VS Report. In the Draft Final VS, evaluations based on the area-wide 95%UCL are provided.

35. *Comment #35.* **Correlation of ammonia concentration with rates of normal development (Figure 7-1 and 7-2, page 125) does not mean that ammonia is the cause of decreased rates of normal development. Please state the sediment holding time prior to initiation of the developmental tests. Sediment samples held beyond recommended holding times or at temperatures above recommended levels could conceivably develop elevated ammonia concentrations.**

Response: The homogenized sediment samples were held approximately 31-40 d in a 4ºC walk-in cold room prior to the Battelle TIE experiment. SPP for TIE testing was prepared within the 6-week holding time limit except for Batch 3: Batch 3 purging to reduce porewater ammonia was initiated within 6 weeks, but actual testing did not occur until after 25 days of purging. Porewater ammonia could have changed in the holding time period, but because the experiment was intended to look at effects of ammonia reduction, measurements were made on the concentration series of SPP test solutions rather than porewater. (Note: all SWI tests conducted for the toxicity line of evidence were initiated within the 96-h holding time limit for SWI cores). It is true that a decrease in normal larval development could occur for reasons other than ammonia, such as particle-associated or dissolved COPECs in the suspended-particulate samples used in the TIE test. However, ammonia is much more soluble than metal or organic contaminants and can freely cross cell membranes of living organisms; ammonia is generally suspected of being the primary toxicant when it is present at toxic levels. If a COPEC was also contributing to toxicity, an additive effect should be visible on the plots. That is, the dose-response would fall below the line expected for response due to ammonia alone—for example, SB-19 in Figure 7-1, which had fairly low ammonia but was toxic at all suspended particulate phase (SPP) concentrations.

36. *Comment #36.* **Unionized ammonia is the component of total ammonia which is most closely correlated with aquatic toxicity. The relationship of unionized ammonia to total ammonia is dependent on hardness, pH and temperature. Therefore, without correction for these factors, or verification that all were identical in each of the three groups, there can be no comparison based on total ammonia. All the samples from locations EW-33, SB-21 and SB-23 (Figure 7-3, page 127) appear to demonstrate normal development rates below the proposed ammonia dose-response curve. This would indicate that in all three locations, there was some adverse effect not attributable to the proposed effect based on total ammonia.**

Response: Comparisons of toxicity with total ammonia are believed to be appropriate for marine toxicity studies with crustaceans and echinoderms because the correlation of toxicity to unionized

ammonia is weaker for these species than it is for vertebrates such as fish. All reported unionized ammonia values were calculated using measured total ammonia, pH, conductivity, and temperature values for the same sample. The Navy agrees that EW-33, SB-21, and SB-23 appear to demonstrate normal-development rates below the ammonia dose-response curve in Figure 7-3, indicating that something other than, or in addition to, ammonia was responsible for adverse effects.

37. ***Comment #37.*** **Please explain the upward slope of the upper confidence limit on the regression line at approximately 1 mg/l total ammonia (Figure 7-3, page 127). Confidence limits on a regression line typically run parallel to the median estimate of the regression.**

Response: Figure 7-3 has been corrected and replaced in the Draft Final VS Report. The ammonia regression figure in Section 5 has been corrected to reflect correctly estimated confidence limit for the regression (see the response to DTSC Comment #24 above).

38. ***Comment #38.*** **The ecological risk assessor for the U.S. Environmental Protection Agency (EPA) has personally witnessed wind-driven waves in the South Basin (i.e., Area IX and X). This would tend to negate the argument made regarding bioavailability (Section 7.1.3, page 128). Please indicate in the assessment of depositional vs. erosional environments, the frequency with which these episodes of wave-generated surge might occur.**

Response: As described in Appendix L (*Sediment Dynamics Study Report*) of the VS Report, site-specific measurements indicated that suspended sediment concentrations in South Basin increased during periods of high winds from the south-southeast (i.e., during winter storm events). Modeling results based on the site-specific data indicated that frequencies of resuspension of the loosely consolidated surficial sediment during winter and summer (combined) at the two South Basin stations were 5% and 9% of modeled days. Frequencies of resuspension of sub-bottom sediment during winter and summer (combined) were 1% and 3% of modeled days, with erosion of sub-bottom sediment only occurring in South Basin during infrequent high wave events (i.e., severe winter storms).

Section 7.1.3 of the Draft VS Report states that ". . . both TIE tests created conditions that increased COPEC bioavailability, a phenomenon that is unlikely unless the sediment bed is significantly disturbed." A major storm event that causes sediment resuspension could be considered a significant disturbance, depending upon the depth to which the sediment bed is eroded (the depth of erosion was not determined in the Sediment Dynamics Study). Resuspension of loosely consolidated surficial sediment is not likely to result in a significant increase in bioavailability because the highest COPEC concentrations are typically found at depth. It should be noted that the SAIC/EFANE TIE study was conducted using porewater samples and a testing scenario that does not represent potential storm conditions. The Battelle TIE study was conducted using suspended-particulate phase (SPP) samples, which more closely approximates resuspended material.

39. ***Comment #39.*** **The comparison of tissue concentrations for depurated *Macoma nasuta* vs. non-depurated *Macoma nasuta* requires further discussion:**

A. Please provide a plausible hypothesis why the tissue concentration for the non-depurated *Macoma nasuta* is lower than that for the depurated *Macoma nasuta* tissue concentration (i.e., aluminum, antimony, barium, iron, manganese, mercury, nickel and vanadium) (Section 7.2.1, page 129). Alimentary canal concentrations of non-incorporated sediments should have elevated the total concentration of the non-depurated *Macoma nasuta* above that of the depurated *Macoma nasuta*.

Response: For the COPECs listed above, the nondepurated tissue concentrations were greater than in depurated tissues, as evidenced by data points above the 1:1 correspondence line shown in Figures 7-4 through 7-7.

B. The cadmium tissue concentration in depurated *Macoma nasuta* for the sample from Area IX appears extremely elevated relative to the non-depurated *Macoma nasuta* tissue concentration (Figure 7-4, page 130). Cadmium in area IX may require further investigation.

Response: The cadmium concentration in one sample of depurated *M. nasuta* tissue from Area IX appears to be a single anomalous observation. The reason for this observation is not clear, although a focused validation of this outlier identified no apparent laboratory error. Examination of all available cadmium data for Area IX (including *Macoma* bioaccumulation data) indicates that this single observation does not reflect an area-wide problem in need of additional investigation.

C. HERD does not necessarily agree with the comment regarding 'double counting' of sediment ingestion regarding the use of non-depurated *Macoma nasuta* (Section 7.2.1, page 128). There are two components of incidental sediment ingestion. One is the intake of sediment adhering to the outside of the organism and the other is the intake of sediment contained in the alimentary canal. As the non-depurated *Macoma nasuta* were presumably washed prior to tissue preparation, the first component is not included in the analysis. The non-depurated tissue concentration may, perhaps, be an underestimate of the total intake. Please amend the text to indicate that '…in this study the non-depurated tissue concentration was considered to represent the total sediment intake…'

Response: The dose model is a two-compartment model that accounts for exposure through both sediment ingestion and prey ingestion. The incidental sediment ingestion parameter includes intake of sediment from all sources including: (1) sediment associated with the prey item, including sediment adhering to the outside of the organism as well as within the alimentary canal, (2) sediment incidentally ingested during foraging (e.g. probing in sediment), or (3) preening. Most studies base their estimation of IR_{sed} on the amount of sediment they find in the bird's GI tract or what is measured after it has passed through the bird's digestive system. Thus, the measure of IR_{sed} is based on all components and the contribution from each individual component cannot be separated. The inability to separate IR_{sed} into its component pieces is not a problem, however, because exposure through this compartment is modeled through simple multiplication of IR_{sed} by the sediment concentration.

The prey ingestion component of the dose model incorporates exposure through ingestion of contaminated prey items. The measured concentrations of chemicals in non-depurated *M. nasuta* tissue samples may potentially over-estimate the actual concentration in tissue if sediment remained in the gut of the clam (even if the outside was washed), because the sediment component has already been independently estimated as discussed above. The text of Section 7.2.1 has not been amended because the estimate of sediment intake is independent of the estimate of prey intake.

40. ***Comment #40.*** **Hypotheses regarding the apparent elevated tissue concentration for SBI, based on unpublished laboratory results (Section 7.2.2, page 143), are not acceptable. If the Navy wishes to raise this issue, the full data set should be provided for review specifying the U.S. Environmental Protection Agency (EPA) or American Society of Testing and Materials (ASTM) protocols followed. The regulatory agencies and resource trustees repeatedly stated that, in the event the field-collected tissue concentrations exceeded the laboratory testing tissue concentration, the field collected tissue concentrations should be used for the assessment of**

upper trophic level hazard. Please revise the surf scoter evaluation to include the most protective tissue concentration.

Response: Please refer to the response to USEPA Specific Comment #5 regarding the dose assessment based on field-collected tissue data. These dose assessment results are included in the Draft Final VS Report. The reference to unpublished laboratory results in Section 7.2.2 has been removed from the Draft Final VS Report because the data are not yet publicly available. However, additional relevant data have become available since the release of the Draft VS Report. The U.S. Army Corps of Engineers (USACE) developed biota-sediment accumulation factors (BSAFs) for amphipods and polychaetes at HPS that indicate that polychaetes do not seem to be accumulating organic compounds at a faster rate than other invertebrates (USACE Biota-sediment accumulation factors: Hunters Point, CA, July 1, 2002). Please refer to the response to DTSC Comment #56 for a more detailed discussion of these data.

41. ***Comment #41.*** **In addition to use of the SBI tissue concentration rather than the depurated *Macoma nasuta* concentration, the results of the upper trophic level evaluation of the surf scoter, as well as the double-breasted cormorant, using the upper 95 percent confidence limit on the mean (95UCL) as the concentration term for tissue should be presented in the text. The sediment concentrations are arguably more well defined than the tissue concentrations. There is, therefore, no justifiable rationale for using the 95UCL of the sediment concentration (Table 7-5, page 144), but the arithmetic mean of the tissue concentration. Please revise the calculations of ecological hazard using the 95UCL for both sediment and tissue concentrations.**

    Response: The dose assessment calculations in Section 7 of the Draft Final VS Report have been revised based on the 95% UCL of sediment and tissue concentrations. Briefly, results using the 95%UCL for tissue and sediment data are similar to those using the arithmetic mean.

42. ***Comment #42.*** **HERD appreciates the Navy's inclusion of a Human Health Risk Assessment (HHRA) regarding the consumption of fish from HPS (Section 9.0). HERD has requested this assessment for ten years. No reply is required for this comment.**

    Response: This comment is acknowledged.

43. ***Comment #43.*** **HERD has reviewed and agrees with the USEPA Region 9 assessment of the HHRA contained in a USEPA memorandum dated June 24, 2002 from Ned Black, Ph.D. In particular, HERD agrees that the most health-protective toxicity values (i.e., cancer slope factors, dermal adherence factors, and toxicity equivalency factors) should be used in the assessment, whether these values are USEPA or California values. Please make the changes outlined in the June 24, 2002 EPA memorandum consistent with the above caveat.**

    Response: Please see response to USEPA Specific Comment #5.

44. ***Comment #44.*** **While not an exposure pathway for the majority of the future population or users of HPS, the direct contact with sediments has been documented for a subpopulation of swimmers at HPS. An article documenting this exposure was published in a weekly San Francisco newspaper approximately two years ago. Please amend the text (Section 9.1.2.1, page 169) to indicate that '…except for subpopulations of swimmers, direct contact with sediments is not a current scenario exposure pathway…'**

Response: As indicated in the response to USEPA Specific HHRA Comment #2, the text has been revised to include an evaluation of direct exposures to sediments while harvesting shellfish. It is assumed that this exposure scenario would encompass any potential risks associated with exposures while swimming; this has been noted in the text.

45. *Comment #45.* **HERD does not agree that a strict arithmetic sum of integer-scored test results is applicable as a WOE approach (Section 8.0, pages 147 through 165). An adverse benthic toxicity result is not countered by a lack of bioaccumulation. Neither is an elevated sediment concentration, dependent on the COC and concentration negated by a lack of adverse benthic toxicity. The fact that the 'Final Sum' values (Figure 8-5 through 8-9) indicate that only one location in Area III (PA-42) and one location in Area X (SB-12) have WOE scores indicating negative effects is not a true representation of the ecological hazard. Neither does the integrated footprint presentation (Figures 10-1 through 10-5, pages 195 through 197) agree with conceptual site model of the releases from HPSY. For example, the gradient of decreasing PCB concentration with greater distance from the Area X shoreline (Section 4.3.3, page 82 and Figure 4-17 and Figure 10-14, page 212) is not presented in WOE integrated score for Area X. The highest ecological hazard appears to be removed from the shoreline. Other examples could be cited. HERD has performed an independent review of the results of the VS, as outlined in the table below. These are the areas of the LVF HERD considers candidates for inclusion in the final Feasibility Study. These locations may change given the Navy revision of the surf scoter calculation of hazard based on the SBI tissue concentration and different home range estimates:**

Areas that should be carried forward for consideration of remedial action		
	HERD concern	**Rationale**
Area I	**Area immediately adjacent to the shore (i.e., IB-59)**	**Lead in surface sediment samples (Figure 4-6), elevated SBI tissue concentrations. Elevated forage fish tissue concentrations of DDx (Figure 7-15). Double-crested Cormorant PCB HQ (Table 7-7).**
Area III	**Area associated with discharge pipe**	**Elevated metal concentrations (e.g., Figure 4-2) and PCB in surface sediments (Figure 4-10). Elevated SBI tissue concentrations. Elevated forage fish tissue concentrations of DDx (Figure 7-15). Double-crested Cormorant PCB HQ (Table 7-7).**
Area VIII	**Area of corroded metal slag**	**Source term to bay and decrease in soft-bottom habitat. Double-crested Cormorant PCB HQ (Table 7-7) in sediments able to be sampled.**
Area IX	**Area offshore of oil reclamation ponds.**	**Elevated SBI tissue concentrations. Elevated forage fish tissue concentrations of DDx (Figure 7-15). Double-crested Cormorant PCB HQ (Table 7-7).**
Area X	**Area offshore of landfill**	**Elevated inorganics in surface sediments (e.g., Figure 4-6), elevated PCB in surface and at depth sediments to 4 feet (Figure 4-13) and DDx concentrations (Figure 4-11) in surface sediments. Elevated forage fish tissue concentrations of DDx (Figure 7-15). Double-crested Cormorant PCB HQ (Table 7-7).**

Response: Section 10 of the Draft Final VS Report has been revised to identify areas for evaluation in the FS based on ecological risk, human health risk, and potential source control issues. Briefly, the rationale for each of the five HPS areas is as follows:

	HERD concern	Response
Area I	Area immediately adjacent to the shore (i.e., IB-59)	Shoreline and debris field to be evaluated in Parcel F FS as potential source of contamination to Parcel F sediment.
Area III	Area associated with discharge pipe	Area III will be included in FS based on potential food chain risk. PRGs developed for mercury and copper. Drainage tunnel from Dry Dock 3 will be investigated as a possible source of contamination.
Area VIII	Area of corroded metal slag	Shoreline to be evaluated in Parcel F FS as potential future source of contamination to Parcel F sediment. Removal action for metal slag is planned.
Area IX	Area offshore of oil reclamation ponds.	Areas IX/X will be included in the FS based on potential risk to upper trophic level receptors. PRGs developed for PCBs. Removal action for Parcel E shoreline in vicinity of landfill is planned.
Area X	Area offshore of landfill	

46. ***Comment #46.*** **Please provide plots of the SBI tissue concentration versus the sediment concentration as provided for the depurated *Macoma nasuta* tissue concentration (Figures 10-6 through 10-11).**

    Response: Plots of SBI and HBI tissue vs. sediment concentrations have been added to Appendix F of the VS Report. It is important to note that the field collected tissue samples and sediment samples depicted in these plots are not collocated; sediment data from the stations closest to the areas where field tissues were collected are shown.

47. ***Comment #47.*** **There appears to be a significant mercury uptake into tissue relative to the sediment concentration in the Point Avisadero (Area III) samples (Figure 10-8, page 201). This area would appear to require consideration in the Remedial Action Plan (RAP) due to ecological hazard to upper trophic levels.**

    Response: The revised dose assessment results presented in Sections 6 and 7 of the Draft Final Validation Study Report indicate that mercury may pose an unacceptable ecological risk; therefore, Point Avisadero (Area III) will be evaluated in the FS.

48. ***Comment #48.*** **The overall pattern of organic contaminants appears to indicate that the highest tissue concentrations occur in the South Basin samples (Figures 10-10 and 10-11, pages 203 and 204). This area would appear to require consideration in the Remedial Action Plan (RAP).**

    Response: The revised dose assessment results presented in Sections 6 and 7 of the Draft Final Validation Study Report indicate that PCBs may pose an unacceptable ecological risk in South Basin; therefore, this area will be evaluated in the FS.

49. ***Comment #49.*** **While the overall quality of the graphic presentation is very helpful, the symbols used in the presentation of the proposed relationship between sediment PCB concentration and *Macoma nasuta* tissue concentration should be presented graphically with each figure, rather than in text at the top right of one graph (Figure 10-12, page 209).**

    Response: Figure 10-12 has been revised to improve the legend as suggested. The revised figure appears as Figure 10-5 in the Draft Final VS Report.

50. *Comment #50.* **HERD agrees that additional sampling to define the elevated area of sediment concentrations in PA-47 may be required (Section 11.1.1, page 213). Any additional sampling, for CLP analysis, should be based upon a screening assessment, similar to that performed by SPAWAR San Diego, as performed for this Validation Study.**

    Response: Additional sampling for mercury, copper, and PCBs was conducted at Point Avisadero (Area III) in October 2003 as part of the FS Data Gaps investigation. PCBs were measured using the screening methodology previously used at HPS; mercury and copper were measured using fixed laboratory methods (a screening method for mercury has not been developed for use at HPS). Analytical results are presented in an addendum to the Draft Final VS Report.

51. *Comment #51.* **Please provide further justification for the conclusion that 'It is unclear whether the field-collected SBI tissues are a fair representation of the tissue burdens in polychaetes in the field.' (Section 11.1.3.2, page 217). The fact that these are results from tissues collected in the field, and the results appear consistent for several inorganic elements and organic compounds, as outlined above, would appear to make them credible. HERD suggests that this sentence be amended to indicate that there <u>may</u> be some variability in SBI tissue concentrations.**

    Response: Section 11 has been revised to clarify that it is unclear whether the field-collected SBI sample results represent tissue concentrations only, rather than tissue plus ingested sediment concentrations.

52. *Comment #52.* **HERD finds it encouraging that the results of the sedimentation rate study in the South Basin (i.e., 1 cm per year) and the conclusion that sediment concentrations decrease below 2 feet (i.e., 66 cm) (Section 12.1.1.1, page 225) coincide with the period of Navy activities at HPS. Sediments identified as candidates for remedial action, are therefore the Navy responsibility.**

    Response: As part of the FS Data Gaps investigation, additional radioisotope data were collected and detailed vertical PCB concentration profiles were generated for South Basin. These data will be used to support development of a detailed conceptual site model to be presented in the FS and used as the basis for evaluating remedial alternatives.

53. *Comment #53.* **The statement that water currents in the South Basin are weak may be true for inflow currents (Section 12.1.1.1, page 225), but do not completely portray the wind-driven sediment redistribution observed by the USEPA ecological risk assessor in the South Basin as stated (Section 12.1.6.1, page 228). Please add an additional numbered item which indicates that wind-driven sediment distribution may occur in the South Basin.**

    Response: The results of the Sediment Dynamics Study (Appendix L of the Draft VS Report) indicated that under the typical winter and summer conditions observed in 2001, the resuspension and transport of sediment in South Basin by wind and wave activity was minor. However, the degree of sediment transport resulting from an extreme weather event was not quantified. The FS Data Gaps investigation included collection of additional sediment dynamics data for South Basin (i.e., direct measurements of sediment stability); these data will be used in conjunction with previously collected hydrodynamic data to predict the effects of an extreme event.

54. *Comment #54.* **Regulatory agencies and resource trustees did not agree that the WOE approach would determine which areas of the LVF would proceed to the FS (Section 12.1.3). Please indicate that difference of opinion in the text.**

Response: Section 2.1.6 of the VS Report has been revised to clarify that consensus was not reached on how the WOE would be used to identify areas for evaluation in the Parcel F FS.

55. ***Comment #55.*** **HERD could not locate the statistical test of sport fish tissue concentration at HPS versus sport fish tissue concentration from other locations in San Francisco Bay (Section 12.1.4, page 228). Please provide a reference in the text if this test is located in one of the Appendices contained on the CD-ROM.**

Response: The results of this test are presented in Table K-2 of Appendix K, which was provided on CD-ROM with the VS Report.

56. ***Comment #56.*** **HERD does not agree with the Site Use Factor of 0.02 used for the surf scoter (Section 12.1.4, page 228) for HPS Area X. The revised hazard assessment using the SBI tissue concentration will be reviewed to continue this discussion on the SUF for Area X, but may be applicable to upper trophic level assessments for other Areas.**

Response: Please refer to the response to USEPA Specific Comment #5 regarding the revised dose assessment based on field-collected tissue data. Section 10 of the VS Report has been revised to present PRGs for a range of SUFs for both the scoter and double-crested cormorant.

In regard to the use of the SBI data, two distinct issues must be addressed: (1) the inclusion of SBI data in the assessment of upper trophic level risk, and (2) the use of SBI data to develop BAFs and PRGs. The first of these issues was discussed in the response to USEPA Specific Comment #5. The second issue is discussed below.

A high degree of uncertainty is associated with using any of the field-collected tissue data to develop BAFs because co-located tissue and sediment data are not available. Therefore, the linkage between sediment and tissue concentrations is uncertain. Additionally, the possible presence of sediment on the surface of the animal or in the gut may introduce error into the estimate of uptake.

Recent work by the USACE (2002) conducted with South Basin sediments in 2001 and 2002 was reviewed to assess the uncertainty associated with using field-collected tissues to develop BAFs. The USACE developed biota-sediment accumulation factors (BSAFs) for polychaetes and amphipods with South Basin sediments based on laboratory controlled studies where the test organisms were allowed to depurate before analysis. BSAFs based on depurated *Neanthes* ranged from 0.155 to 0.181, and were lower than the BSAFs developed for the amphipod *Leptocheirus* (BSAFs ranging from 0.386 to 1.334). The BSAFs for *Neanthes* were also lower than BSAFs developed for South Basin as part of the VS using the depurated *M. nasuta* data (0.418 for sediment stations < 2000 ppb). Thus, in South Basin sediments, depurated polychaete tissue appears to have lower uptake in tissue on a lipid basis than either amphipods or bivalves.

BSAFs developed using field-collected SBI tissue data (see the table below) are greater than those developed in the laboratory by the USACE for *Neanthes*. It is likely that these differences are due to the absence of co-located sediment data and possible presence of ingested sediment in the gut. There is no reason to believe, however, that field-collected polychaetes would behave differently from those evaluated under laboratory conditions if these factors were controlled. Other studies where BSAFs were compared across species and habitat groups (e.g., infaunal deposit feeders, epifaunal filter feeders, scavengers and benthically-coupled fish) have shown that variability in BSAFs was greater within species than across feeding types (Tracey & Hansen 1996). Thus, the elevated BSAFs and

chemical signatures seen in the field-collected SBI data from HPS are unlikely to be the result of species or foraging differences.

Although COPEC concentrations were generally elevated in SBI tissue samples relative to laboratory *M. nasuta* samples, PRGs were not developed using the SBI data. A number of studies from the literature have cautioned against the use of non-depurated tissue data when developing an estimate of bioaccumulation (Brooke et al, 1996; Mount et al 1999, Neumann et al. 1999). For example, errors in PAH and PCB uptake can approach 30-fold with oligochaete worms (Mount et al 1999), and over-estimates reached 438% for lead with the amphipod *Hyallela azteca* (Neumann et al. 1999). The strongest link between sediment and tissue is the collocated sediment and depurated laboratory *M. nasuta* data. PRGs developed from this data set should also be protective of soft-bodied invertebrates because BSAFs developed from the *M. nasuta* data at South Basin were an order of magnitude greater than the *Neanthes* BSAF developed by the USACE.

In summary, BAFs and PRGs based on SBI data from HPS would have a high level of uncertainty. The strongest link between sediment and tissue concentrations is associated with the depurated laboratory *M. nasuta* data, and BAFs based on these data have a lower degree of uncertainty.

	Total PCBs tissue	Lipid	Moisture	Total PCBs sediment	TOC	Normalized Total PCBs tissue	Normalized Total PCBs sediment	BSAF
	mg/kg dw	% ww	%	mg/kg dw	mg/kg dw			
HPS SBI Area I	0.4323	0.83	84.27	0.07692	32472.51735	8.19286627	2.3687723	3.458697
HPS SBI Area III	1.0989	1.39	77.51	0.36659	23823.77623	17.7800439	15.387569	1.155481
HPS SBI Area VIII	0.30298	0.8	80.4	0.02026	17232.27632	7.42301	1.1757007	6.31369
HPS SBI Area IX	7.33166	2.08	75.88	0.14194	41123.69092	85.0190573	3.4515384	24.63222
HPS SBI Area X	13.43592	1.44	76.96	2.6052275	22668.96505	214.97472	114.92485	1.870568
							Ratio Estimator	2.428035

References:

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Mount, D.R., T.D. Dawson & L.P. Burkhard. 1999. Implications of gut purging for tissue residues determined in bioaccumulation testing of sediment with *Lumbriculus variegatus*. ET&C. 18(6): 1244-1249.

Neumann, P.T.M., U. Borgmann & W. Norwood. 1999. Effect of gut clearance on metal body concentrations in *Hyallela azteca*. ET&C. 18(5): 976-984.

Tracey, G.A. and D.J. Hansen. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch. Environ. Contam. Toxicol. 30:467-475.

United States Army Corps of Engineers (USACE). 2002. Biota-sediment accumulation factors: Hunters Point, CA. July 1.

57. ***Conclusion Comment.*** **While the Navy has demonstrated that some areas of the Low Volume Footprint (LVF) contained in the Draft Feasibility Study may be excluded, some portions of Area I, Area III, Area VIII, the area between Area VIII and Area IX, Area IX and Area X appear candidates for inclusion in the Feasibility Study.**

HERD does not agree that the proposed WOE approach identified the areas for further consideration at HPS. HERD would not support use of this WOE at other Navy sites under HERD review.

The development of Ecological Preliminary Remediation Goals (EPRGs) in the Validation Study Report appears to indicate that only Area X is a candidate for consideration of remedial alternatives. HERD does not agree with that implied conclusion. Other areas for consideration in the FS are identified in the Specific Comments.

Response: As discussed in the response to DTSC Specific Comment #45, all LVF areas will be addressed in the Feasibility Study (FS). Please refer to the response to USEPA General Comment #1 regarding the contaminants and areas to be included in the Parcel F FS, and approach to be used for developing the FS footprint.

It should be noted that the WOE approach presented in the Draft Final VS Report has not been substantially revised; however, the WOE results are not used directly to identify the FS footprint.

California Regional Water Quality Control Board, San Francisco Bay Region
Response to July 26, 2002 Comments

General Comments

1. **The major conclusions drawn by the Navy in the VS are: 1. PCBs are the major risk driver; 2. a preliminary risk goal of 2 mg/kg would be protective of piscivorous birds and; 3. Area X along the Site IR-02/21 landfill is the only area within the low-volume footprint that needs to go forward into the feasibility study. Board Staff does not concur with these conclusions. Staff agrees that PCBs are one of the major risk drivers. However, other contaminants, e.g., mercury, copper, tributyltin, pose significant risks in some areas (Areas III, IX, X) and need to be included in follow-on remediation evaluations. In addition, the proposed preliminary risk goal of 2 mg/kg PCBs is not protective of ecological or human health risks. Regional Board Staff is in the process of developing TMDLs for PCBs and Mercury for the San Francisco Bay to address existing impairments in water quality objectives and beneficial uses associated with these contaminants. The target cleanup level for PCBs in sediments is expected to be significantly lower than 2 mg/kg. Since impairments exist for these contaminants, the additional risks posed by elevated contaminant levels in sediments at HPS are of concern. Comparisons to reference or ambient conditions do not diminish the fact that significant releases of CERCLA hazardous substances have occurred and continue to occur at Hunters Point.**

   Response: Three major points are raised in the comment above:

   1) Other contaminants in addition to PCBs (e.g. mercury, copper, and tributyltin) pose a significant risk in some areas.
   2) The proposed PCB PRG of 2 ppm is not protective of ecological or human health; and
   3) Comparisons to reference or ambient conditions may not adequately address risks posed by contaminants at HPS because ambient concentrations represent an impaired water body condition.

   Please refer to the response to USEPA General Comment #1 for a summary of the revised approach for identifying areas for consideration in the FS. Briefly, the revised bioaccumulation evaluation presented in Sections 6 and 7 of the Draft Final VS Report indicates that PCBs in Areas IX-X, and mercury and copper in Area III are the major ecological risk drivers in Parcel F. PCBs are also a human health concern in Areas IX-X. Ranges of PRGs for these contaminants have been developed in Section 10 of the Draft Final VS Report. These PRGs will be used as the basis for identifying areas for consideration in the FS. Potential source control issues in other areas are also addressed.

   The evaluation criteria for the three lines of evidence in the Validation Study (i.e., comparison of HPS results to reference conditions for San Francisco Bay) were developed in consultation with the agency technical group during the VS Work Plan development. The application of the TMDLs for PCBs and mercury to the CERCLA cleanup at HPS will continue to be discussed during the Parcel F FS process.

Specific Comments

1. ***Comment #1*. Section 1.3.1 Validation Study Objectives: the report states that three lines of evidence, sediment chemistry, toxicity and bioaccumulation will be used to validate the FS footprint. However, in the quantitative weight of evidence scoring, toxicity has the weight of two lines of evidence. This is clearly inappropriate. Areas where high sediment chemistry is**

associated with bioaccumulative compounds should go forward into the FS stage, rather than be excluded, as is currently the case.

Response: Three lines of evidence (sediment chemistry, toxicity and bioaccumulation) were evaluated in the VS. Two different endpoints were associated with the toxicity line of evidence (amphipod bulk sediment bioassay and a larval sediment-water-interface bioassay), resulting in a total of four endpoints. The issue of whether or not to equally weight the four endpoints was discussed as part of the development of the Validation Study Work Plan (see the meeting minutes from 6/15/2000 in Appendix A of the Work Plan), and a decision was made by the Navy and agency technical group to equally weight them.

Please refer to the response to USEPA General Comment #1 regarding the revised approach for identifying areas for consideration in the FS.

2. ***Comment #2.*** **Section 1.3.1, Page 10: please explain why the debris-lined shoreline is not of primary ecological concern.**

Response: The debris-lined shoreline was not of primary ecological concern in the VS because the focus of the investigation was on the soft intertidal and subtidal sediments below the break in slope at the base of the debris-lined shoreline. The debris-lined shorelines in Parcels B and E are currently being addressed as part of the upland parcel investigations. The potential for these areas to act as future sources of contamination to Parcel F sediments will be evaluated in the Parcel F FS Report.

3. ***Comment #3.*** **Section 2.1.2, Sediment Chemistry Line of Evidence: Please state whether the ERM-Q was calculated in the same manner as done for the Bay Protection and Toxic Cleanup Program, i.e., were the same chemicals included in the quotient.**

Response: ERM-Qs were calculated for both HPS and reference sites using the same list of constituents (see Draft VS Report Appendix F, page F-2), and were calculated in the same manner as they were for the BPTCP. The ERM-Qs calculated in the VS Report included all constituents that were detected at HPS for which ER-Ms were available. This included the 16 constituents used by BPTCP plus:

- DDT, DDE, DDE individually (as well as total DDxs),
- Tributyl tin (TBT)
- Selenium.

The methods used for calculating ERM-Qs for the VS were developed by Dr. Donald MacDonald of NOAA and Dr. J.Q Word, then of the Pacific Northwest National Laboratories. The method included incorporating the DDxs individually and as a total, and to include TBT using a threshold value of 25 ppb because no ER-M was available. Finally, instead of total chlordanes (which were not measured), alpha chlordane was used.

4. ***Comment #4.*** **Section 2.1.6, Weight of Evidence (WOE) Framework: the first step of the WOE approach is to determine the weight of the endpoint. Three lines of evidence are presented but four endpoints are presented. The report states that the four endpoints were given equal weight, instead of the three lines of evidence being given equal weight. The bioaccumulation line of evidence represents multiple endpoints even though only one endpoint, surf scoter, is evaluated. Please edit this step to state that the three lines of evidence will be given equal**

weight and not the endpoints themselves. This will require a recalculation of the integrated scores for the WOE.

Response: As discussed in response to the RWQCB Specific Comment #1, the Navy and agency technical group decided to weigh each of the four endpoints equally. Because the WOE results will not be used directly to identify areas for consideration in the FS, the WOE methodology was not modified in the Draft Final VS Report.

5. *Comment #5.* **Section 4.1.3.1 PCBs, Figure 4-13: No cores were collected from sample locations showing the highest surface sediment concentrations, i.e., those closest to the shoreline. Depth profiles for many stations show higher contaminant levels at depth than at the surface. It would be helpful to have information regarding vertical profiles for these areas of higher surface contamination. These data could be collected as part of the parcel E data gap analysis.**

   Response: Vertical PCB profile data were collected along the Parcel E and F shoreline and in South Basin as part of the FS Data Gaps investigation in October 2003. These data are provided as an addendum to the Draft Final VS Report.

6. *Comment #6. Isoconcentration Maps:* **It would be helpful to have isoconcentration maps of mercury and total PCBs in sediments included in Section 4.0. These maps would need to include areas from both the low and high volume footprint. Board Staff is interested in seeing areas contaminated with mercury at levels greater than 0.2 ppm and total PCBs greater than ambient.**

   Isoconcentration maps can only be generated in cases where the number and location of samples and spatial variability of the contaminants support such maps. The only area in Parcel F where both of these conditions are met is in South Basin. Insufficient data density outside of the LVF would result in a high level of uncertainty in an isoconcentration map.

   Isoconcentration plots of PCBs and mercury in South Basin sediments are presented in an addendum to the Draft Final VS Report. The PCB map includes all of the FS Data Gaps investigation data collected in 2003 (adjusted immunoassay screening results and confirmatory lab results), all VS data, and data collected during the VS Work Plan development, including immunoassay screening results and confirmatory lab results). The mercury map includes all VS data. The historical data (i.e., data collected before 2000) were not included because the samples were analyzed using standard Contract Laboratory Program (CLP) methods that did not provide adequate detection limits for some of the key constituents.

   For Point Avisadero (Area III), PCB, mercury, and copper concentrations were too variable to generate accurate isoconcentration maps. Therefore, bubble plots are provided in the addendum to the Draft Final VS Report.

7. **Comment #7. Section 5.2, SWI Test Results: the report states that the lack of toxicity in this test at sample locations with the highest metals chemistry (PA-47 and PA-41) suggests that metals are not fluxing from the sediment to the overlying waters. Board Staff does not think that this conclusion can be drawn based on the toxicity results alone. The toxicity test is based on surface grab samples taken in the upper 5 cm. Cores collected from these locations show significantly higher concentrations at depth. In-situ there is most likely a higher gradient and a greater likelihood of flux from contaminated sediments than might be observed from a grab sample brought into the laboratory. In order to draw conclusions about flux into the water**

column, measurements must be taken in the field. Additionally, station PA-41 showed the greatest decrease in normal development of any station tested.

Response: The SWI test is designed to look at flux of bioavailable contaminants from the uppermost 5 cm of sediment to the overlying water column, which is theoretically enhanced by replacing in-situ overlying water with clean filtered seawater. The SWI test is not designed to look at toxicity of contaminants that flux from deeper sediment to surface sediment, and field concentrations could be different than those in the laboratory exposure. However, it is likely that the dilution potential is much greater, and the chance of pelagic larval exposures at the sediment-water interface is much lower in the field than in the laboratory test chambers. Without site-specific measurements, it is not possible to predict whether there are higher contaminant gradients or likelihood of contaminant flux in the field.

8. ***Comment #8. Section 6.0 Bioaccumulation:*** **Regional Board comments on the Navy's Validation Study Work Plan indicated concerns about relying on *Macoma* data rather than field collected tissue data to model risks to upper trophic level receptors. The work plan states that the *Macoma* data would be adjusted, as required, to account for the fact that this bioaccumulation test does not reach steady state for some contaminants within the 28-day test period. It does not appear that any adjustments were made and the data were used as collected. The field-collected tissue data presented in Section 7.0 reinforces the conclusion that for some contaminants, this test is best used to represent bioaccumulation potential and not the magnitude of that potential. Use of this data in the bioaccumulation line of evidence leads to an underestimate of risk across all upper trophic level receptors.**

   Response: Please refer to the response to USEPA Specific Comment #5 regarding the use of field-collected tissue data in the dose assessment. Section 7 of the Draft Final VS Report has been revised to include this assessment. All dose assessment results have been considered in the development of the FS footprint in Chapter 10 of the Draft Final VS Report.

   Please refer to the response to USFWS Comment #2 for a discussion of the evidence supporting the use of unadjusted results from the 28-day bioaccumulation test. Briefly, comparisons of the laboratory *M. nasuta* data and the field-collected hard-bodied invertebrate (HBI) data demonstrated that, in general, the field-collected HBI tissue data and the laboratory *M. nasuta* data yielded similar HQs in the dose assessment. Therefore, it does not appear that risk was significantly underestimated across all upper trophic level receptors.

9. ***Comment #9. Table 6-2, M. nasuta Bioaccumulation Test:*** **the low percent survival rate at some of the stations, e.g., SB-04 and SB-19, should be discussed further and considered in determining areas that should go forward into the FS.**

   Response: Please refer to the response to USEPA Specific Comment #4 for a discussion of this issue.

10. ***Comment #10.*** **Table 6.5: Body weights identified for the NOAEL vs. LOAEL studies should be presented in the table in the same fashion.**

    Response: Table 6-5 has been revised as suggested.

11. **Comment #11. Section 6.3.2 Refinement of Site Use Factor (SUF): the scoter is the only assessment endpoint representing exposures to upper trophic level receptors. The exposure pathway for the scoter is modeled based on laboratory-exposed bivalves. Other potential assessment endpoints may consume the more-contaminated forage fish or invertebrates. A number of COPECs are elevated in other areas of the San Francisco Bay and concerns exist that the contribution to cumulative risk from Hunters Point sediments is significant. Given these facts, a SUF of 1 should be used to conservatively estimate risk to the scoter. Or, in the alternative, the Navy should consider impacts to other assessment endpoints, e.g. resident fish species, which are more representative of a site use factor of 1.**

    Response: Please refer to the response to USEPA General Comment #1 for discussion regarding the identification of contaminants and areas for consideration in the FS. Section 10 of the VS Report has been revised to present ranges of PRGs for protection of both the surf scoter and double-crested cormorant based on a range of SUFs. It is important to note that the areas of concern at HPS are small relative to the foraging range of the scoter and cormorant (and the great majority of the bird species that are likely to be foraging at HPS).

    The assessment endpoints addressed in the VS were selected in consultation with the Navy and agency technical group during the development of the VS Work Plan. Because assessment endpoints and receptors were discussed in detail during Work Plan development, additional assessment endpoints were not evaluated in the Draft Final VS Report.

12. ***Comment #12. Table 6-11:*** **The Navy screens average tissue concentrations of areas of the low volume footprint against the 90 percentile of the pooled reference site data and presents the results on this table. This does not seem appropriate. Board Staff has previously commented (October 17, 2000 letter from Brad Job) that the validation study workplan relied excessively on comparisons to reference samples to evaluate and dismiss risks. This comment is still appropriate. Please identify those COPECs which would be greater than the reference sites if the 95% UCL (UCL95) was used instead of the arithmetic mean. Risk estimates that exceed an HQ of 1 should not be dismissed solely based on comparisons to reference tissue concentrations. Cumulative risk estimates across COPECs need to be included in the report.**

    Response: Please refer to the response to RWQCB General Comment #1 regarding comparisons to reference or ambient concentrations to evaluate risks. Table 6-11 has been revised to present HQs based on the 95% UCL rather than the arithmetic mean of sediment and tissue concentrations. Risk estimates were generated for all COPECs, regardless of whether or not they exceed reference concentrations (see Appendix H of the Draft Final VS Report). However, the development of the FS footprint focused on those COPECs that both present a potential risk <u>and</u> exceed reference/ambient concentrations, because remediation to levels that are below reference/ambient concentrations may lead to recontamination of the site.

    Please see the response to USFWS Specific Comment #11 regarding estimating cumulative risks across COPECs.

13. ***Comment #13.*** **Section 7.1.2, TIE testing: much effort was spent in identifying ammonia as a cause of toxicity. Metals were also shown to be a source of toxicity. These ancillary data have not been utilized to their full extent to identify areas at HPS that need to be further evaluated in the FS.**

Response: Section 7.1.2 provides a brief summary of TIE testing performed by EFANE. The results indicate that *porewater* toxicity to water column organisms (silverside fish, sand dollar or sea urchin larvae) was reduced when ammonia and metals were removed. The stations tested by EFANE were not toxic to sea urchin larvae in the SWI exposure conducted for the VS, with the exception of Station EW-33, for which both the SWI and TIE tests provide evidence for ammonia toxicity. In almost all cases, the ancillary TIE data did not support the identification of any areas for further evaluation in an FS.

14. ***Comment #14. Figures 7-10 to 7-14:*** **It appears that different sets of laboratory *Macoma* data are presented for each comparison shown on these figures, i.e., to forage fish, hard-bodied invertebrates, and soft-bodied invertebrates. Please explain. It seems like it would be difficult to select with any credibility those stations that might represent the area where the field-collected organisms were exposed.**

    Response: As noted in the figure legends, laboratory *M. nasuta* data from stations closest to the areas where field-collected organisms are presented. While this effort did involve some judgment as to which stations to include, they provide the most closely comparable data. Clearly, forage fish have a larger foraging range than field collected mollusks, and laboratory *M. nasuta* data from stations within the polygon from which fish were collected were included in the evaluation.

15. ***Comment #15.*** **Section 7.7.2 Field-collected Invertebrates and Fish Tissue Data: It appears that no field collected mussels were collected from HPS during this effort. Please elaborate.**

    Response: Field collection of mussels was discussed during the VS planning meetings and conference calls. Mussels are water column feeders that are typically found on hard substrates in the intertidal and upper subtidal zones, and consequently it is more difficult to directly relate mussel tissue contamination to sediment contamination. Therefore, mussels were not collected for the VS.

16. ***Comment #16. Section 7.2.2, Page 143:*** **The VS attributes the increased body burdens for soft-bodied invertebrates as compared to hard-bodied invertebrates to the sediment signature in the gut. The document should also state that organisms that feed on these invertebrates will ingest the gut sediment, and therefore their dose will be greater.**

    Response: Please refer to the responses to USEPA Specific Comment #9 and DTSC Specific Comment #39 for a discussion of this issue. The sediment ingestion estimates used in the dose assessment are derived from studies of upper trophic level bird feces, not from studies of gut contents or incidental ingestion during probing the sediment. Therefore, the dose assessment adequately accounts for sediment ingestion, and must consider the additional tissue contribution separately.

17. ***Comment #17. Table 7-7:*** **This table should be revised to reflect the UCL95 of the mean. Staff disagrees with the conclusion drawn that risks to piscivorous birds are relatively low at HPS.**

    Response: This table has been revised in the Draft Final VS Report to present HQs based on forage fish tissue concentrations and 95% UCL sediment concentrations. HQs are greater than one for several contaminants and areas when a SUF of 1 is used; however, the HQs are below one when an SUF of less than 1 is used. These results suggest that risk to piscivorous birds is relatively low through exposure to prey at HPS. PRGs for the double-crested cormorant have been developed in Chapter 10 of the Draft Final VS Report based on a range of SUFs.

18. ***Comment #18. Section 7.0, page 145:*** **Please delete the reference to "reasonable" SUFs being ≤0.1.**

    Response: Section 7 has been revised to delete the reference to "reasonable" SUFs. However, it should be noted that an SUF of ≤0.1 is supported by data collected in San Francisco Bay for the double-crested cormorant.

19. ***Comment #19.*** **Section 8.2, 8.3: Staff repeats their earlier comment that toxicity is one line of evidence and should be treated as such in the WOE scoring.**

    Response: Please refer to the response to RWQCB Specific Comment #1 for discussion of this issue. The WOE scoring methodology was not changed in the Draft Final VS report because it would be unlikely to more clearly identify areas for consideration in the FS.

20. ***Comment #20.*** **Section 8.0: Staff disagrees with the language used in this section regarding the scoring for the various lines of evidence. Generally, there is no such thing as a negative or positive risk. Scoring should always be positive, representing low to high relative risk.**

    Response: The terminology for 'positive' and 'negative' findings was developed as part of the Massachusetts WOE process (Menzie et al, 1996), which was the basis for the WOE model developed for the VS. 'Positive' and 'negative' do not define relative risk, but rather the risk finding. A positive finding of risk means that there is evidence (either of a low or high magnitude) that there is the potential for unacceptable risk. A negative finding of risk means that there is evidence (either of a low or high magnitude) that risk is acceptable. A negative finding does not imply negative risk, rather that the risk is low enough to be considered acceptable. Section 8 has been revised to remove references to negative and positive risk.

21. ***Comment #21.*** **Figure 8-4: Board Staff is more supportive of having the areas identified as gray or black on this figure going forward to the FS stage. In the alternative, the Navy could consider going forward with an evaluation in the FS of all gray areas in Figure 8-10.**

    Response: Please refer to the response to USEPA General Comment #1 regarding the approach for identifying contaminants and areas for consideration in the FS. Figure 8-4 depicts the WOE scores for the bioaccumulation line of evidence only. Analysis of the individual lines of evidence and ancillary data collected for the VS indicates that ingestion of contaminated prey is the pathway driving risk at HPS. Ranges of PRGs based on this pathway have been developed in Section 10 of the Draft Final VS Report. These PRGs will be used in conjunction with contaminant distribution data to identify areas for evaluation in the FS.

22. ***Comment #22.*** **HHRA - use of laboratory Macoma data: The VS reports on a human health risk assessment (HHRA) designed to evaluate consumption of recreationally-caught shellfish in the vicinity of Hunters Point. Regional Board Staff has commented previously that use of macoma data to represent shellfish tissue concentrations will underestimate the true exposure to contaminants.**

    Response: As shown in Section 7.2.2 of the VS Report, the laboratory *Macoma* tissue concentrations are comparable to the tissue concentrations measured in field-collected clam tissue samples and represent a reasonable surrogate for this study. In addition, the primary shellfish species actually consumed at HPS are likely to be mussels. Mussels filter food from the water column and have less

direct contact with sediments than clams; therefore, it is assumed that *Macoma* provide a more conservative estimate of exposures to shellfish consumers.

23. *Comment #23.* **Table 9-2 Exposure Factors: The San Francisco Bay Seafood Consumption Survey ingestion rates should be used. The average ingestion rate for consumers as indicated the report is 16 g/day and the 90th percentile is 48 g/day. The 90th percentile does not necessarily reflect subsistence consumption rates. If non-consumers are included, the 95th percentile (32 g/day) must be used.**

    Response: The results of the SFEI study were not available at the time the Draft VS Report was completed; however, the findings of the SFEI study do not differ substantially from the ingestion rates suggested in the APEN (1989) study that was used in the VS report. Because the SFEI study is a more comprehensive investigation of seafood consumption Bay-wide, the Draft Final VS Report has updated to calculate risks using ingestion rates for recreational fish consumers of 48 grams/day based on the SFEI study. The risk estimates were also updated using revised mercury toxicity criteria (in response to RWQCB Specific Comment #27) and EPCs representing either the maximum measured concentration or the 95 percent UCL (whichever was lower) (see response to USEPA Specific Comment #2). As discussed in response to USEPA Specific Comment #3, the revision to the ingestion rate does not change the conclusion of the evaluation, which is that risks associated with exposure to sediments at HPS are above 1×10^{-6}, but are comparable to those risks associated with the reference areas.

24. *Comment #24.* **Section 9.1.2.2: The UCL95 should be applied to both the RME and the CTE exposure scenarios. Please amend language in this section regarding the reasonableness of using the UCL95.**

    Response: As discussed in the response to USEPA Specific Comment #3, the risk estimates have been recalculated using the either the maximum measured concentration or the 95 percent UCL (whichever was lower). As noted in response to RWQCB Comment #23, the resulting risk estimates based on the 95 percent UCL do not alter the conclusions of the human health evaluation.

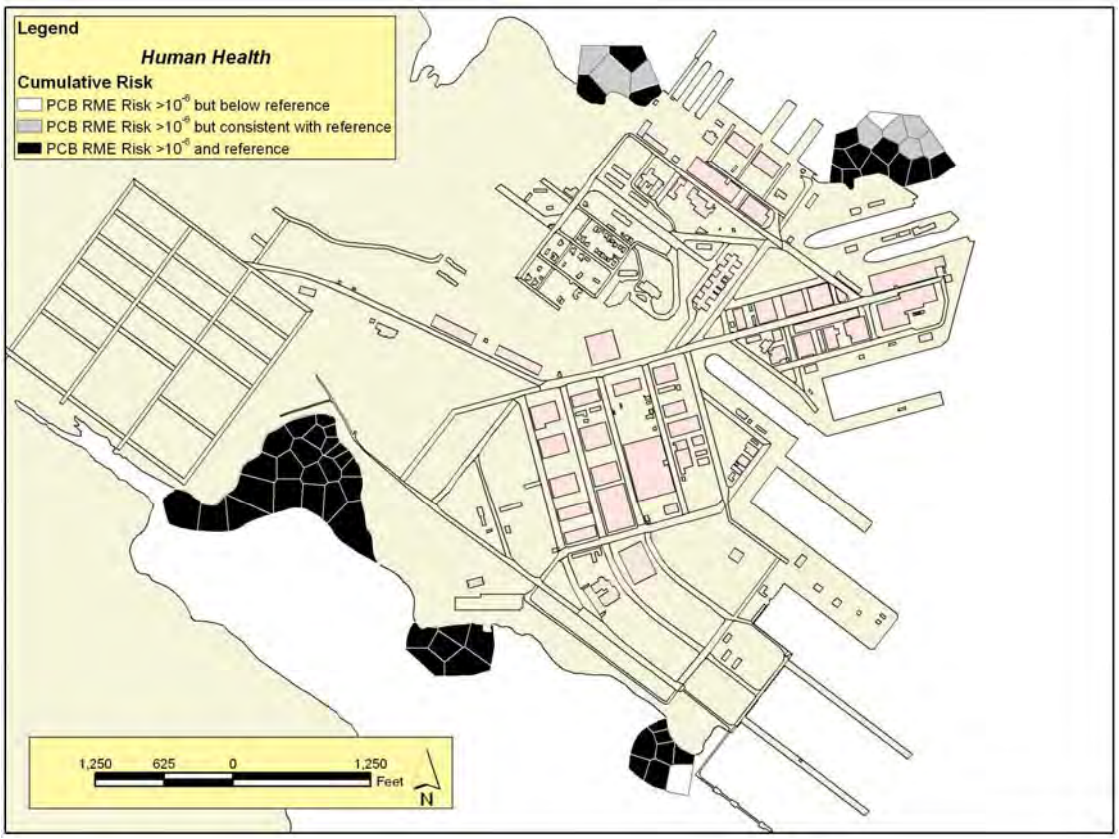
25. *Comment #25.* **Section 9.1.2.3 Exposure Duration: A 9-year exposure duration represents the median of the distribution, and 30 years represents the 90th percentile. The latter is not a worst-case scenario. The discussion regarding the probability of continuous consumption of mussels assumes harvesting is 100% complete each year. For recreational scenarios, this seems improbable and, if included in the discussion at all, needs to be supported with a scientific reference.**

    Response: The text in Section 9.1.23 has been revised to refer to 30 years as the reasonable maximum exposure rather than the worst case exposure, and references to the probability of continuous consumption of mussels have been removed.

26. *Comment #26.* **Section 9.1.6 Human Health Risk Assessment Summary: Please provide a map of cancer and non-cancer risk estimates based on the RME scenario for PCB exposures only. Based on Table 9-4, it appears that all areas exceed Total Congener risk estimates calculated for the reference areas.**

    Response: A map showing the PCB cancer risks based on the RME scenario is provided below. As indicated in Appendix C of the VS Work Plan, a reference dose for total PCBs was not available from the sources evaluated for toxicity values (i.e., IRIS, DTSC) at the time the report was prepared.

Currently, oral RfDs are available through IRIS for individual aroclors, namely Aroclor 1016 and Aroclor 1254, but are not unavailable for the combined total PCBs. Because it is not considered appropriate to apply surrogate toxicity values to those compounds lacking agency approved criteria, noncarcinogenic risks associated with exposure to total PCBs were not assessed in the Draft Final VS report.



27. ***Comment #27.*** **Table 9-3: The oral RFD for methylmercury is 1.0E-04. This is the form of the mercury that is of concern. Please correct the table and the associated calculations.**

Response: This value has been corrected in the Draft Final VS Report. The resulting hazard for mercury was increased three fold at each area, but found to be below the reference hazard at all areas except for Point Avisadero (Area III), where the hazard was equal to the USEPA benchmark of 1.0.

28. ***Comment #28.*** **Section 9.1.4.2: Please provide some discussions on a station-by-station basis of risks due to shellfish contamination by mercury.**

Response: A station-by-station comparison of hazards associated with ingestion of shellfish for mercury is has been incorporated into the Draft Final VS Report. All of the stations have hazards associated with the RME scenario below the USEPA benchmark of 1.0 except for stations PA-39 and PA-44. The hazard associated with the reference stations ranged from 0.16 for the RME scenario to 0.027 for the CTE scenario. The CTE hazards at all HPS stations were below the benchmark of 1.0.

29. ***Comment #29.*** **Section 9.2: Questions regarding risk communication have not been framed correctly. Contaminated sediment at Hunters Point represents some of the higher concentra-**

tions in the San Francisco Bay for select COPECs, PCBs, Hg etc. Current risks to recreational fishers in the Bay are viewed as unacceptable. Dismissing risks due to comparisons to the RMP are inappropriate.

Response: In accordance with the Final Human Health Evaluation Work Plan (Battelle et al., 2001), the risk communication conclusions were based on the results of statistical evaluations of the HPS and reference site data collected for the evaluation. The RMP data were included for comparative purposes only.

30. *Comment #30.* **Section 9.2.3: Please also present the non-lipid normalized tissue concentrations for comparison. Please also add information regarding when the fish were collected to help evaluate potential seasonal differences in lipid content.**

Response: All fish evaluated were collected in May/June 2001, which corresponds to the same season (May-July) that fish were are collected as part of the RMP survey. Non-lipid normalized tissue data are provided in Tables C-20 through C-25 (Appendix C) of the Draft Final VS Report. Non-lipid normalized tissue data from HPS are consistent with tissue measurements collected during the RMP survey and from ambient locations in this evaluation.

31. *Comment #31.* **Surface Water Quality Evaluation: No evaluation of ambient water quality criteria was performed as part of the Validation Study. The available pore water data should be evaluated against ambient water quality criteria and included as a line of evidence.**

Response: Collection of porewater data for comparison to ambient water quality criteria was not identified as a line of evidence during the development of the VS Work Plan by the Navy and agency technical group. Instead, a sediment-water interface bioassay was performed to directly evaluate potential toxic effects to water column organisms.

32. *Comment #32.* **Section 11.0 Uncertainty: This section of the report should identify uncertainties that over-estimate and under-estimate risks. It reflects a bias towards identifying those uncertainties that lead to over-estimates of risk.**

Response: The effect of many of the uncertainties discussed in Section 11 of the Draft VS Report (i.e., whether they tend to result in an over- or under-estimation of risk) is unknown. Section 11 has been revised where possible to clarify the expected effect of a given uncertainty on risk estimates.

33. *Comment #33. Section 12.1.6.2:* **No information was provided regarding radionuclide surveys associated with past operations at HPS that may have been conducted in the offshore sediment areas. This should also be included in any assessment of potential ecological risk.**

Response: Please refer to the response to USEPA Specific Comment #10 for a discussion of this issue.

34. *Comment #34.* **Appendix C: does not include information regarding fish size classes or weight. This information should be included or a discussion presented in the report.**

Response: Forage fish species, numbers, size classes, and sample weights are reported in Appendix A, Table A-7, of the Draft VS Report. Sport fish catch records have been added to Appendix A in the Draft Final VS Report. These records are also provided in the *Hunters Point Shipyard Parcel F*

Validation Study and Human Health Evaluation Field Summary Report San Francisco, California of July 26, 2001.

35. ***Comment #35.*** **Appendix F: Additional discussion needs to be included regarding the fact that the Eastern Wetland Area VIII is more coarse-gained than fine-grained and should be compared to ambient concentrations for 40% fines. Please also include statistical data summaries of the sediment chemistry data in Appendix F.**

Response: Appendix F has been revised to include statistical summaries of sediment chemistry data. Inorganic sample results from the five coarse-grained stations in Area VIII (EW-30, 31, 33, 34, 36) were compared to the published coarse-grained ambient values. For the ten metals that were measured by the RMP, copper, lead, and cadmium are present at values slightly above the ambient threshold value (see table below). As discussed in Appendix F and illustrated in Figure F-2, chromium data from the VS were compared to data from BPTCP reference stations (due to sample preparation by total digestion); however, none of the BPTCP stations were composed of coarse-grained sediments. Chromium concentrations at three coarse-grained Area VIII stations (EW-30, 34 and 36) exceeded the ambient value calculated for the BPTCP sites. In all cases, except chromium at EW-30, the values were well below the relevant ER-Ms.

Summary of Area VIII Stations with Inorganic Results Exceeding Ambient Values

Coarse Grained Station	Analyte	Result	<40% Fines Ambient Value	<100% Fines Ambient Value
EW-30	Copper	32.9	31.7	68.1
EW-30	Lead	20.6	20.3	43.2
EW-30	Chromium	400	NA	244[(1)]
EW-33	Cadmium	0.264	0.25	0.33
EW-34	Chromium	300	NA	244[(1)]
EW36	Chromium	246	NA	244[(1)]

[(1)] BPTCP reference station value.

36. ***Comment #36.*** **Historical Data: Please insure that historically-collected data representing subsurface contamination is included in the feasibility study.**

Response: All relevant historical (i.e., Phase IIB ERA) and more recent subsurface data (i.e., from the VS and FS Data Gaps investigation) will be included in the FS.

37. ***Concluding Comment.*** **Regional Board Staff finds that the WOE approach used at HPS is fundamentally flawed and should not be applied to other sites. All three lines of evidence should be scored equally and negative and positive scoring is unacceptable. At the conclusion of the VS, a small area of contaminated sediments is identified for further evaluation in the feasibility study. Staff disagrees with the conclusions presented in the VS. A larger footprint needs to be evaluated for remediation and should include most areas of the low volume footprint as well as those areas of elevated mercury and PCB contamination (see comment no.6) within the high volume footprint. One alternative the Navy should also consider evaluating in the feasibility study is remediating the sediment chemistry hot spots as identified on Figure 8-1.**

Response: Please refer to the response to USEPA General Comment #1 regarding the approach for developing the FS footprint. The WOE approach presented in the Draft Final VS Report has not been substantially revised; however, the WOE results are not used directly to delineate the FS footprint.

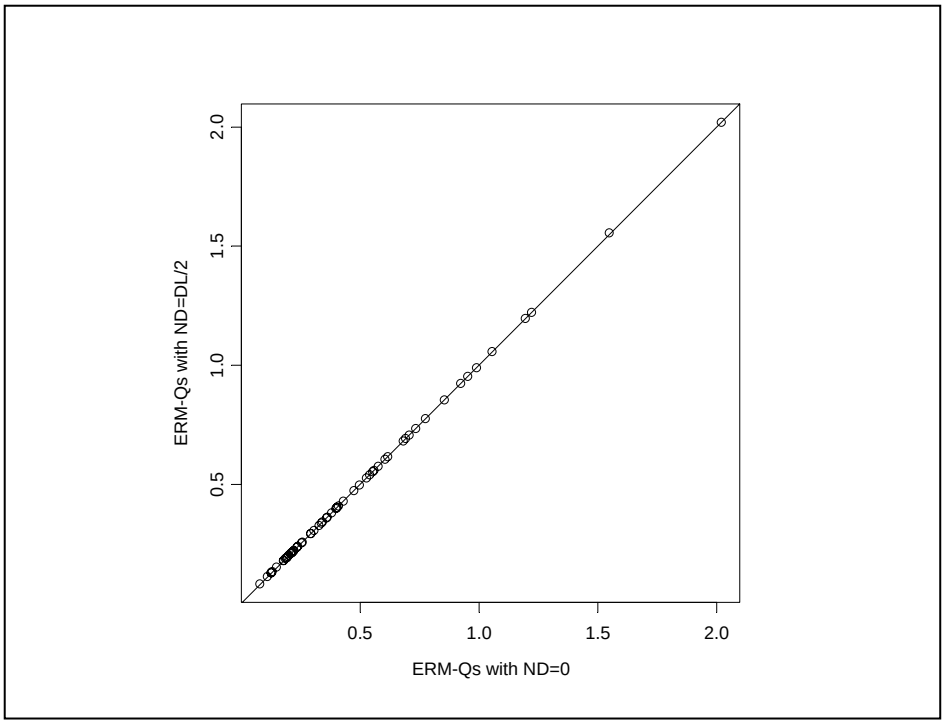
U.S. Department of the Interior, Fish and Wildlife Service
Response to July 23, 2002 Comments

Specific Comments

1. ***Page 17, first paragraph.*** **This section discusses calculation of Effects Range Medium Quotients (ERM-Qs). A review of appendix F indicates that non-detect constituents were given a value of zero, which potentially underestimates the ERM-Qs. Values for non-detect constituents should be set at 50 percent of the detection limit or those constituents should be eliminated from the ERM-Q calculation.**

   Response: The substitution of zeroes for non-detected constituents is a common practice for summed constituents when the analytical results achieved low detection limits, as was the case for the VS. The figure below is a bivariate plot of the ERM-Q calculated both ways, and shows an almost perfect fit to the 1:1 line. Therefore, substituting values of 50% of the detection limit for non-detected constituents has very little impact on the ERM-Q.

Bivariate Plot of ERM-Qs Calculated with Non-detects = ½ DL vs Non-detects = 0



2. ***Page 20, fourth paragraph.*** **The discussion of *Macoma* bioaccumulation tests provides no evidence from literature or other sources that a 28-day exposure is sufficient for the organisms to reach steady-state concentrations of bioaccumulative compounds. Data from the United Heckathorn Superfund Site suggest that it is not. At that site, dichlorodiphenyltrichloroethane (DDT) tissue concentrations in *Macoma* exposed to site sediment for 28 days were about half of those in *Macoma* exposed for 90 days (USEPA 1994). The implication for the bioaccumulation factor (BAF) used in the oral dose models is discussed below.**

Response: Site-specific data from HPS can be used to address this comment. A qualitative comparison of field-collected hard-bodied invertebrate (HBI) tissue concentrations (which we assume are at steady-state equilibrium) to laboratory-exposed *M. nasuta* tissue concentrations indicate that they are similar (see Figure 7-15 of the Draft Final VS Report). Another way to evaluate this more quantitatively is to estimate the relative percent difference (RPD) between laboratory *M. nasuta* and the field-collected HBI for DDxs and PCBs:

AREA	Total DDx			Total PCBs		
	HBI (ug/kg DW)	Macoma (ug/kg DW)	Relative % Difference (based on HBI)*	HBI (ug/kg DW)	Macoma (ug/kg DW)	Relative % Difference (based on HBI)*
Area I	29.89	15.60	47.81%	256.22	137.06	46.51%
Area VIII	12.88	9.30	27.80%	465.20	281.84	39.42%
Area IX	14.51	21.84	-50.52%	942.70	893.06	5.27%
Area X	40.08	43.09	-7.52%	2510.88	3766.57	-50.01%

RPD(HBI)=100(HBI-Mac)/HBI; this assumes that the HBI value is "truth"
HBI were not collected in Area III

The data in the above table suggest that the RPD between the laboratory *M. nasuta* data and the field-collected data varies between Parcel F Areas. For DDxs in South Basin, the laboratory *M. nasuta* tissues had slightly higher concentrations than tissues from the field-collected bivalves.

A second way to evaluate the significance of the RPDs developed for the HBI vs. the laboratory *M. nasuta* data are to compare them to laboratory *M. nasuta* data where replicates from the same station were analyzed. For the VS, five replicates were analyzed for each of the five reference locations. RPDs for both DDxs and PCBs for the reference stations are presented below.

	Relative % Difference	
Ref Area	PCBs	DDXs
Alameda Buoy	22.45%	18.71%
Bay Farm	43.80%	68.85%
Paradise Cove	35.77%	60.85%
Alcatraz Environs	56.91%	52.42%
Red Rocks	54.82%	55.30%

RPD=100*(max-min)/mean

The data presented in this table indicate that the range of RPDs found for replicates of the laboratory samples are within the same range as those observed in the comparison of laboratory and field-collected data. This further lends support to the conclusion that the 28-day bioassay was sufficient for animals to reach conditions close to steady-state for organic compounds at HPS.

3. ***Page 25, Table 2-5.*** **The WOE scoring matrix should be revised to eliminate the negative scores. Philosophically, it does not seem appropriate for points to be subtracted from the cumulative score because conditions at a site are near ambient conditions for the bay. We suggest that the scores run from a low of zero to a high of at least three, but preferably four (see comments in**

Weight of Evidence section below.) We also suggest that the data referred to as "ancillary" be incorporated into the WOE matrix.

Response: Positive and negative scores in the WOE scoring matrix were used to define positive and negative findings of risk, which are standard terms developed for the Massachusetts WOE process (Menzie et al, 1996) upon which the VS model was based. Changing the scoring system so that all values are positive would not impact the overall results because there would be no relative changes. The ancillary data cannot be evaluated within the quantitative WOE model because it is not available at every station. However, the development of the FS footprint in Section 10 of the Draft Final VS Report is based on the evaluation of all the data, including the ancillary data.

4. ***Page 27, first paragraph.*** **This section discusses Regional Monitoring Plan (RMP) data for San Francisco Bay. It implies that the RMP represents an "ambient" data set, and that fish tissue data have limited utility because concentrations of certain bioaccumulative toxicants are elevated throughout the bay; however, the RMP intentionally includes data from sites with known contamination, such as the Oakland Inner Harbor. In addition, review of the RMP data (SFEI 1999) shows that tissue concentrations of mercury, DDT, and polychlorinated biphenyls (PCBs) in fish from those sites can be distinguished statistically from those in fish from less contaminated sites. The use of fish tissue data for site-specific assessments is therefore supported by the RMP. See the comment below regarding the use of RMP data presentation in the Human Health Evaluation.**

   Response: As noted in the response to RWQCB Specific Comment #29, the RMP data were provided for comparative purposes only, and to provide an historical context. The statistical evaluations performed for the human health evaluation were based on data collected concurrently from HPS and the reference locations identified in the Human Health Evaluation Work Plan (Battelle et al., 2001). Figures 9-3 through 9-6 of the Draft Final VS Report have been revised to compare the HPS fish tissue data to the previously collected RMP data, excluding the Oakland Inner Harbor samples. The exclusion of the Oakland Inner Harbor data does not change the overall findings of the human health evaluation (i.e., that the HPS results are comparable to data from both ambient locations and the RMP).

5. ***Page 29, first paragraph.*** **Additional effort should be made to collect white croaker data. White croaker from the vicinity of Hunter's Point have been demonstrated to have significantly elevated concentrations of PCBs and DDT, associated with significantly elevated occurrences of various types of liver lesions (Myer *et al.* 1994). Similar results were reported for starry flounder.**

   Response: Despite repeated efforts, attempts to collect white croaker were not successful during the May/June 2001 sampling period. The BCT was consulted regarding these difficulties at the time of sampling, and an agreement to abandon sampling for this species was reached at that time.

6. ***Page 94, second paragraph*****. The bioavailability of metals from specific locations is not addressed as a potential confounding factor in explaining bioassay results.**

   At no point in this chapter is the potential for sub-lethal effects to benthic invertebrates discussed. Hornberger *et al*. (2001), for example, reported reproductive, population-level effects in field-collected *Macoma balthica* exposed to silver and copper in sediment at concentrations between the Effects Ranges Low (ERLs) and ERMs. The question of sublethal effects to fish

from organic contaminants is also not addressed, in spite of evidence of adverse effects to fish from the Hunter's Point area in literature (Myers *et al*. 1994).

Response: In the SWI larval test, which has both lethal and sublethal endpoints, the potential COPEC contribution to toxicity (lethal and sublethal endpoints) at specific locations was difficult to address because of the considerable uncertainty introduced by the non-COPEC confounding factors. In the amphipod test, lethality was low in general, and did not appear related to COPEC concentrations. The SWI and amphipod toxicity endpoints were selected because of their sensitivity, because there is a large reference database for San Francisco Bay against which to assess relative risk, and because of the need for site-specific sediment chemistry and effects data for developing a FS footprint.

Potential sublethal adverse effects to fish were not directly evaluated in the VS because the study design focused on toxicity endpoints that could most readily and confidently be correlated with sediment COPECs. As a result, relevant site-specific data were not collected for such an evaluation. Although not presented in the VS Work Plan or Report, available toxicity data for various fish and invertebrate endpoints were compiled to assess the relative sensitivity of invertebrates vs. fish. For many contaminants for which data were available (e.g., copper, cadmium, zinc, pesticides), invertebrate endpoints such as echinoderm embryo development and crustacean survival were more sensitive than fish.

The work of Hornberger et al. (2000) evaluating reproductive success in *M. balthica* is a good example of the value of long-term data collection, even if based on only ten clam samples per event. The sediment chemistry data are not directly comparable with HPS because of differences in collection, sample manipulation, and analytical methods, but clam body burden concentrations can be compared. The HPS field-collected hard-bodied invertebrate (HBI) samples (0.1-0.7 ppm silver, 9-31.6 ppm copper) and most *Macoma nasuta* body burdens (undetected-1.7 ppm silver; 10-191 ppm copper, avg. 24 ppm copper) were within the range of concentrations associated with improved reproductive success in *M. balthica* (<20 ppm copper, <100 ppm copper), and generally close to the regional background (0.5 ppm silver, 25 ppm copper).

7. ***Page 96, first paragraph*. Regarding Macoma nasuta survival in laboratory bioaccumulation tests, it would be helpful to see the result of regressing percent survival against ERM-Qs.**

   Response: Please refer to the response to USEPA Specific Comment #4.

8. ***Page 97, last paragraph*. The text states that hazard quotients (HQs) were calculated for all contaminants of potential ecological concern (COPECs) with toxicity reference values (TRVs). The text should also explain which COPECs, if any, lacked TRVs and how those compounds will be evaluated. If an approved TRV is not available for a specific COPEC, such as chromium, it is incumbent upon the Navy to recommend the best TRV available based on current literature. The threshold tissue values used to carry compounds forward into dose assessment were based on the 90th percentile concentrations from reference stations. It is not clear why subsequent dose calculations are based on mean sediment and tissue values, rather than on the 90th percentiles. This appears to increase conservatism in carrying compounds forward, but reduce conservatism in calculating oral doses for comparison to the TRVs.**

   Response: Chemical-specific TRVs used in the dose assessment were developed by the Navy, in consultation with the USEPA Region 9 Biological Technical Assistance Group (BTAG) (EFA West 1998). It was agreed that additional TRVs would be developed in conjunction with the BTAG for

those compounds with sufficient high quality data. Due to the dearth of high quality toxicity data for birds and mammals, TRVs were only developed for a limited subset of COPECs. As part of work done for offshore sediments at Alameda Point (Battelle et al., 2001, Data Summary Memorandum for Alameda Point), a literature search was performed to determine if TRVs were available for other COPECs. The results of this literature search indicated that insufficient data were available to formally develop additional TRVs for the remaining COPECs. Should toxicity data of sufficiently high quality for the remaining COPECs lacking formal TRVs be available, the data will be reviewed for possible inclusion in the evaluation. Section 11.1.3.4 of the VS Report discusses the uncertainty associated with the bioaccumulation assessment for those COPECs lacking formal TRVs.

The 90th percentile tissue values were meant to provide an upper bound to reference tissue conditions. Thus, site tissue concentrations less that the 90th percentile of reference were assumed to be part of the reference distribution and to not be elevated above reference. Refined dose calculations estimated potential risk associated with exposure based on an estimate of the central tendency of the data set. The central tendency included an evaluation of the 95% UCL and the arithmetic mean. Since the purpose of this exercise was an estimation of the central tendency, the use of the 90th percentile of HPS concentrations as the EPC was not considered appropriate.

9. P*age 98, third paragraph*. **The exposure assessment includes an assumption limiting tissue data used in the oral dose models to depurated, laboratory *Macoma* data. For comparison, doses should also be calculated using field-collected soft-bodied invertebrate data. If double counting incidental sediment ingestion is a concern, then the sediment ingestion rate in the calculation can be reduced. In addition, the possibility that the laboratory *Macoma* data underestimate steady state should be evaluated by doubling the tissue concentrations for PCBs and DDTs used in the model.**

   Response: Please refer to the response to USEPA Specific Comment #5 for a discussion of the dose assessment using the field-collected tissue data. As discussed in the response to USFWS Comment #2 above, examination of site-specific data for field and laboratory clam tissue samples suggests that the 28-day exposure was sufficient to provide a realistic evaluation of PCB and DDx uptake. Therefore, doubling the tissue concentrations for PCBs and DDxs is not considered to be necessary.

10. *Page 99, last paragraph*. **The TRV scaling formula provided in the text, which is based on body weight differences with no allometric exponent, is inconsistent with risk assessments being performed at other Navy sites such as Mare Island and Concord. At both of those sites, the allometric scaling exponents developed by Sample and Arenal (1999) are being applied. In addition, the Navy's draft TRV document (U.S. Navy 1997) recommended a scaling exponent of 0.33. The document should evaluate the effect of strict body weight scaling versus the various possible allometric scaling exponents on TRV calculations.**

    Response: Section 6 of the Draft Final VS Report has been revised using the Sample and Arenal (1999) equation, and the dose assessment and WOE were rerun using these new TRVs. The correct equation is:

$$TRV_w = TRV_l * (BW_s/BW_r)^{1-1.2}$$

Where:	TRV_w	=	weight-adjusted TRV (mg/kg-day)
	TRV_l	=	literature-based TRV (mg/kg-day)
	BW_s	=	body weight of toxicity study receptor (kg)
	BW_r	=	body weight of ecological receptor (kg).

As noted above, a number of different body weight scaling formulae are available. Depending on the size of the receptor of concern in relation to the test study organism, the different scaling factors can either increase or decrease the adjusted TRV. For those COPECs with HQs close to 1, the differences in these scaled TRVs can raise or lower them enough that a different decision about potential risk might be made. This highlights the level of "noise" present in the dose model and that, for HQs close to 1, it may be impossible to determine whether they are less than, equal to, or greater than one. TRVs presented in the Draft VS Report and revised TRVs developed using the equation above are summarized in the tables below for the surf scoter and double-crested cormorant.

Comparison of Surf Scoter TRVs from the Draft VS Report and Calculated Using Sample and Arenal (1999)

Surf Scoter	Draft VS TRVs						Revised TRVs					
COPEC	NOAEL Study Receptor Body Weight (kg)	Literature-Based Low Avian TRV (NOAEL) (mg/kg/day)	Weight-Adjusted Low TRV (mg/kg/day)	LOAEL Study Receptor Body Weight (kg)	Literature-Based High Avian TRV (LOAEL) (mg/kg/day)	Weight-Adjusted High TRV (mg/kg/day)	NOAEL Study Receptor Body Weight (kg)	Literature-Based Low Avian TRV (NOAEL) (mg/kg/day)	Weight-Adjusted Low TRV (mg/kg/day)	LOAEL Study Receptor Body Weight (kg)	Literature-Based High Avian TRV (LOAEL) (mg/kg/day)	Weight-Adjusted High TRV (mg/kg/day)
Aluminum		NA	NA		NA	NA		NA	NA		NA	NA
Antimony		NA	NA		NA	NA		NA	NA		NA	NA
Arsenic	1.1722	5.50E+00	5.86E+00	1.17E+00	2.20E+01	2.35E+01	1.1722	5.50E+00	5.43E+00	1.17E+00	2.20E+01	2.17E+01
Barium		NA	NA		NA	NA		NA	NA		NA	NA
Cadmium	0.7985	8.00E-02	5.81E-02	8.40E-02	1.04E+01	7.96E-01	0.7985	8.00E-02	8.53E-02	8.40E-02	1.04E+01	1.74E+01
Chromium		NA	NA		NA	NA		NA	NA		NA	NA
Cobalt		NA	NA		NA	NA		NA	NA		NA	NA
Copper	0.639	2.30E+00	1.34E+00	4.09E-01	5.23E+01	1.94E+01	0.639	2.30E+00	2.56E+00	4.09E-01	5.23E+01	6.37E+01
Iron		NA	NA		NA	NA		NA	NA		NA	NA
Lead	0.084	1.40E-02	1.07E-03	8.00E-01	8.75E+00	6.36E+00	0.084	1.40E-02	2.34E-02	8.00E-01	8.75E+00	9.33E+00
Manganese		NA	NA		NA	NA		NA	NA		NA	NA
Mercury	1	3.90E-02	3.55E-02	1.00E+00	1.80E-01	1.64E-01	1	3.90E-02	3.98E-02	1.00E+00	1.80E-01	1.83E-01
Molybdenum		NA	NA		NA	NA		NA	NA		NA	NA
Nickel	0.61375	1.38E+00	7.70E-01	5.80E-01	5.53E+01	2.91E+01	0.61375	1.38E+00	1.55E+00	5.80E-01	5.53E+01	6.28E+01
Selenium	1.1077	2.30E-01	2.32E-01	1.11E+00	9.30E-01	9.37E-01	1.1077	2.30E-01	2.30E-01	1.11E+00	9.30E-01	9.29E-01
Silver		NA	NA		NA	NA		NA	NA		NA	NA
Vanadium		NA	NA		NA	NA		NA	NA		NA	NA
Zinc	0.955	1.72E+01	1.49E+01	9.55E-01	1.72E+02	1.49E+02	0.955	1.72E+01	1.77E+01	9.55E-01	1.72E+02	1.77E+02
HMW PAH		NA	NA		NA	NA		NA	NA		NA	NA
LMW PAH		NA	NA		NA	NA		NA	NA		NA	NA
Total PCBs	0.8	9.00E-02	6.55E-02	1.72E+00	1.27E+00	1.98E+00	0.8	9.00E-02	9.59E-02	1.72E+00	1.27E+00	1.16E+00
Total 4,4′-DDx	3.5	9.00E-03	2.86E-02	1.00E+00	6.00E-01	5.45E-01	3.5	9.00E-03	7.14E-03	1.00E+00	6.00E-01	6.12E-01
alpha-Chlordane		NA	NA		NA	NA		NA	NA		NA	NA
Dieldrin		NA	NA		NA	NA		NA	NA		NA	NA
Endosulfan II		NA	NA		NA	NA		NA	NA		NA	NA
Endrin		NA	NA		NA	NA		NA	NA		NA	NA
gamma-Chlordane		NA	NA		NA	NA		NA	NA		NA	NA
Heptachlor		NA	NA		NA	NA		NA	NA		NA	NA
Dibutyltin	0.0965	7.30E-01	6.40E-02	0.0965	4.59E+01	4.02E+00	0.0965	7.30E-01	1.19E+00	0.0965	4.59E+01	7.46E+01
Monobutyltin		NA	NA		NA	NA		NA	NA		NA	NA
Tetrabutyltin		NA	NA		NA	NA		NA	NA		NA	NA
Tributyltin	0.0965	7.30E-01	6.40E-02	0.0965	4.59E+01	4.02E+00	0.0965	7.30E-01	1.19E+00	0.0965	4.59E+01	7.46E+01

Comparison of Cormorant TRVs from the Draft VS Report and Calculated Using Sample and Arenal (1999)

Cormorant	Draft VS TRVs						Revised TRVs					
COPEC	NOAEL Study Receptor Body Weight (kg)	Literature-Based Low Avian TRV (NOAEL) (mg/kg/day)	Weight-Adjusted Low TRV (mg/kg/day)	LOAEL Study Receptor Body Weight (kg)	Literature-Based High Avian TRV (LOAEL) (mg/kg/day)	Weight-Adjusted High TRV (mg/kg/day)	NOAEL Study Receptor Body Weight (kg)	Literature-Based Low Avian TRV (NOAEL) (mg/kg/day)	Weight-Adjusted Low TRV (mg/kg/day)	LOAEL Study Receptor Body Weight (kg)	Literature-Based High Avian TRV (LOAEL) (mg/kg/day)	Weight-Adjusted High TRV (mg/kg/day)
Aluminum		NA	NA		NA	NA		NA	NA		NA	NA
Antimony		NA	NA		NA	NA		NA	NA		NA	NA
Arsenic	1.1722	5.50E+00	3.86E+00	1.17E+00	2.20E+01	1.54E+01	1.1722	5.50E+00	5.43E+00	1.17E+00	2.20E+01	2.17E+01
Barium		NA	NA		NA	NA		NA	NA		NA	NA
Cadmium	0.7985	8.00E-02	3.83E-02	8.40E-02	1.04E+01	5.25E-01	0.7985	8.00E-02	8.53E-02	8.40E-02	1.04E+01	1.74E+01
Chromium		NA	NA		NA	NA		NA	NA		NA	NA
Cobalt		NA	NA		NA	NA		NA	NA		NA	NA
Copper	0.639	2.30E+00	8.80E-01	4.09E-01	5.23E+01	1.28E+01	0.639	2.30E+00	2.56E+00	4.09E-01	5.23E+01	6.37E+01
Iron		NA	NA		NA	NA		NA	NA		NA	NA
Lead	0.084	1.40E-02	7.04E-04	8.00E-01	8.75E+00	4.19E+00	0.084	1.40E-02	2.34E-02	8.00E-01	8.75E+00	9.33E+00
Manganese		NA	NA		NA	NA		NA	NA		NA	NA
Mercury	1	3.90E-02	2.34E-02	1.00E+00	1.80E-01	1.08E-01	1	3.90E-02	3.98E-02	1.00E+00	1.80E-01	1.83E-01
Molybdenum		NA	NA		NA	NA		NA	NA		NA	NA
Nickel	0.61375	1.38E+00	5.07E-01	5.80E-01	5.53E+01	1.92E+01	0.61375	1.38E+00	1.55E+00	5.80E-01	5.53E+01	6.28E+01
Selenium	1.1077	2.30E-01	1.53E-01	1.11E+00	9.30E-01	6.17E-01	1.1077	2.30E-01	2.30E-01	1.11E+00	9.30E-01	9.29E-01
Silver		NA	NA		NA	NA		NA	NA		NA	NA
Vanadium		NA	NA		NA	NA		NA	NA		NA	NA
Zinc	0.955	1.72E+01	9.84E+00	9.55E-01	1.72E+02	9.84E+01	0.955	1.72E+01	1.77E+01	9.55E-01	1.72E+02	1.77E+02
HMW PAH		NA	NA		NA	NA		NA	NA		NA	NA
LMW PAH		NA	NA		NA	NA		NA	NA		NA	NA
Total PCBs	0.8	9.00E-02	4.31E-02	1.72E+00	1.27E+00	1.30E+00	0.8	9.00E-02	9.59E-02	1.72E+00	1.27E+00	1.16E+00
Total 4,4′-DDx	3.5	9.00E-03	1.89E-02	1.00E+00	6.00E-01	3.59E-01	3.5	9.00E-03	7.14E-03	1.00E+00	6.00E-01	6.12E-01
alpha-Chlordane		NA	NA		NA	NA		NA	NA		NA	NA
Dieldrin		NA	NA		NA	NA		NA	NA		NA	NA
Endosulfan II		NA	NA		NA	NA		NA	NA		NA	NA
Endrin		NA	NA		NA	NA		NA	NA		NA	NA
gamma-Chlordane		NA	NA		NA	NA		NA	NA		NA	NA
Heptachlor		NA	NA		NA	NA		NA	NA		NA	NA
Dibutyltin	0.0965	7.30E-01	4.22E-02	0.0965	4.59E+01	2.65E+00	0.0965	7.30E-01	1.19E+00	0.0965	4.59E+01	7.46E+01
Monobutyltin		NA	NA		NA	NA		NA	NA		NA	NA
Tetrabutyltin		NA	NA		NA	NA		NA	NA		NA	NA
Tributyltin	0.0965	7.30E-01	4.22E-02	0.0965	4.59E+01	2.65E+00	0.0965	7.30E-01	1.19E+00	0.0965	4.59E+01	7.46E+01

11. ***Page 101, first paragraph.*** **The document does not adequately address the potential for additive or synergistic contaminant effects (Walker *et al*. 2001) on birds. The standard way to address this issue is by summing individual hazard quotients into a hazard index.**

    Response: A mixture of contaminants at a site poses the possibility of additive, synergistic or antagonistic effects. USEPA guidance recommends using a hazard index (HI) approach only for those COPECs that have similar modes of action (USEPA 1997). The determination of which COPECs have similar modes of action requires intensive evaluation of each individual TRV so that the COPECs that should be evaluated together can be identified. Because the development of PRGs is based on individual COPECs, the most significant contributors to the HI must be identified. For example, the most significant contributor to risk in South Basin are PCBs, and the extra level of effort required to develop HIs would not better define risk drivers, aid in developing PRGs, or refine the proposed FS footprint. Therefore, the uncertainty associated with evaluating mixtures has been addressed in Section 11 (Uncertainty) of the Draft Final VS Report.

12. **Page 111, first paragraph. The site use factor should be set at no less than 0.5 unless there is site-specific data to support a different value. Although site use by both the surf scoter and the double-crested cormorant might be less, this is by no means clear. In addition, those receptors are intended to represent members of feeding guilds that are not individually represented in the risk assessment, and the site use factor appropriate for those receptors is entirely unknown. A site use factor of 0.5 therefore seems reasonable.**

    Response: HPS-specific data on site use for either the scoter or the double-crested cormorant are not available. However, San Francisco Bay-specific information is available for the double-crested cormorant that can be used to develop a fairly reasonable estimate of site use. No such SF Bay-specific data are available for the scoter. However, scoters are only present in SF Bay half of the year, so a SUF of 0.5 would mean that, over the winter, they spend 100% of their time at HPS. This is likely to be an overly conservative assumption based on what is known about scoters in other habitats such as Puget Sound, Washington (Mahaffy, M.S., C.R. Bennett, and W. Parsons. 1995. "Puget Sound Waterbirds as Contaminant Monitors." *Puget Sound Research '95, Proceedings*. Puget Sound Water Quality Authority. January 12-14).

    Because of the uncertainty associated with these home range data, a range of SUFs is presented in Section 6.3.2.1 of the Draft Final VS Report to illustrate the impact of the SUF on the resulting HQs. The scoter is meant to represent benthic-invertebrate feeding birds that can access both shallow and deep sediments (scoter can dive up to 10 m deep). Most of the birds that have foraging habits (and thus exposure) similar to the scoter are also winter migrants. In fact, few species of shorebirds/diving ducks spend all year in San Francisco Bay or would, when present in the Bay, forage exclusively at HPS. Section 10 of the Draft Final VS Report presents PRGs based on a range of SUFs.

13. ***Page 111, second paragraph.*** **There is a typographical error in the formula presented in this section. The combined reference and site dose should be the sum rather than the product of the two doses.**

    Response: The typographical error has been corrected. This typographical error had no impact on the figures or calculations, as the actual working equation was correct.

14. ***Page 121, last paragraph.*** **In the discussion of site wide hazard quotients, it is important to note that with a site use factor of 0.5, there is a significant contribution to risk to the surf scoter from Hunter's Point contamination for all of the compounds that exceed the tissue threshold values.**

Response: For many COPECs, the HQ is less than 1 at a SUF of 0.5, indicating a low potential for risk to upper-trophic level receptors. Although for some of these COPECs there is a significant contribution to exposure from HPS, the cumulative exposure still results in an HQ < 1.

15. ***Page 129, third paragraph.*** **This section discusses the results of analyses performed on field-collected invertebrates and fish. While it is true that in general field-collected organisms have concentrations similar to laboratory *Macoma*, this trend does not hold for the bioaccumulative compounds that are of the most concern, including DDTs, PCBs, and mercury. In addition, there are apparent differences for a number of metals, including cadmium, chromium, and lead, in soft-bodied invertebrates compared to laboratory *Macoma* and hard-bodied invertebrates. These differences have not been accounted for in the surf scoter oral dose calculations.**

    Response: Please refer to the response to USEPA Specific Comment #5 regarding the use of field-collected tissue data in the dose assessment. Section 7 of the VS Report has been revised to include dose calculations based on field-collected tissue data.

16. ***Page 150, Table 8-1.*** **Over 50 percent of stations fall into a category needing further evaluation based on the integrated WOE score. This low level of resolution indicates a need to reevaluate the scoring criteria. As was discussed above, we recommend that the negative scores be eliminated, and that a score of zero be used to represent ambient conditions. In addition, the current scoring method provides insufficient differentiation for the magnitude of exceedences of ERM values for the sediment data and TRVs for the bioaccumulation line of evidence. Finer resolution could be attained by adding another score to each line of evidence.**

    Response: Please refer to the response to USEPA General Comment #1 regarding the approach for developing the FS footprint. There are a number of options for revising the WOE model and potentially improving its resolution; however, changes in WOE methodology are unlikely to change the overall findings and recommendations of the VS. Instead, Section 10 of the Draft Final VS Report has been revised to provide a detailed evaluation of all the data to identify the pathways and contaminants driving risk, and to develop ranges of PRGs.

17. ***Page 184, first paragraph.*** **The document uses RMP data on contaminant concentrations in fish to support an assertion that concentrations of mercury, DDT, and PCBs in fish from Hunter's Point are representative of San Francisco Bay in general; however, the RMP data from 1997 (SFEI 1999) show statistically significantly higher wet weight concentrations of DDTs, mercury, and PCBs in shiner surfperch and of mercury and PCBs in jacksmelt from the Oakland Inner Harbor than from other locations where these species were sampled. Oakland Inner Harbor data for these species should, therefore, not be included in the box plots in figures 9-3, 9-5, and 9-6.**

    Response: Figures 9-3 through 9-6 have been revised to present the RMP data with the Oakland Inner Harbor samples removed for those chemicals found to be statistically different from ambient. As discussed in response to USFWS Comment #1, the range of chemical concentrations at HPS for both surfperch and jacksmelt were consistent with concentrations measured in concurrently-collected samples from ambient areas, and reported tissue levels from RMP surveys (excluding Oakland Inner Harbor data), with the exception of total PCBs.

18. ***Page 205, second paragraph.*** **Copper and mercury need to be included, along with PCBs, in the development of the feasability study (FS) footprint for the South Basin area.**

Response: Revised dose assessment results reported in the Draft Final VS Report indicate that PCBs and copper are driving risk in South Basin, and mercury and copper are driving risk at Point Avisadero (Area III). PRGs for these COPECs have been developed in Section 10 of the Draft Final VS Report. Please refer to the introduction to this response to comments for further discussion of the revised approach for the development of the FS footprint.

19. ***Page 205, last paragraph.*** **The copper and mercury concentrations in the Point Avisadero sediments are high, and further, are clearly associated with a Hunter's Point source. Given the greater bioavailability of mercury and copper in the Point Avisadero area to benthic invertebrates shown in the validation study data, there is no justification for excluding the affected stations from the FS footprint.**

Response: PRGs for copper and mercury have been developed in Section 10 of the Draft Final VS Report based on data from Point Avisadero (Area III). These PRGs will be used to delineate the FS footprint in Area III.

20. ***Page 207, third paragraph.*** **The *Macoma* bioaccumulation results suggest that lead should also be included as risk driver for the Oil Reclamation area.**

Response: Because the potential risk from exposure to lead from Area IX approaches that from ambient exposure at SUFs near and below 0.5 (Figure 6-14 of the Draft Final VS Report), lead is not believed to drive risk in Area IX (Oil Reclamation Area). This is in contrast to PCBs, where the majority of exposure is from PCBs at the site rather than from ambient exposure.

21. ***Page 208, second paragraph.*** **Formula 10-6 contains a typographical error. The term [(TRV*BW)/SUF] should be divided by (IR_{sed}+IR_{prey}*BAF), not multiplied. In addition, the reference or ambient dose (AD) to receptors has to be taken into account when calculating preliminary remediation goals (PRGs). The formula presented in this section should be modified as follows:**

$$X=\{[(TRV*BW)-AD]/SUF\}/(IR_{sed}+IR_{prey}*BAF)$$

where: $AD=\{[(IR_{sed}*C_{refsed})+(IR_{prey}*C_{refprey})]*(1-SUF)\}$ **with units of mg/day.**

If prey data are lacking, the reference or ambient concentration in prey ($C_{refprey}$) can be replaced by the term C_{refsed}*BAF. In addition, the calculations for surf scoter do not consider that the *Macoma* data used in the oral dose model might underestimate the true BAF. The United Heckathorn data (USEPA 1994) suggest the BAF could potentially be twice as high. As an example, Tables 1 and 2 compare the Navy's calculated PRGs for PCBs to PRGs calculated for surf scoters and cormorants using the correction for ambient exposure shown above and for surf scoters using a BAF of 4.0 vice 2.0. An ambient sediment concentration of 0.0296 mg PCB/kg was used (Gandesbery and Hetzel 1998). Other parameters, such as body weights and ingestion rates are those used in the validation study.

Table 1 - Surf Scoter

Site Use Factor	Navy PRG (mg/kg)	PRG Corrected for Ambient Exposure (mg/kg)	PRG Corrected for Ambient Exposure with BAF=4.0 (mg/kg)
1	0.42	0.42	0.21
0.5	0.85	0.82	0.40
0.1	4.23	3.96	1.86
0.02	21.1	19.7	9.20

Table 2 - Double-Crested Cormorant			
Site Use Factor	**Navy PRG (mg/kg)**	**PRG Corrected for Ambient Exposure (mg/kg)**	**PRG Corrected for Ambient Exposure with BAF=4.0 (mg/kg)**
1	**0.09**	**0.09**	**Not applicable**
0.5	**0.17**	**0.15**	**Not applicable**
0.1	**0.87**	**0.67**	**Not applicable**
0.025	**3.49**	**2.60**	**Not applicable**

Tables 1 and 2 suggest that, with the recommended site use factor of 0.5, the PRG of 2.0 mg/kg proposed by the Navy is not sufficiently protective of either avian species. A value of approximately 0.2 mg/kg, based on cormorant exposure, would be more appropriate.

Response: The typographical error in Formula 10-6 has been corrected in the Draft Final VS Report. The BAFs developed from the laboratory *M. nasuta* data are not believed to underestimate the uptake of bioaccumulative compounds. As discussed in the response to USFWS Comment #2, site-specific data indicate that the laboratory *M. nasuta* sample results appear to adequately represent field concentrations of bioaccumulative compounds.

Inclusion of ambient exposure into the PRG equation is not believed to be warranted because sufficient conservatism has already been built into the model (i.e., use of low TRVs as targets, assumption of 100% uptake and assimilation from diet, etc.). For PCBs, which are the main risk driver in South Basin, the addition of ambient exposure into the equation does not significantly change the PRG because the contribution of ambient is minimal in comparison to that from the site.

A SUF of 0.5 may be an overly conservative estimate for the receptors of concern at the site. However, Section 10 of the Draft Final VS Report has been revised to present ranges of PRGs for both the scoter and double-crested cormorant based on a range of SUFs.

22. **Page 213. A number of factors that contribute to uncertainty were not adequately addressed in this chapter. First, no attempt is made to account for the potential additive or synergistic effects of multiple contaminants. Second, the effect of different allometric scaling methods on TRVs has not been evaluated. Third, there is no discussion of the regional status of the avian receptor populations. Fourth, the implications of the lack of assessment provided for other potential receptors such as benthic foraging fish, marine mammals, and benthic invertebrates, are not discussed, even though literature suggests risks to such receptors (Myers *et al.* 1994; Hornberger et al. 2001). Fifth, the interaction of non-contaminant stressors with chemical exposure in the receptors of concern is not discussed.**

    Response: Section 11 of the Draft Final VS Report has been revised to include discussion of the factors identified above.

23. ***Page 229, third paragraph.* The conclusion that ecological risk associated with the offshore sediments at Hunter's Point can be attributed primarily to bioaccumulation and food-chain transfer to upper trophic level receptors is misleading, since the potential for chronic effects to benthic fish and invertebrates was not evaluated. In addition, mercury, copper and lead should be considered risk drivers in specific areas, as discussed above. Finally, a PRG of 2 mg/kg PCBs will not be adequately protective of piscivorous birds, or of the other receptors that those species are intended to represent.**

Response: Section 12 of the Draft Final VS Report has been revised to indicate that bioaccumulation and food chain transfer are the pathways driving risk based on the endpoints that were evaluated in the VS. These endpoints were selected by the Navy and agency technical group during the VS Work Plan development. Mercury and copper have been identified as risk drivers in Area III, and PRGs for these metals have been developed in Section 10 of the Draft Final VS Report. Quantitative PRGs were not developed for lead because of uncertainty associated with the lead TRV. However, lead concentrations in sediment are highest in Area X, where they generally co-occur with high PCB concentrations. Section 10 of the Draft Final VS Report presents a range of PRGs for both the scoter and cormorant based on a range of SUFs.

San Francisco Redevelopment Agency
Response to June 20, 2002 Comments

General Comment

1. **The studies described in this draft report of the HPS (Hunter's Point Shipyard) were generally well designed and executed, and most improvements in assessing the environmental risks addressed would require more data collection and consequent increased costs. Most of the risks from sediment contamination by the COPECs (Chemicals of Potential Ecological Concern) evaluated were acceptable (by the criteria used). The FS (Feasibility Study) footprint was determined primarily by the risks associated with bioaccumulation of PCBs (polychlorinated biphenyls), although risks from lead contamination could not be assessed adequately because of a lack of information on bioavailability and an extremely conservative TRV (Toxicity Reference Value).**

   Response: This comment is acknowledged.

Specific Comments

1. ***Section 1.Introduction. Comment #1.*** **The study design includes three lines of evidence commonly used in contaminated sediment assessments, 1) sediment chemistry, 2) toxicity (both bulk sediments and sediment-water interface), and 3) bioaccumulation. The only major line of evidence that was not used (and are often used in studies of sediment contamination) was an assessment of resident population/ community level effects. This is not necessarily a shortcoming of the study, since population/ community assessments are typically very costly for the information they provide.**

   Response: This comment is acknowledged.

2. ***Section 1.Introduction. Comment #2.*** **The use of amphipods for bulk sediment toxicity testing (Eohaustorius estuaries 10 day acute toxicity test) and the SWI (Sediment -Water Interface test) using Strongylocentrotus purpuratus (normal larval development) are routine, although the latter test is less often employed and usually yields more variable results, as it did in this study. Table 2-5, Step 5 (Developing a decision rule) mentions that "if ammonia concentrations in test water were within acceptable limits, then any observed toxicity was not attributed to potential confounding factors." The meaning of "potential confounding factors" is unclear, since only ammonia is being evaluated, and numerous other water quality parameters other than the COPECS and ammonia could affect larval development, some of which were measured (oxygen, pH, salinity), but not mentioned with ammonia in the comparison to acceptable limits.**

   Response: The analysis of the VS toxicity data included evaluation of all water quality parameters to determine whether they were within acceptable range and to identify those that were not. Uncertainties related to the toxicity tests are discussed in Section 5 of the Draft Final VS Report.

3. ***Section 4. Sediment Chemistry.*** **In 4.3.2, the four lines of evidence are presented suggest that PCBs at the stations near Yosemite Creek (SB-01 and SB-02) did not originate from the Navy site- One interpretation of the results is that the intermediate stations (west shore of South Basin) have low concentrations of PCB because there are two distinct sources of PCB, one from the Navy site to the east, and the other from Yosemite creek to the west. This implies that neither source contributes significantly to the area near the other source. This seems to be**

corroborated by the compositional analysis of the PCB mixtures, and the resulting PCA (Principal Components Analysis) plot which shows a progressive dechlorination of PCBs from eastern to western stations within South Basin (Area X). An alternative explanation is also offered, that weathering through time has occurred, implying that PCBs in the western stations were deposited earlier and have been subject to more weathering. This could also mean that some PCBs from the HPS sites were deposited in the western stations (near Yosemite Creek) at an earlier time, and have since weathered and been dechlorinated (as well as buried somewhat) in the intervening time. As suggested in the study, more data is necessary to further evaluate the relative contributions of sources and weathering, but it seems unlikely from the chemical composition and burial depth patterns that PCBs were deposited in the HPS area from the Yosemite Creek area.

Response: Additional data would be required to more fully address PCB source identification in South Basin and Yosemite Creek. Please refer to the Response #5 of the DTSC Comments section of this document for further discussion.

4. ***Section 5. Toxicity.*** **The toxicity tests indicated no significant toxicity to benthic invertebrates that was attributable to COPECs. There was very little toxicity from any source, with the assumption that other confounding factors, such as water quality, were responsible for any toxicity observed in the SWI test with *Strongylocentrotus purpuratus*. This seems reasonable based on the data, and is supported by the lack of correspondence between observed SWI toxicity and the presence of COPECs. The lack of a spatial pattern to observed toxicity seems to support this conclusion as well. If contaminants from the site are contributing to the small amount of toxicity observed, they have not yet been identified as COPECs for the site.**

   Response: This comment is acknowledged. Please refer to the response to USEPA Specific Comment #2 for further discussion of this issue.

5. ***Section 6. Bioaccumulation. Comment #1.*** **The bioaccumulation studies are routine for this type of study, and appear to be well implemented. It would be useful to know the sources (reference citations) of the NOAEL (No Observed Adverse Effects Level) and LOAEL (Lowest Observed Adverse Effects Level) data. Although they are presumably discussed in another report, it would be useful to reviewers to have that information included in the text or in Table 65. It is unclear whether the low TRV is based on the lowest NOAEL found, the highest, or the mid-range of all NOAELS found in the literature for appropriate test species.**

   Response: Information on the TRVs can be found in "Interim Final, Development of Toxicity Reference Values as Part of a Regional Approach for Conducting Risk Assessments at Naval Facilities in California," prepared by Engineering Field Activity West, Naval Facilities Engineering Command in 1998.

6. ***Section 6. Bioaccumulation. Comment #2.*** **In 6.3.2, refinement of SUF (Site-Use Factor), the ratio of the validation study area to the estimate of Scoter foraging area is 0.024 (0.17 km2/ 7 km2). If the 0.17 value is accurate, and Scoters are in the area for only half the year, then the average expected SUF would be 0.012. In 6.3.2.1, the site wide HQlow (Hazard Quotient Low) for PCB is equal to 1.0 with an SUF set to one. At the more realistic SUF of 0.012, the HQlow is slightly greater than 0.06, indicating a very low risk to Scoters.**

   Response: This comment is acknowledged.

7. ***Section 6. Bioaccumulation. Comment #3.*** **This same section mentions that the site contribution is dominant for PCBS at all SUFs except 0.01. This statement is also found in several other sections of the report, but its implications are unclear. It appears to only mean that background levels for PCBs are low relative to HPS concentrations, and does not necessarily mean that there is an unacceptable risk from HPS.**

   Response: The interpretation provided above is correct.

8. ***Section 6. Bioaccumulation. Comment #4.*** **Figure 6-11 shows that the PCB HQlow is less than one at SUF =1, and less than 0.5 at SUF = 0.5. However, the calculations in table 6-12 show that the actual values are 1.0 and 0.528, respectively. Some of the other graphs are also slightly misleading for the same reason, especially figure 6-15, which indicates an HQlow for lead at SUF=1 at distinctly less than 400 (it should be 402 according to table 6-14). These do not necessarily indicate that miscalculations were made (I suspect the errors were in the graphing procedure), but the discrepancies in the graphical presentation are confusing for the reader.**

   Response: These figures have been revised to present results in 2-D format in the Draft Final VS Report. The 3-D bar charts were visually misleading.

9. ***Section 6. Bioaccumulation. Comment #5.*** **In 6.3.2.2, 6.3.2.3, and 6.3.2.4, HQ values for bioaccumulation do not appear to consider that SUF values for areas III, IX, AND X should each be less than the site wide SUF by the proportionate area. For example, the bioaccumulation and HQ for each site could also be calculated using the SUF for the site (much less than 0.12 for any one area), plus the SUF for the rest of the areas within HPS, plus the reference. Alternatively, bioaccumulation could be calculated separately for each area and summed for the entire site, subset of sites, etc. Although the refinement of SUF is not considered in more detail than the presentation of HQ values for a range of SUF values, it should at least be mentioned that for calculating an HQ for an area smaller than the entire site, a lower SUF than for the entire HPS site needs to be used. For example, if Area X were 30% of the entire HPS area, then an appropriate average SUF for Area X would be 0.3 x 0.012, or 0.004.**

   Response: Because of the small area of each part of the low volume footprint, SUFs were not developed for each part. However, as noted above, the resultant SUF overestimated site use in any part of the low volume footprint.

10. ***Section 7. Ancillary Data. Comment #1.*** **On page 126, last sentence of the first paragraph, cadmium is mentioned as a possible contributing factor to the toxicity observed in samples SB-23 and EW-33. However, the concentrations of cadmium in those tests were less than in SB-22 (table 7-2), and ammonia concentrations were similar (figure 7-2), so this conclusion needs further explanation.**

    Response: Metals data presented in Table 7-2 provided little insight into the toxicity drivers associated with Stations SB-23 and EW-33. This sentence has been revised in the Draft Final VS Report.

11. ***Section 7. Ancillary Data. Comment #2.*** **Table 7-4 compares dose assessment for Surf Scoter for depurated tissues, with HQlow >1 for several COPECS. The SUF used for this should be included or stated in the text (presumably SUF= 1). The same comment applies to table 7-7 for the Double-Crested Cormorant.**

    Response: An SUF of 1 is assumed for both Table 7-4 and Table 7-7.

12. ***Section 7. Ancillary Data. Comment #3.*** **In the summary for this section (7.4), the last sentence states that PCBs, especially at South Basin, are contributing most significantly to exposure. However, this should be put into perspective by stating the values for HQlow, preferably at a realistic SUF (or at least a spectrum of more realistic SUF values) are less than one for the Cormorant.**

    Response: This comment is acknowledged. Section 10 of the Draft Final VS Report includes a discussion of the range of appropriate SUFs for South Basin.

13. ***Section 10. Development of Feasibility Study Footprint. Comment #1.*** **In 10.1.1, second to last paragraph, last sentence, the statement is again made that "the contribution from reference does not exceed the contribution from the site until the SUF decreases to 0.01". While this is a useful perspective, it is another way of saying that background levels are low relative to the site levels (among other possibilities that would lead to the same situation). This is not the same as actual risk, in which case the first part of the previous sentence is much more informative, "At a SUF of 0.5, the risk from exposure to PCBs decreases to 1". The second part of the sentence means the same thing as the next sentence. Since the average expected SUF for the Scoter is 0.012 (based on area and time in the Bay area), it appears that the HQ is far below one at a realistic SUF.**

    Response: This comment is acknowledged.

14. ***Section 10. Development of Feasibility Study Footprint. Comment #2.*** **Also, as mentioned earlier in this review for section 6, the SUF for each individual site should be adjusted downward to account for the smaller area of each site (or at least that SUF should be described and presented). This applies to all the areas when considered individually (sections 10.1.1 through 10.1.5).**

    Response: Using an SUF based on the size of the entire LVF rather than the area at South Basin results in a more conservative PRG as discussed in the response to USFWS Comment #21.

15. ***Section 10. Development of Feasibility Study Footprint. Comment #3.*** **In section 10.2.1, the BAF (Bioaccumulation Factor) for PCB bioaccumulation appears to be based on the low range of concentrations of PCB in sediment, despite the statement that "the Area X data show a curvilinear pattern with higher uptake at low sediment concentrations (i.e., less than 2000 µg/kg)". If this is true, then the BAF of interest is in the range of values around the likely PRG (Preliminary Remediation Goal). The slope of the [tissue PCB] vs. [sed PCB] line (or BAF) tends to level off around 500 µg/kg. For example, the average BAF for all sediment and tissue pairings in Area X with concentrations of PCB in sediment over 500 µg/kg is about 1.76, and at 1000 µg/kg PCB in sediment and over it reduces to about 1.27. The report does state that a BAF of 2 is conservative, but BAF calculations for the higher concentrations of interest should also; be presented. Other alternative approaches would be to refine the BAF estimate by using a curvilinear equation, or even to divide the areas into the Thiesen polygon sub areas, represented by their respective samples, and model and sum accumulation from each sub area individually. Either approach would provide a more accurate estimate of bioaccumulation.**

    Response: The approach presented in the VS Report focuses on data from stations with less than 2,000 ppb PCBs. This represents the simplest way to develop a BAF that results in a reasonable and conservative estimate of uptake from South Basin sediments into *M. nasuta* tissue. Figure 10-12 of the Draft VS Report presents a BAF for all South Basin stations (including those greater than

2,000 ppb dry weight) as 1.5. Although a curvilinear equation would provide an alternate (and perhaps better) description of the relationship between tissue and sediment at high and low sediment concentrations, integration of the mathematics required to use this in a PRG equation is cumbersome and is unlikely to substantially alter the calculated result. Rather, the SUF element of the equation would have the greatest potential effect on the calculation of a PRG.

16. ***Section 10. Development of Feasibility Study Footprint. Comment #4.*** **Perhaps my algebra is wrong, but equation 10-6 seems to be incorrect. It should be**

X = (TRV*BW)/(SUF*(IRsed+IRprey *BAF))

(Where IR = Ingestion rate) (The last parenthetical term of the original equation should be in the denominator). This equation then results in the values in Table 10-1.

Response: This equation has been corrected in the Draft Final VS Report. It should be noted, however, that the correct equation was used in the VS mathematical evaluations, and that the error was only a typographical error.

17. ***Section 10. Development of Feasibility Study Footprint. Comment #5.*** **PRGs should be presented for more realistic estimates of BAF and SUF. For example, if the PRG is calculated using a BAF of 1.27 and a SUF of 0.004 (assuming that AREA X is 30% of the total HPS area), then the PRG is 165.3 mg/ kg. The contribution from the rest of HPS (minus Area X) should also be added, since it could be assumed that contiguous areas would likely be in the foraging range as well. The rest of the bioaccumulation amount for the background (reference levels) should also be factored in (as already done in the assessment). I have not made the calculations, but the final PRG would probably be more than 100 mg/kg, and after applying an uncertainty factor of 10 would still result in a figure much higher than the 2.1 mg/kg figure used in the assessment.**

Response: This comment is acknowledged.

18. ***Section 10. Development of Feasibility Study Footprint. Comment #6.*** **I do not propose that the above example is a more accurate approach, but it would be useful for the reader to have the risk estimated all the way through for the average expected SUF (based on areas and time) and BAF (for relevant concentrations) without conservative assumptions being applied. Conservative assumptions can then be added and the PRGs recalculated so the reader can more easily judge their appropriateness.**

Response: This comment is acknowledged.

19. ***Section 10. Development of Feasibility Study Footprint. Comment #7.*** **Another alternative is to perform a probabilistic assessment, using a combination of point estimates along with distributions (when available). The variability and probability distribution of COPEC concentrations in both sediment and tissue can be estimated from existing data, and a curvilinear relationship used to estimate a BAF for each sediment concentration. Combined with point estimates for other variables, the risk estimate would be more informative. It may also be possible to estimate a probability distribution for the TRV, Scoter body weight, SUF, and even ingestion rates, if there is sufficient data available in the literature (I don't know if there is). A probabilistic estimate would involve considerable additional work, and the refinement of the FS footprint that is possible beyond its present delineation may not justify the added effort of a probabilistic assessment. However, the PRGs determined for this report have a large amount of uncertainty**

associated with them, which has resulted from the use of multiple conservative assumptions, and should not necessarily be applied elsewhere without careful consideration of the factors discussed above.

Response: This comment is acknowledged. A probabalistic assessment would be an effective means of addressing the multiple sources of uncertainty in the evaluation. However, the additional refinement is unlikely to refine the footprint sufficiently to justify the effort.

20. ***Section 10. Development of Feasibility Study Footprint. Comment #9.*** **Some of the same considerations apply to the risk assessments for both the Doublecrested Cormorant and for Human health, with some differences based on the model differences and assumptions inherent in each type of assessment.**

    Response: This comment is acknowledged.

21. ***Section 12. Summary and Conclusions. Comment #1.*** **Although the study provided sufficient information to estimate risks at the HPS site, the conclusions are based on site-specific assumptions that limit their application to the HPS site.**

    Response: This comment is acknowledged.

22. ***Section 12. Summary and Conclusions. Comment #2.*** **The sediment chemistry data supports a conclusion that HPS sources of PCB have probably not contributed to Yosemite Creek affected areas (SB-01 and SB-02 in the western portion of South Basin). The report does not emphasize the converse conclusion, that the Yosemite Creek sources of PCB have probably not contributed to the HPS site, although the evidence is at least as strong for the latter conclusion (based on chemical composition, intermediate station concentrations, and burial depth patterns).**

    Response: PCBs originating from Yosemite Creek (including the area around Stations SB-01 and SB-02) were unlikely to have been transported to and deposited on the eastern side of South Basin in significant quantities. Conversely, it is also unlikely that significant quantities of PCBs were transported from the eastern side of South Basin and deposited in Yosemite Creek.

23. ***Section 12. Summary and Conclusions. Comment #3.*** **The risks to the Scoter from PCBs was considered to be the main risk driver, and a PRG of 2.1 mg/kg PCB in sediment was developed to protect Scoters from the risks of bioaccurnulating too much PCB. However, the extremely conservative nature of the risk estimate, due to a number of uncertainties, should be emphasized more strongly. Estimates of Risk based on average exposures should also be presented whenever risk estimates are stated, so as to minimize the impression that the highly conservative characterization that results from multiplying several conservative estimates together is the most appropriate. In particular, the SUF should be carried through the risk calculation at an average expected level, and should be adjusted to the size of each sub area being evaluated. The BAF for the clam *Macoma nasuta* also appears to be too high and to over-estimate risks from bioaccumulation.**

    Response: This comment is acknowledged.

24. ***Section 12. Summary and Conclusions. Comment #4.*** **Because of the site-specific nature of the data collected, and the highly conservative nature and uncertainties remaining in the risk estimates, the risk estimates and PRG developed for PCB should not be applied to other sites**

within or outside the San Francisco Bay system without careful consideration of the site specific characteristics that will be important to the accurate assessment of risks.

Response: This comment is acknowledged.

ATTACHMENT A

Table A-1. Area I comparison of dose assessment results from field-collected data versus laboratory *M. nasuta* from adjacent stations

	HQ low			
	India Basin			
	HBI	Lab Macoma	SBI	Lab Macoma
Sample ID	AAB-369	IB-59	AAB-398	IB-59
Aluminum	NA	NA	NA	NA
Antimony	NA	NA	NA	NA
Arsenic	1.08E-01	2.53E-01	2.67E-01	2.53E-01
Barium	NA	NA	NA	NA
Cadmium	4.72E-01	2.83E-01	3.95E-01	2.83E-01
Chromium	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA
Copper	9.89E-01	9.83E-01	1.17E+00	9.83E-01
Iron	NA	NA	NA	NA
Lead	3.73E+01	2.21E+02	4.70E+01	2.21E+02
Manganese	NA	NA	NA	NA
Mercury	2.58E-01	3.10E-01	4.01E-01	3.10E-01
Molybdenum	NA	NA	NA	NA
Nickel	8.40E-01	1.32E+00	2.68E+00	1.32E+00
Selenium	1.25E+00	1.57E+00	1.61E+00	1.57E+00
Silver	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA
Zinc	5.11E-01	4.37E-01	4.28E-01	4.37E-01
HMW PAH	NA	NA	NA	NA
LMW PAH	NA	NA	NA	NA
Total PCBs	2.05E-01	1.62E-01	3.45E-01	1.62E-01
Total 4,4′-DDx	3.21E-01	4.19E-02	5.02E-01	4.19E-02
alpha-Chlordane	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA
Endrin	NA	NA	NA	NA
gamma-Chlordane	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA
Dibutyltin	1.66E-02	1.70E-02	4.17E-03	1.70E-02
Monobutyltin	NA	NA	NA	NA
Tetrabutyltin	NA	NA	NA	NA
Tributyltin	5.42E-02	8.20E-02	1.33E-02	8.20E-02

Yellow highlights denotes stations an order-of-magnitude greater than their partners for HQs greater than 1

Table A-2. Area III comparison of dose assessment results from field-collected data versus laboratory *M. nasuta* from adjacent stations

	HQ low		
	Pt. Avisadero		
	SBI	Lab Macoma	Lab Macoma
Sample ID	AAB-460	PA-40	PA-41
Aluminum	NA	NA	NA
Antimony	NA	NA	NA
Arsenic	3.35E-01	2.67E-01	2.75E-01
Barium	NA	NA	NA
Cadmium	2.76E+00	3.33E-01	3.64E-01
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	9.48E+00	1.02E+00	2.86E+00
Iron	NA	NA	NA
Lead	1.14E+02	2.31E+02	4.49E+02
Manganese	NA	NA	NA
Mercury	1.13E+00	3.30E-01	5.99E-01
Molybdenum	NA	NA	NA
Nickel	2.45E+00	9.97E-01	1.13E+00
Selenium	3.28E+00	9.50E-01	1.20E+00
Silver	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	7.27E-01	5.19E-01	4.94E-01
HMW PAH	NA	NA	NA
LMW PAH	NA	NA	NA
Total PCBs	8.83E-01	8.76E-02	1.93E-01
Total 4,4′-DDx	6.30E-01	3.39E-02	2.91E-02
alpha-Chlordane	NA	NA	NA
Dieldrin	NA	NA	NA
Endosulfan II	NA	NA	NA
Endrin	NA	NA	NA
gamma-Chlordane	NA	NA	NA
Heptachlor	NA	NA	NA
Dibutyltin	6.57E-02	5.36E-02	1.34E-01
Monobutyltin	NA	NA	NA
Tetrabutyltin	NA	NA	NA
Tributyltin	1.12E-01	6.24E-01	1.39E+00

Yellow highlights denotes stations an order-of-magnitude greater than their partners for HQs greater than 1

Table A-3. Area VII comparison of dose assessment results from field-collected data versus laboratory *M. nasuta* from adjacent stations

	Eastern Wetland				
	HQ low				
	HBI	Lab Macoma	SBI	Lab Macoma	Lab Macoma
Sample ID	AAB-377	EW-30	AAB-372	EW-31	EW-35
Aluminum	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA
Arsenic	1.04E-01	3.58E-01	2.49E-01	2.86E-01	2.62E-01
Barium	NA	NA	NA	NA	NA
Cadmium	7.12E-01	7.10E-01	5.14E-01	3.21E-01	3.45E-01
Chromium	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA
Copper	3.65E-01	1.61E+00	1.25E+00	6.19E-01	8.09E-01
Iron	NA	NA	NA	NA	NA
Lead	1.09E+01	3.89E+02	4.07E+01	1.92E+02	1.93E+02
Manganese	NA	NA	NA	NA	NA
Mercury	3.04E-01	3.69E-01	3.93E-01	7.58E-03	2.34E-01
Molybdenum	NA	NA	NA	NA	NA
Nickel	5.42E-01	1.04E+00	1.99E+00	7.00E-01	8.23E-01
Selenium	1.26E+00	1.69E+00	3.22E+00	1.65E+00	1.69E+00
Silver	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA
Zinc	4.81E-01	7.44E-01	4.31E-01	4.44E-01	6.51E-01
HMW PAH	NA	NA	NA	NA	NA
LMW PAH	NA	NA	NA	NA	NA
Total PCBs	3.71E-01	3.29E-01	2.42E-01	2.02E-01	1.47E-01
Total 4,4′-DDx	1.38E-01	2.48E-02	2.56E-01	2.75E-02	2.97E-02
alpha-Chlordane	NA	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA
gamma-Chlordane	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA
Dibutyltin	5.13E-03	1.01E-02	2.25E-03	9.61E-03	9.66E-03
Monobutyltin	NA	NA	NA	NA	NA
Tetrabutyltin	NA	NA	NA	NA	NA
Tributyltin	2.04E-02	3.50E-02	8.50E-03	2.68E-02	2.60E-02

Yellow highlights denotes stations an order-of-magnitude greater than their partners for HQs greater than 1

Table A-4. Area IX comparison of dose assessment results from field-collected data versus laboratory *M. nasuta* from adjacent stations

	HQ low			
	Oil Reclamation			
	HBI	Lab Macoma	SBI	Lab Macoma
Sample ID	**AAB-404**	**OR-29**	**AAB-456**	**OR-29**
Aluminum	NA	NA	NA	NA
Antimony	NA	NA	NA	NA
Arsenic	1.01E-01	3.26E-01	1.51E-01	3.26E-01
Barium	NA	NA	NA	NA
Cadmium	6.82E-01	2.89E-01	8.65E-01	2.89E-01
Chromium	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA
Copper	3.27E-01	8.58E-01	5.99E-01	8.58E-01
Iron	NA	NA	NA	NA
Lead	1.17E+01	2.89E+02	2.32E+01	2.89E+02
Manganese	NA	NA	NA	NA
Mercury	3.70E-01	3.22E-01	3.24E-01	3.22E-01
Molybdenum	NA	NA	NA	NA
Nickel	7.17E-01	9.52E-01	1.05E+00	9.52E-01
Selenium	1.56E+00	1.42E+00	1.56E+00	1.42E+00
Silver	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA
Zinc	3.94E-01	4.73E-01	4.96E-01	4.73E-01
HMW PAH	NA	NA	NA	NA
LMW PAH	NA	NA	NA	NA
Total PCBs	7.55E-01	1.05E+00	5.84E+00	1.05E+00
Total 4,4′-DDx	1.56E-01	5.84E-02	1.41E+00	5.84E-02
alpha-Chlordane	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA
Endrin	NA	NA	NA	NA
gamma-Chlordane	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA
Dibutyltin	8.44E-04	1.54E-02	3.24E-03	1.54E-02
Monobutyltin	NA	NA	NA	NA
Tetrabutyltin	NA	NA	NA	NA
Tributyltin	3.18E-03	5.27E-02	4.46E-03	5.27E-02

Yellow highlights denotes stations an order-of-magnitude greater than their partners for HQs greater than 1

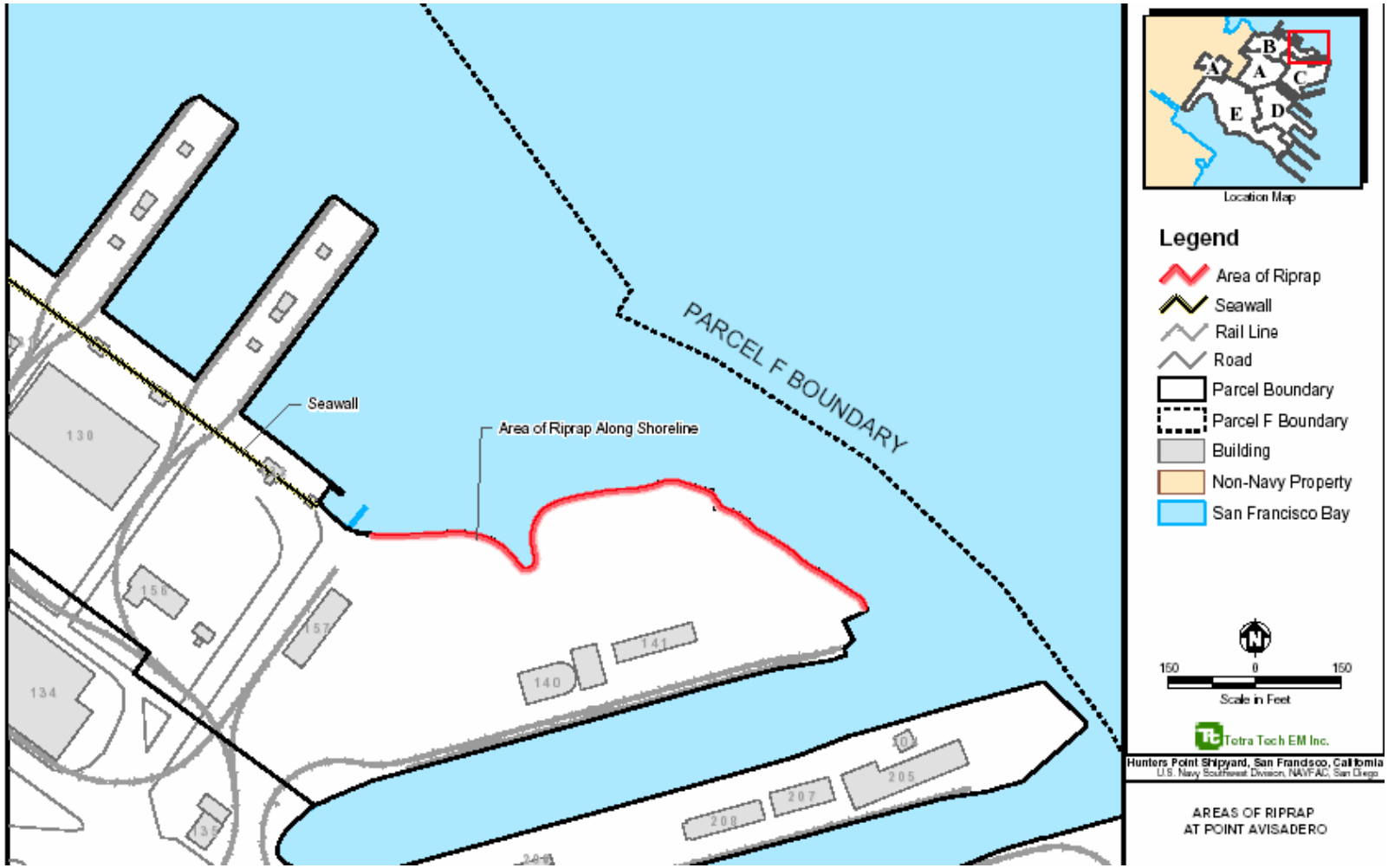
Table A-5. Area X comparison of dose assessment results from field-collected data versus laboratory *M. nasuta* from adjacent stations

	HQLow								
	Area X								
	HBI	Lab Macoma	Lab Macoma	Lab Macoma	SBI	Lab Macoma	Lab Macoma	Lab Macoma	Lab Macoma
Sample ID	AAB-399	SB-21	SB-22	SB-23	AAB-453	SB-20	SB-21	SB-22	SB-23
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	9.45E-02	2.48E-01	2.80E-01	2.27E-01	1.44E-01	2.52E-01	2.48E-01	2.80E-01	2.27E-01
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7.54E-01	2.41E-01	7.11E-01	3.05E-01	7.15E-01	3.02E-01	2.41E-01	7.11E-01	3.05E-01
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	5.52E-01	1.75E+00	1.51E+00	1.72E+00	2.27E+00	1.52E+00	1.75E+00	1.51E+00	1.72E+00
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	2.47E+01	6.08E+02	8.18E+02	6.99E+02	1.08E+02	6.60E+02	6.08E+02	8.18E+02	6.99E+02
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	4.12E-01	4.23E-01	3.82E-01	4.27E-01	6.23E-01	6.43E-02	4.23E-01	3.82E-01	4.27E-01
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	5.77E-01	1.42E+00	1.08E+00	8.71E-01	1.81E+00	9.09E-01	1.42E+00	1.08E+00	8.71E-01
Selenium	1.68E+00	1.19E+00	1.20E+00	1.69E+00	1.65E+00	1.01E+00	1.19E+00	1.20E+00	1.69E+00
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	4.99E-01	5.46E-01	4.51E-01	4.08E-01	6.76E-01	5.82E-01	5.46E-01	4.51E-01	4.08E-01
HMW PAH	NA	NA	NA	NA	NA	NA	NA	NA	NA
LMW PAH	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PCBs	2.02E+00	5.04E+00	2.94E+00	5.54E+00	1.07E+01	3.01E+00	5.04E+00	2.94E+00	5.54E+00
Total 4,4′-DDx	4.33E-01	1.23E-01	1.16E-01	1.11E-01	1.98E+00	1.70E-01	1.23E-01	1.16E-01	1.11E-01
alpha-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA
gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibutyltin	1.08E-03	2.58E-02	3.50E-02	3.78E-02	6.79E-03	1.06E-02	2.58E-02	3.50E-02	3.78E-02
Monobutyltin	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrabutyltin	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tributyltin	5.69E-03	2.00E-01	8.99E-02	2.90E-01	1.31E-02	7.96E-02	2.00E-01	8.99E-02	2.90E-01

Yellow highlights denotes stations an order-of-magnitude greater than their partners for HQs greater than 1

ATTACHMENT B

Depiction of the Extent of Shoreline Rip-rap and Debris in Parcel F



<u>Attachment B-1</u>. Areas of Shoreline Rip-Rap and Debris at Point Avisadero (Area III)

Final HPS Parcel F Validation Study
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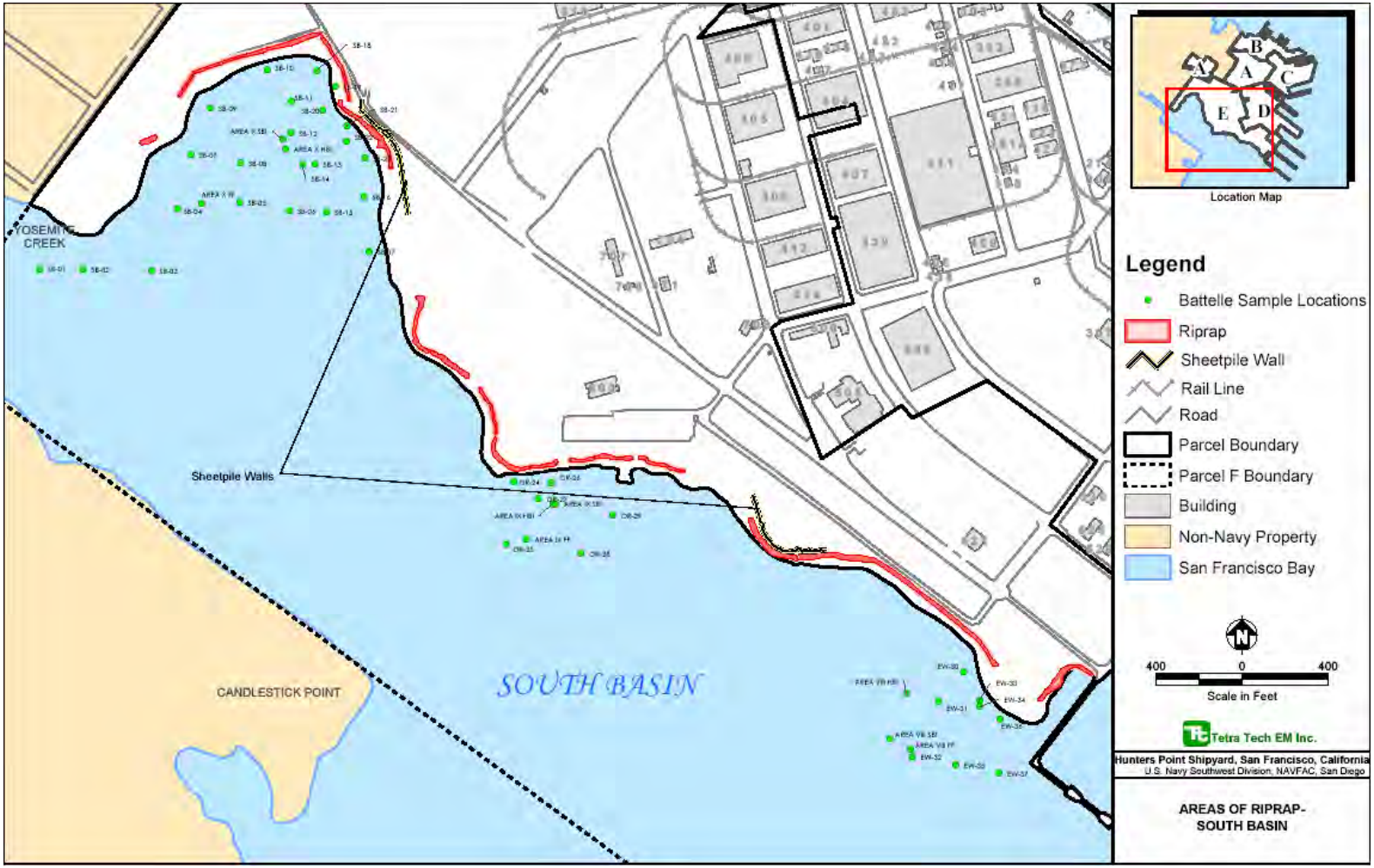
May 2005



<u>Attachment B-2.</u> Areas of Shoreline Rip-Rap and Debris at South Basin (Area X)

Final HPS Parcel F Validation Study
Appendix Q – RTC: Draft Final HPS VS Report
May 2005

U.S. ENVIRONMENTAL PROTECTION AGENCY COMMENTS ON THE DRAFT FINAL HUNTERS POINT SHIPYARD PARCEL F VALIDATION STUDY REPORT, HUNTERS POINT SHIPYARD, SAN FRANCISCO, CA
October 8, 2004

Specific Comments

1. **Section 10.1, Identification of Pathways and Contaminants Driving Risk, Pages 10-1 to 10-5: The conclusions in Section 10.1 of the Draft Final Hunters Point Shipyard Parcel F Validation Study Report (Draft Final VS) regarding the ecological risks associated with individual areas rely on discounting certain risks identified in the assessment. As discussed during a meeting between the Navy and the regulatory agencies on September 8, 2004, the conclusions of the document have been substantially revised and do not explicitly rely on the weight of evidence provided in Section 8.0. However, there are still certain conclusions that are based on professional judgment that do not result in a protective conclusion regarding the risks to the environment. For example, in Sections 10.1.1 and 10.1.3, the Navy concludes that soft sediments in Areas I and VIII do not appear to warrant inclusion in the Parcel F Feasibility Study (Parcel F FS), but this conclusion is partially based on discounting risks to upper trophic levels that are associated with field-collected invertebrate tissues. Discounting these risks because field-collected tissues are not available from reference sites is not a protective professional judgment. In general, the interpretation presented in Section 10.1 addresses uncertainty in the risk assessment by excluding areas for consideration in the Parcel F FS despite reported risks. Please revise Section 10.1 to provide conclusions that include the discounted data. Please provide the risk managers with a more protective footprint that includes all identified risks, the proposed footprint, and a discussion of the uncertainty associated with each footprint.**

   Response: Dose assessment results based on field-collected tissue data were not discounted in the evaluation of pathways and chemicals driving risk; rather, they were given less weight than dose assessment results based on laboratory *Macoma* data for the following reasons:

   - Data quality objectives (DQOs) for field-collected tissue were developed for use of the data to qualitatively evaluate the uncertainty associated with using laboratory *Macoma* data in the food chain model. The type and quantity of field tissue data are insufficient for fully evaluating risk to upper trophic level receptors, or for developing sediment-biota accumulation factors. Only one composite tissue sample of each type (hard-bodied and soft-bodied invertebrate) was collected in each area, and each composite tissue sample only represents a portion of each area. Collocated sediment samples were not collected; therefore, no direct relationship between field tissue and sediment can be established.
   - All dose calculations for field-collected tissue data are based on a single tissue concentration and assume a site use factor of one, which is equivalent to a conservative, screening-level assessment. However, it is not possible to refine the dose calculations based on realistic exposure parameters because the quantity of data is insufficient and there is no basis for estimating the offsite contribution to exposure. Therefore, it is inappropriate to conclude that ecological risk is unacceptable and remedial action is warranted based <u>solely</u> on dose assessment results for field-collected tissue. The Navy does not propose to discount these results, but rather to discuss their significance as part of developing a protective footprint during the FS scoping process.

The paired sediment and laboratory *Macoma* data set is large and provides complete coverage of the HPS study area and five reference sites. The field-collected tissue data for hard-bodied invertebrates and non-depurated laboratory *Macoma* data generally correspond with the laboratory, depurated *Macoma* data, which supports its use in the food chain model. There is greater uncertainty in the dose assessment for receptors that primarily consume soft-bodied invertebrates because of inconsistencies between field-collected worm tissue data and laboratory *Macoma* data.

Section 10 of the Final VS Report has been revised to remove language that implies that risk management decisions about specific areas (i.e., Areas I and VIII) have already been made. The final report indicates that all five areas (Area I, Area III, Area VIII, Area IX and Area X) will be evaluated in the FS, where the appropriate risk management decisions will be developed in consultation with the BRAC Cleanup Team (BCT). A summary table has been added to Section 10 to support the identification of the primary risk drivers. During the Parcel F FS scoping process, the Navy proposes to develop an initial footprint based on the preliminary remediation goals (PRGs) developed for the primary risk drivers. This initial footprint can then be modified in consultation with the BCT to address uncertainties associated with other contaminants or areas identified in the dose assessment based on field-collected tissue data as well as source control considerations. Through this process, the Navy is confident that a technically defensible and protective footprint can be developed.

2. **Response to General ERA Comment 1: It appears that the response addresses the comment by indicating that the approach for identifying areas for evaluation in the Parcel F FS has been revised. Apparently, the weight of evidence (WOE) approach will not be the only method used to determine areas for evaluation in the FS. In the Draft Final VS, individual lines of evidence and ancillary data are used to identify the pathways and contaminants driving risk at each site. As indicated by the response, the Navy has decided to make the final determination regarding areas to be evaluated by the FS in consultation with the BCT and will present their conclusions in the Parcel F FS Report. The response does indicate, however, that preliminary remediation goals (PRGs) were developed for contaminants of potential ecological concern (COPECs) driving risk at only Areas III (mercury and copper) and IX/X (PCBs) despite risks reported for other areas.**

   Response: The Navy has developed PRGs for contaminants identified as driving ecological risk based on multiple lines of evidence (i.e., a relationship between elevated chemical concentrations in sediment and adverse biological effects) with the greatest degree of certainty. Specifically, PRGs were developed for chemicals that were elevated in *Macoma* tissue above reference threshold values, were associated with hazard quotients of greater than one based on a site use factor of one, and had sediment concentrations exceeding San Francisco Bay ambient levels. PRGs were not developed for chemicals that were identified as posing a potential ecological risk based solely on dose assessment results for field collected tissue (see the response to USEPA Specific Comment #1).

3. **Response to Specific Comment 1: It appears that the Navy included the requested tables, but did not include all of the requested parameters (standard deviation and location of maximum). The comment requested that the tables be provided in the body of the report, however, these tables were provided in Appendix F.**

   Response: These summary tables have been added to Section 4.0 of the report, and standard deviation has been added (location of maximum was already included).

4. Response to Specific Comment 3: The response indicates that the requested information was included in the Draft Final VS, but the response does not include consideration of the of the amphipod toxicity test results in light of the toxicity identification evaluation (TIE) results. The reasons provided for this were that (1) acute toxicity was not observed for Hunters Point Shipyard (HPS) stations, (2) the species were different, and (3) the exposure media were different.

Regarding (1), while acute toxicity to the amphipod was not observed in HPS stations (when defined as reduced survival relative to the reference sites or reference envelope), there were stations with greater mortality than others. It seems reasonable to explore the results to see if any patterns emerge showing a relationship between metals indicated by the TIE and stations with greater mortality in the amphipod test.

Regarding (2), although the species are different, it still seems reasonable to look for relationships in toxic effects. Interspecies variability may be expected but a broad pattern of toxic effects may also be reasonable to expect.

Regarding (3), the difference in exposure media should not prevent a full exploration of the results, especially given that the toxic effects associated with bulk sediment concentrations are often associated with concentrations in interstitial water or the sediment-water interface.

In summary, there appears to be a persistent technical disagreement between EPA and the Navy regarding the appropriate use of the ancillary data, in particular the TIE results. Please provide a discussion of the TIE results in Section 5 relative to *Eohaustorius* and *Strongylocentrotus* toxicity test results.

Response: The decision criteria for the amphipod toxicity test were based on the reference envelope tolerance limits for San Francisco Bay as developed by the State Water Resources Control Board. These criteria were agreed upon during the Parcel F Validation Study Work Plan development. Based on these decision criteria, unacceptable amphipod toxicity was not observed in any HPS sample. Given that toxicity was not observed in the bulk sediment exposure, the Navy does not believe that additional investigation of the relationship between amphipod survival and bulk metals concentrations is warranted. Please note that Section 7.1.3 of the Validation Study Report includes a discussion of the significance of the TIE and sediment-water interface toxicity test results.

5. Response to Specific Comment 4: The response provides additional discussion of the *M. nasuta* results but does not include the information in the main body of the report as requested. The information included in the response should be added to the VS.

Response: This information has been added to Section 6.1 of the final report.

6. Response to Specific Comment 5: The response indicates that the field-collected tissue is still not included in the WOE approach. The FS footprint is no longer solely based on the WOE. However, a review of the revised Section 10.0 defining the new footprint for the FS shows that risks associated with the field-collected tissue data are still discounted.

Response: Please refer to the response to USEPA Specific Comment #1.

7. **Response to Specific Comment 6: The response appears to address the comment and was incorporated into the document by revising Section 6.2 to explain that tissue reference threshold values were not used to develop reference exposure point concentrations (EPCs). The response indicates that the doses to the scoter were calculated for all COPECs and are presented in Appendix H. However, there appears to be no revision to Section 6.0 to summarize the results that are presented only in the appendix; this would make the document clearer. Please revise Section 6.0 to include a summary of the results presented in Appendix A.**

   Response: Section 6.2 of the report has been revised to include tables and brief discussions presenting the dose assessment results for all COPECs.

8. **Response to Specific Comment 7: If the Navy prefers to keep Tables 6-6 through 6-10 as summary tables, perhaps the additional summary tables (similar to Table 6-11) that contain the actual hazard quotient values could be created from Appendix H and moved into the body of the VS to aid readers' review of the VS.**

   Response: Tables 6-6 through 6-10 have been replaced with tables presenting hazard quotient values for all stations and COPECs.

9. **Response to Specific Comment 8: It does not appear that the response addressed the comment by revising the site use factor (SUF) adjustments. If the SUF is small, it does not account for other areas that the receptors may forage in, which may be other contaminated parts of Hunters Point. In the interest of using protective estimates, please adjust risk estimates using site use factors by making the appropriate comparison to contamination in adjacent sites.**

   Response: The analysis currently includes evaluation of exposure to all five of the HPS study areas at a range of SUFs (see Table 6-12 of the final report), which accounts for the scenario where receptors forage in multiple contaminated areas of HPS as well as outside of HPS. Adjusting the evaluations for each individual area are likely to have minimal impact on the risk estimates presented in Section 6.3.2.

10. **Response to Specific Comment 10: It appears that radioisotopes will be handled under a different program. However, there is no reference to when or where an ecological risk assessment will be conducted and the Navy Radiological Affairs Support Office previously indicated that they do not perform ecological risk assessments. Please discuss where and when an ecological risk assessment that includes radioisotopes will be conducted.**

    Response: A survey of potential radiological contamination in Parcel F will be carried out following the recommendations in the Historical Radiological Assessment; however, details regarding the scope and schedule have not yet been determined. Remedial actions in response to the radiological survey will be incorporated into actions based on chemical contamination.

DEPARTMENT OF TOXIC SUBSTANCES CONTROL COMMENTS
DRAFT FINAL HUNTERS POINT SHIPYARD PARCEL F VALIDATION STUDY REPORT, SAN FRANCISCO, CA
September 29, 2004

General Comments

HERD accepts the proposal that removal of the slag-like metal debris in Area VIII will be addressed as part of Parcel E onshore activities and evaluation of remedial alternatives for the rip rap material in Area III will be addressed as part of Parcel B onshore activities.

HERD has responded only to those issues which were not adequately addressed in the Navy response to HERD comments (Appendix Q) on the Draft Validation Study Report.

Specific Comments To Responses

1. **Response to General Comment 1: The fact that the highest concentrations of PCBs in the south basin occur in areas with the highest concentrations of mercury and copper does not indicate that sediment concentrations of mercury and copper should be eliminated from consideration in evaluating remedial alternatives. Sediment concentrations of mercury and copper, and any other contaminants which have been identified as 'elevated' should be presented with any remedial alternative being considered in the Feasibility Study for each area of Parcel F.**

   Response: This comment is acknowledged. Concentrations of all identified contaminants of concern will be determined for each of the remedial alternatives developed in the Parcel F FS.

2. **Response to Specific Comment 3: The point of HERD's original comment was that a steel door is not a permanent closure for the tunnel leading from Dry Dock 3 to San Francisco Bay. Steel doors will deteriorate over time when in contact with saline water in San Francisco Bay. This comment is meant for the DTSC Project Manager and no response is required from the Navy or Navy contractors.**

3. **Response to Specific Comment 5: The 'ambient' sediment mercury concentration is less than 0.5 mg/kg for 210 'ambient' stations considered in the Validation Study (Figure F-7, page F-11, CD-ROM filename dft fin HPS VS AppF sed chem data analysis.pdf). Please explain the rationale for utilizing '>1 ppm' as the evaluation criterion of elevated mercury concentration in the area between Area VIII and Area IX. This sample is listed with a sample ID of CAD-0013-THG station ID of OR-131 (Validation Study Report Addendum, Table 2, page 17) with a sediment mercury concentration of 1.215 mg/kg.**

   Response: The decision rule in the Parcel F FS Data Gaps Work Plan DQOs specified 1 ppm as the evaluation criterion because this is the proposed mercury preliminary remediation goal (PRG) based on a site use factor of one. The San Francisco Bay ambient threshold value is 0.4 ppm for fine-grained sediments; use of this value as the evaluation criterion does not change the conclusion: only one 2003 sample result was above the ambient threshold value in the area between Areas VIII and IX.

4. **Response to Specific Comment 6: HERD was unable to locate the 'attached maps (Attachment B) of Areas III and X' showing the extent of shoreline rip rap. HERD searched the text document and both CD-ROMs for a file or printed section listed as**

Attachment B. Please make certain the referenced maps of shoreline rip rap are included in the Final Validation Study Report.

Response: The missing material was provided to DTSC via email on 11/11/2004.

5. **HERD and other regulatory agencies and resource trustees agreed that the soft bodied invertebrate tissue (SBI) concentration would be used instead of the laboratory estimate of tissue concentration using *Macoma nasuta* in the event the field collected tissue concentration exceeded the laboratory estimate. Use of the SBI tissue concentration in the surf scoter hazard calculation indicates that the hazard quotient, based on the low Toxicity Reference Value (TRV_{low}) (HQ_{low}) for copper exceeds 1.0 in all areas but Area IX (Table 7.6, page 7-22). The use of hard bodied invertebrate tissue (HBI) concentrations in the surf scoter hazard calculation yields a HQ_{low} for copper greater than 1.0 only in Area I. The HBI surf scoter HQ_{low} for mercury does not exceed 1.0 while the SBI HQ_{low} for mercury exceeds 1.0 in Area I. The HBI surf scoter HQ_{low} for total polychlorinated biphenyls (PCBs) exceeds 1.0 in Area X while the SBI surf scoter HQ_{low} for PCBs exceeds 1.0 in area IX and Area X. These results indicate that the SBI tissue concentration should be used in assessing the ecological hazard via food web transfers rather than the *Macoma nasuta* tissue concentration.**

   Response: Please refer to the response to USEPA Specific Comment #1. A summary table has been added to Section 10 of the Validation Study report that summarizes hazard quotient values for all dose assessment calculations.

6. **Response to Specific Comment 13: The discussion of the benthic community assessment of bioturbation (Appendix M) begins with the inability of the sampling device used in former studies to penetrate deeper than approximately 10 cm into the sediment. Cores taken during the radioisotope investigation contained worms to a depth of 2 feet below the water sediment interface. Capture of worms in a relatively small bore core sampler would indicate that bioturbation must be considered at least to two feet below the water sediment interface and probably deeper. This comment is meant for the DTSC Project Manager and no response is required from the Navy or the Navy contractors.**

7. **Response to Specific Comment 17: The maps of the Feasibility Study (FS) Data Gaps sampling conducted in October 2003 (Addendum, Graphic Presentation III, Figure 18 through Figure 32) provided indicate elevated copper (>1000 mg/kg, Figure 25) and mercury (>10 mg/kg, Figure 32) sediment concentrations in the last portion of the core samples in Area III at 2 feet to 3 feet below the water sediment interface. This portion of Area III is correctly recommended for inclusion in the Parcel F Feasibility Study by the Navy. This comment is meant for the DTSC Project Manager and no response is required from the Navy or the Navy contractors.**

8. **A check of several contaminant fish tissue concentrations for HPSY reference station fish tissue against contaminant fish tissue concentrations collected by other agencies in San Francisco Bay (e.g., San Francisco Estuary Institute) were found to be within the range of those detected in these other studies. This comment is meant for the DTSC Project Manager and no response is required from the Navy or the Navy contractors.**

9. **Response to Specific Comment 30: There appears to be some mislabeling associated with material contained in an addendum or an attachment. Specifically, HERD was unable to**

locate Table A-1 through A-5 in 'Attachment A' referred to in the response. The Table of Contents does not list any Attachments only Addenda. One CD-ROM contains only these Addenda as Adobe files while the other CD-ROM contains mostly Excel spreadsheets. Please advise HERD as to the location of this material comparing HQs from stations adjacent to those were field invertebrates were obtained.

Response: The missing material was provided to DTSC via email on 11/11/2004.

10. **Response to Specific Comment 33: The point of the original comment was exactly that the form of lead in sediments is unknown (i.e., no tests to positively determine the lead compound were performed). This difference of opinion regarding the interpretation of potential lead hazard can be addressed when outlining the specific areas to be included in the Feasibility Study. This comment is meant for the DTSC Project Manager and no response is required from the Navy or the Navy contractors.**

11. **Response to Specific Comment 45: The Areas identified in the response are those indicated in the original HERD comment and are listed in the text (Section 12.1.5, page 12-4). This comment is meant for the DTSC Project Manager and no response is required from the Navy or the Navy contractors.**

12. **Response to Specific Comment 46: The Point Avisadero (Area III) SBI tissue inorganic element concentrations (coded magenta) are the maximum or among the maximum tissue concentrations (Addendum F, Figure F-41 to F-44). Use of the SBI tissue estimate of hazard versus the *Macoma nasuta* tissue concentration will be a point of discussion when determining the portion of Area III to proceed in the Feasibility Study. This comment is meant for the DTSC Project Manager and no response is required from the Navy or the Navy contractors.**

<u>Specific Comments Not Related To Responses</u>

13. **The maximum SBI tissue concentration exceeds the paired *Macoma nasuta* tissue concentration for aluminum, antimony, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, zinc, α-chlordane, dieldrin, dibutyl tin, tributyl tin, total DD_x, total high molecular weight PAHs, low molecular weight PAHs and total PCBs (Figures 7-10 through 7-15). This difference argues strongly for the use of SBI tissue concentrations in development of the area to be considered for evaluation of remedial alternatives.**

    Response: Please refer to the response to USEPA Specific Comment #1.

14. **Sediment Ecological Preliminary Remediation Goals (PRGs) were developed for invertebrate-feeding birds, based on the surf scoter, and piscivorous birds, based on the cormorant, which are estimated to be protective of avian intake from Parcel F sediments and food items (Section 12.1.6, page 12-4). A range of Ecological PRGs based on Site Use Factors (SUFs) of 1.0 and 0.1 are incorrectly presented in the text (Section 12.1.6, page 12-4). The summary text (Section 12.1.6) incorrectly lists the Ecological PRG for a Site Use Factor (SUF) of 0.01 as the Ecological PRG for a SUF of 0.1. The correct proposed Ecological PRGs (Section 10.2, pages 10-9 and 10-10), together with the National Oceanic and Atmospheric Administration (NOAA) Effects Range-Low (ER-L) and Effects Range-Median (ER-M) are:**

	Copper (mg/kg)	Mercury (mg/kg)	PCBs (mg/kg)
Benthic Invertebrate-Feeding Bird with SUF = 1.0 (Table 10-1)	**135**	**0.94**	**0.62**
Benthic Invertebrate-Feeding Bird with SUF = 0.1 (Table 10-1)	**1350**	**9.4**	**6.2**
Benthic Invertebrate-Feeding Bird with SUF = 0.5 (Table 10-1)	**271**	**18.7**	**1.24**
Piscivorous Birds SUF =1.0 (Table 10-2)			**0.23**
Piscivorous Birds SUF =0.1 (Table 10-2)			**2.25**
Piscivorous Birds SUF =0.5 (Table 10-2)			**0.45**
NOAA ER-Ls	**34**	**0.150**	**0.023**
NOAA ER-Ms	**270**	**0.710**	**0.18**

It is HERD's opinion that the NOAA ER-L and ER-M concentrations should be continue to be presented in the FS as some landmark to the risk managers for the ecologically-based sediment concentrations being considered, which are based mainly on trophic level transfers.

Response: The typographical error in Section 12.1.6 has been corrected in the final report. ER-Ls and ER-Ms will be included in the FS for informational purposes, although they will not be used as cleanup levels.

15. **There appear to be some errors in data files included on one of the two CD-ROM enclosures, named *Parcel E Shoreline PCB Data.XLS*, shows PCB concentrations in excess of unity (more than 1 million parts per million):**

SEDIMENT	**IR01SH036**	**IR01SH036BOT**	**450632.07**	**1457826.4**	**10.0-10.5ft**	**AROCLOR-1260**	**1300000**		**mg/kg**

Other sample locations in the shoreline of Parcel E data file indicate elevated concentrations of PCBs in shallow soils which would likely pose a risk to ecological receptors:

SEDIMENT	IR01SH026	IR01SH026005	450850.49	1457626.6	0.0-0.5ft	AROCLOR-1016	170	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026005	450850.49	1457626.6	0.0-0.5ft	AROCLOR-1221	340	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026005	450850.49	1457626.6	0.0-0.5ft	AROCLOR-1232	170	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026005	450850.49	1457626.6	0.0-0.5ft	AROCLOR-1242	170	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026005	450850.49	1457626.6	0.0-0.5ft	AROCLOR-1248	170	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026005	450850.49	1457626.6	0.0-0.5ft	AROCLOR-1254	170	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026005	450850.49	1457626.6	0.0-0.5ft	AROCLOR-1260	9400		mg/kg
SEDIMENT	IR01SH026	IR01SH026025	450850.49	1457626.6	2.0-2.5ft	AROCLOR-1016	150	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026025	450850.49	1457626.6	2.0-2.5ft	AROCLOR-1221	310	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026025	450850.49	1457626.6	2.0-2.5ft	AROCLOR-1232	150	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026025	450850.49	1457626.6	2.0-2.5ft	AROCLOR-1242	150	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026025	450850.49	1457626.6	2.0-2.5ft	AROCLOR-1248	150	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026025	450850.49	1457626.6	2.0-2.5ft	AROCLOR-1254	150	U	mg/kg
SEDIMENT	IR01SH026	IR01SH026025	450850.49	1457626.6	2.0-2.5ft	AROCLOR-1260	10000		mg/kg

Perhaps both of these issues are related to the units specified for these measurements. Please check the units designated for samples from previous studies in Parcel E to ensure that the correct units are indicated.

Response: The units associated with the Parcel E data file have been corrected, and revised data files are provided on the CD-ROM included in the Parcel F FS Data Gaps Draft Technical Memorandum.

16. **HERD recommends a default Dermal Absorption Factor (DAF) of 0.01 for inorganic elements for which there is no chemical-specific DAF rather than the 0.001 used in the HHRA (Section 9.1.2.3, page 9-5) for the shellfish ingestion scenario and direct contact with sediment. Use of a DAF of 0.01 rather than 0.001 for inorganic elements would have a minimal impact on the conclusions for this scenario as inorganic elements (i.e., arsenic and chromium) which account for more than 90 percent of the risk in the Area I and Area III Reasonable Maximum Exposure (RME) risk estimates (Table 9-4c, page 9-9), but were comparable to reference locations.**

Response: Section 9 of the report has been revised to use a default DAF of 0.01 as suggested.

17. **HERD supports detailed assessment of mercury, as requested by the San Francisco Regional Water Quality Control Board (SFRWQCB), even though mercury was not identified as a primary risk driver for non-carcinogenic effects (Section 9.1.4.2, page 9-11). The RME hazard for all but two stations (PA-39 and PA-44) in Area III did not exceed 1.0. No clams were found in Area III during field sampling.**

Response: This comment is acknowledged.

18. **HERD defers to the U.S. EPA Region 9 and other CalEPA and California Departments regarding the remaining detailed comments on the human health risk assessment. Inclusion of the 95 percent upper confidence limit on the mean as the exposure point concentration in the Central Tendency Exposure estimates and the presentation of a mussel collection (i.e., dermal exposure to sediment) and consumption scenario address previous HERD concerns regarding the HHRA for potentially-complete HPSY exposure pathways.**

Response: This comment is acknowledged.

Conclusions

Several issues which will potentially impact the extent of the areas and depths to be evaluated in the Feasibility Study for development of ecologically-based Remedial Action Objectives (RAOs) remain to be resolved.

The areas proposed for inclusion in the FS are, with the exception of one area between Area VIII and Area IX which was resampled for mercury, those listed by HERD in previous discussions and the HERD memorandum reviewing the Draft Final Validation Study Report.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD STAFF COMMENTS DRAFT FINAL HUNTERS POINT SHIPYARD PARCEL F VALIDATION STUDY REPORT, SAN FRANCISCO, CA
December 2004

General Comment:

1. **Staff notes that the regulators and resource trustees continue to disagree with the Navy on use and interpretation of the data collected as part of the Validation Study for Parcel F (see U.S. EPA, U.S. FWS and DTSC's recent comments on the Draft Final VSR). Board Staff agrees with many of these comments. The Navy has responded to many of the concerns raised in the draft version of the VSR, including concerns about using the weight of evidence approach to define a footprint for consideration in the Feasibility Study, pooling of RMP data etc, however many of the issues raised in our original comments remain a concern in this draft final version of the VSR. Those concerns are echoed in the comments from other agencies, for example, use of field-collected tissue data rather than laboratory data in the risk assessment.**

   Response: Please refer to the response to USEPA Specific Comment #1 regarding the use of field-collected tissue rather than laboratory data in the risk assessment.

Specific Comments:

1. **Human Health Risk Assessment: The VSR presents a risk calculation based on consumption of shellfish and evaluates sport fish consumption from the perspective of risk communication.**

   a) **The risk assessment concludes that PCBs are a concern for human health at Hunters Point South Basin yet points to cumulative risk repeatedly to say that the actual contribution to overall risk from PCBs is minimal. The emphasis on cumulative risk is an argument of convenience, given that contaminants like arsenic, chromium and dioxin approach a 1:1 relationship between Hunters Point and the reference sites, whereas PCBs represent a 2 to 50:1 relationship. References to cumulative risk appearing in the summary and conclusion sections of the report should be removed.**

      Response: A discussion of cumulative risk is appropriate when summarizing human health risk assessment results; however, text of the final report has been revised to clarify that potential human health risks due to PCBs will be addressed in the remedial action objectives for the Parcel F FS. As discussed in the March 8, 2005 meeting, the Navy will develop a human-health based preliminary remediation goal for PCBs based on a shellfish ingestion scenario during the FS scoping process.

   b) **Appendix K presents the analysis of the human health risk communication for sport fish consumption. The approach used by the Navy involves a statistical analysis comparing the mean and variance of data collected at Hunters Point sites and reference sites. This approach does not appear valid for composited data of unequal sample sizes. Perhaps it is better to look at the means and distribution of the data and disregard discussions about statistical significance. In particular, Staff disagrees**

with the Navy's conclusion that mercury at Hunters Point is not a concern for human health based on consumption of sport fish. Neither jacksmelt nor perch represent the species of most concern to recreational fishers in San Francisco Bay due to mercury contamination (please see Figure 5.1, Mercury in San Francisco Bay, Total Maximum Daily Load (TMDL) Proposed Basin Plan Amendment and Staff Report). Higher trophic level fish species (e.g., striped bass) pose a greater concern. The data collected by the Navy indicates that the range of mercury concentrations in jacksmelt is greater at Hunters Point than at the reference locations (See VSR Figure 9-3), however all but one sample was below the proposed mercury TMDL target of 0.2 ppm (RWQCB, 2004). All samples at the reference area were below the TMDL target of 0.2 ppm. Parcel F sediments are elevated in mercury, especially at Point Avisadero and the South Basin and represent the upper end of contamination in the San Francisco Bay. These mercury-contaminated sediments are a source of mercury to the Bay, via the food web and suspended sediments in the water column, and are a source of mercury to upper level trophic fish consumed by recreational fishers. Our understanding of the relationship between the site and fish contamination levels would be improved be evaluating different size classes of sport fish and their contaminant levels.

Response: The sport fish tissue sample collection and data analysis were conducted in accordance with the DQOs developed in the Parcel F Human Health Evaluation Work Plan; therefore, the data analyses were not revised in response to this comment. Please note that mercury-contaminated sediments will be targeted in the Parcel F FS based on ecological risk, and remediation of these sediments will also reduce risk to upper trophic level fish. However, chemical concentrations in sport fish tissue samples will not be used to evaluate the effectiveness of the remedy for Parcel F sediments. Because sport fish species are relatively mobile, chemical concentrations in tissue cannot be clearly tied to specific sediment sources.

2. **Wading was not considered an independent exposure pathway, except in the case of collection of shellfish. The South Basin area adjoins an area of Hunters Point that will be reused as open space, for recreational uses. As such, it is entirely likely that adults and children will in the future wade into the Bay at this location and the risk assessment should consider this as a future complete exposure pathway.**

   Response: Analysis of a direct contact pathway was added to the Draft Final VS Report (i.e., dermal contact during shellfish collection). The exposure parameters for this scenario are comparable to those for a wading scenario. The text in Section 9.1.2.1 of the report has been revised to note that the exposure parameters for the direct contact pathway are also representative of a wading scenario.

3. **Section 6.0, Bioaccumulation: Staff agree with the final conclusion presented in section 6.4 that copper, mercury and PCBs are risk drivers at Hunters Point.**

   Response: This comment is acknowledged.

4. **Figure 1-1: Hunters Point Shipyard (HPS) Parcel A property boundaries do not appear to match the property boundaries depicted in the Parcel A Final FOST (October 14, 2004). Please review Figure 1-1 and adjust the Parcel A property boundaries as appropriate.**

Response: Figure 1-1 has been updated to reflect current parcel boundaries.

5. **Section 1.2.1- Area I (India Basin), page 1-5: Figure 1-3 (Potential Onshore Sources in Area 1) shows one storm drain outfall in the vicinity of the India Basin low-volume footprint. The text states that contaminated solids may have been transported into the offshore area via this one outfall in the past. Staff notes that Figure 8.3.6.A (Storm Drain System, Parcel A) of the Final Historical Radiological Assessment (HRA) for HPS shows five storm drain outfalls in the same general area. Please review the information included in the Final HRA and revise Figure 1-3 and the Section 1.2.1 as appropriate.**

   Response: Figure 1-3 has been revised to include all identified storm drains and outfalls, and the text has been revised accordingly.

6. **Section 1.2.2 – Area III (Point Avisadero), page 1-6: The storm drain system depicted on Figure 1-4 (Potential Onshore Sources in Area III) does not agree with the storm drain/outfall system depicted in the Final HRA (Figure 8.3.6.1B). Please review the information contained in the Final HRA and revise Figure 1-4 and Section 1.2.3 text as appropriate.**

   Response: Figure 1-4 has been revised to include all identified storm drains and outfalls, and the text has been revised accordingly.

7. **Contaminant Transport to Offshore Parcel F: – One the mechanisms for contaminant transport noted from onshore Site IR-26 (Point Avisadero Area III) and Area X (South Basin IR/21 Landfill) is groundwater discharge to the offshore parcel.**

   Please elaborate on your conceptual model for the physical and chemical processes that govern contaminant transport from IR-26 to Parcel F via groundwater. Please explain why similar contaminant transport mechanisms via groundwater (i.e., similar conceptual model) are not applied to the shoreline areas adjacent to Area I-India Basin, Area VIII-Eastern Wetland, and Area IX (Oil Reclamation).

   Response: Conceptual models for contaminant transport via groundwater were included in the Parcel F FS Data Gaps Investigation Draft Technical Memorandum for Point Avisadero (Area III) and South Basin (Area IX/X). Groundwater transport in the other areas was not evaluated because chemical concentrations in sediments in these areas are generally not elevated.

8. **Section 1.2: Please clearly delineate the low-volume footprint on Figures 1-3, 1-4, 1-5, 1-6 and 1-7 (Potential Onshore Sources to Areas I, III, VIII, IX, and X, respectively).**

   Response: These figures have been revised to show the extent of the low-volume footprint areas.

9. **Page 1-10, Section 1.3.1: The text states that the Validation Study focuses on soft sub-tidal sediments below the break in slope that forms the shoreline or below the toe of debris along the shoreline, as appropriate. This break in slope comprises the approximate boundary between HPS Parcel F and the adjacent uplands parcels. Shoreline and inter-tidal areas that are covered with riprap or disposal debris such as concrete, bricks, or metal rebar have been characterized as part of Parcel B and Parcel E activities and will be managed as part of the adjacent upland parcels. Please clearly delineate the HPS Parcel F boundary that is described in Section 1.3.1 on an appropriately sized figure.**

Response: Details regarding the characterization and management of shoreline and intertidal areas are under discussion. Maps indicating the precise location of the Parcel F boundary are being developed as part of this discussion, and will be incorporated into the Parcel F FS.

10. **Section 1.2.4, Area IX (Oil Reclamation), page 1-8: Section 1.2.4. states that "a former small arms firing range is a potential source of contamination to Area IX (Oil Reclamation)." Staff notes that PCBs have also been detected in shallow sediments at concentrations greater than ER-M (Figure 4-10) within Area IX. Are the reported detections of PCBs in shallow sediments attributable to the Oil Reclamation source area (i.e., erosion and runoff from the Oil Reclamation Area to offshore Area IX)? If so, please amend Section 1.2.4 to reference the Oil Reclamation Area as a potential source of contamination to Area IX.**

    Response: Section 1.2.4 has been amended to clarify that Area X (South Basin) is believed to be the source of PCBs to Area IX; the upland area and shoreline adjacent to Area IX do not appear to be the source of PCBs based on 2002 Parcel E shoreline sampling results. Interpretation of the shoreline sampling results will be included in the pending Parcel E Shoreline Technical Memorandum.

11. **Appendix L, page L-23: Text refers to the "1998 El Nino Storm on February 6, 2001, was chosen for the extreme event analysis.'' Please review the dates referenced in this sentence and correct as appropriate.**

    Response: The date has been corrected to indicate that the storm occurred in 1998.

12. **Section 11.0 Uncertainty, Site Use Factors, page 11-6: Statements about which SUF for the surf scoter is likely to be representative of the true exposure at the site is inappropriate in this section of the report.**

    Response: Statements referring to representative SUFs were removed from the uncertainty discussion.

13. **Section 10, Identification of the Parcel F FS Study Area: This section of the report states that use of field collected tissue data results in greater uncertainty than using laboratory M. nasuta data. The fact that field-collected data were observed in many cases to be more highly contaminated than the laboratory data indicates a high degree of uncertainty relying on the laboratory data for decision-making purposes.**

    Response: Please refer to the response to USEPA Specific Comment #1.

<u>Conclusions:</u>

Staff is pleased that the Navy has responded to many of the concerns raised in the draft version of the VSR, however, several issues which will potentially impact the lateral and vertical extent of sediment column evaluated in the FS remain a significant concern and are yet to be resolved to our satisfaction.

Specifically, we are concerned that both PCBs and mercury should be evaluated in the FS for all offshore areas contained in Parcel F. Additionally, Staff recalls that the Navy agreed

to evaluate a 200 ppb sediment PCB concentration (protective of human health) forward into the FS, yet the draft Final VSR makes no mention of this PRG.
Staff recommends that all stakeholders meet (after digestion of comments received on the Draft Final VSR) to discuss our comments and to hammer out a mutually acceptable path forward for the Parcel F FS and evaluation/selection of remedial alternatives.

Response: This comment is acknowledged. As noted in the response to USEPA Specific Comment #1, the Navy proposes to work in consultation with the BCT during the FS scoping process to resolve any outstanding issues and develop a footprint for the Parcel F FS that is both technically defensible and protective. The Navy acknowledges concerns about human health protection, including the consumption of sport fish. The 200 ppb PCB criterion proposed by the RWQCB will be evaluated as part of the ARAR identification process and documented in the Parcel F FS report.

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE COMMENTS DRAFT FINAL HUNTERS POINT SHIPYARD PARCEL F VALIDATION STUDY REPORT, SAN FRANCISCO, CA
October 27, 2004

General Concerns:

1. **Comparison of surface (top 5 cm) sediment chemistry to effects-range median (ER-M) values only evaluates relative toxicity based on amphipod mortality, and does not directly relate to other endpoints and other receptors.**

   Response: Chemical concentrations in sediment were compared to ER-M values for discussion purposes only. Other lines of evidence were used to evaluate other endpoints and receptors (i.e., the bioaccumulation evaluations presented in Sections 6 and 7).

2. **Lab bioaccumulation data were used to determine dietary exposure even for chemicals where field-collected tissues had higher concentrations and were more relevant to the actual diet of the receptors.**

   Response: Please refer to the response to USEPA Specific Comment #1 regarding the use of laboratory *Macoma* data versus field-collected tissue data in the dose assessments.

3. **Bioaccumulation factors (BAFs) were calculated as mean clam over mean sediment rather than mean of individual site-specific clam and sediment ratios. Therefore, the BAFs should be re-calculated and the preliminary remediation goals (PRGs) should be revised based on the new BAFs.**

   Response: The ratio estimator used to develop BAFs is an appropriate statistical method for developing uptake factors. The ratio estimate (Cochran, 1963) is a statistic used to estimate the rate or ratio between two variables both of which vary from sample to sample. The ratio estimate has the advantage of being less variable (less uncertain) and less biased than the average of the individual station ratios. It is preferred over regression-based analyses that have slopes that may be dominated by a single influential point, a tendency even more pronounced when the regression is modeled through the origin to obtain a simple rate based on slope alone.

   Cochran, W. G. (1963). *Sampling Techniques*, Second Edition. John Wiley and Sons, Inc., New York.

4. **The site use factor (SUF) was based on the portion of the year spent on site even though the units of both the dose and toxicity reference value (TRV) are per day.**

   Response: Please see the response to USFWS Specific Comment #1 below.

5. **The requirement that bioaccumulation test results exceed reference threshold values is an unnecessary and ecologically irrelevant criterion. Prey concentrations are only one component within the overall exposure estimation. With the exception of comparisons between metal concentrations and appropriate ambient concentrations, comparisons between site and ambient or reference conditions should occur at the risk management stage where the relative contribution of the two components to the overall risk can be evaluated.**

Response: Comparison of HPS tissue results to reference threshold values as part of bioaccumulation evaluation was an agreed upon approach documented in the VS Work Plan. Nevertheless, dose assessment results for all COPECs were added to Section 6.2 of the final report to provide information about both site and ambient conditions.

Specific Comments:

1. **The SUF used in the subject document was based on the portion of the year spent on site even though the units of both the dose and TRV are per day. Therefore, a SUF applies only to the representative amount of time spent at the site for each day based on the units of both the dose and the TRV. Furthermore, the toxicity reference values are preferentially selected from exposures lasting at least 3 months (i.e., chronic) or a shorter period if during a critical life stage, illustrating that toxicity thresholds can be exceeded for receptors even if they are only seasonally present. If the Navy wants to evaluate appropriately the period of exposure, they could determine the original exposure duration and/or total dose from the TRV study and compare this to the time in which they are present and the estimates of accumulated dose.**

   Response: Section 6.3.2 of the report has been revised to clarify that the SUF refinement is a spatial rather than a temporal evaluation (i.e., a SUF of 1.0 implies that the scoter's foraging range is limited to HPS, and lower SUFs indicate that a smaller percentage of the scoters' foraging range is at HPS). The information regarding the amount of time a scoter spends in SF Bay each year is intended to provide supporting information regarding its foraging behavior; however, the dose assessment assumes that the exposure to the scoter is chronic.

2. **Although fish samples were initially described as whole body, the samples had head, fin, tail, and guts removed prior to analysis. This tissue preparation is inconsistent with ecological risk assessments since piscivorous animals typically consume most if not all of the fish. This difference is particularly important for chemicals that preferentially accumulate in specific tissues and organs, such as the liver, that animals consume, but were not included in the analyzed sample. In the absence of new data for whole fish, please address this issue as a data gap that increases uncertainty, particularly in the direction of underestimating risk since the tissues removed typically have higher concentrations for several contaminants.**

   Response: Fish samples that were used to support the ecological risk evaluation were whole body samples, whereas the fish tissue samples that were used for human health evaluation were analyzed as filet only, which is the part of the fish that is typically consumed by humans.

3. **The document describes Area III contamination as occurring at some of the deeper locations (greater than 30 feet) where diving ducks are unlikely to forage. Surf scoters have been observed foraging in the approximately 2 to 10 meter depth range (Miles, 2000). In a recent U.S. Geological Survey (USGS) study of greater and lesser scaup, scaup foraged at depths ranging from -0.5 to at least 13 meters (Wainwright, unpublished results). This information should be considered in evaluations of likely diving duck exposures based on bathymetry. In addition, please provide a graph of water depth versus total polychlorinated biphenyls (PCBs) concentrations for all Area III data.**

Response: The text referenced above was removed from the final report because bathymetric information was not used to characterize risk to diving ducks in Area III. Therefore, a graph of water depth versus total PCBs was not added to the final report. However, this information may be relevant in the risk management phase of the project.

4. **Concentrations in field-collected polychaetes were higher than in depurated clams from a 28-day laboratory study for metals and many organics. Similarly, field-collected forage fish had higher concentrations of many organics. Therefore, field-collected tissue data should be used to evaluate dietary exposure from those chemicals to the appropriate receptors. Furthermore, the use of laboratory clam data instead of available forage fish data for the obligate piscivore cormorant is inconsistent with the ecology of this species and introduces unnecessary uncertainty into the exposure estimates for this species and the feeding guild it represents.**

   Response: Please refer to the response to USEPA Specific Comment #1 regarding the use of laboratory *Macoma* and field-collected tissue data in the dose assessments. Please note that field-collected forage fish tissue data were used in the dose assessment for the double-crested cormorant.

5. **The text describes cormorant risk evaluations as using the mean tissue concentration, but 95th upper confidence limit values were supposedly used for scoters. Please revise this discrepancy in the text and calculations as appropriate.**

   Response: The cormorant evaluation was based on a single forage fish tissue value for each area rather than a mean or 95% UCL because only one composite sample from each area was available.

6. **The bioaccumulation factors as described were calculated as the mean value of all Parcel F depurated clam data for each chemical divided by the mean sediment value. This process ignores the importance of corresponding tissue and sediment data, despite the apparent ease of determining which sediments the clams were exposed to in the laboratory. The Service recommends that the concentration in the clams be divided by the corresponding concentration from the sediment sample to which they were exposed, thereby calculating a population of site-specific bioaccumulation factors on which statistical evaluations (e.g. type of distribution, appropriate regressions, measures of central tendency) can be done.**

   Response: Please refer to the response to USFWS General Comment #3.

7. **Sediment samples were analyzed in 2-foot composites, however 2 feet of sediment represents approximately 60 years of accumulation (based on the sediment accumulation rate provided), and would be expected to be of heterogeneous composition and concentration depending on the degree of bioturbation.**

   Response: The purpose of sediment core analysis in the Validation Study was to provide an initial indication of vertical distribution of contaminants. More detailed vertical contaminant profiles were collected as part of the Parcel FS Data Gaps investigation.

8. **Service staff previously requested sediment samples be analyzed for sulfide, sulfate, methyl mercury, and total mercury to determine the degree of mercury methylation and potential relationships with organism uptake as shown by tissue concentrations. The data recently**

provided included sulfide, methyl mercury, and total mercury in sediment for a subset of locations, but these locations were different from the locations from which field organisms were collected and from which sediment was collected for the laboratory clam bioaccumulation tests. Service staff conducted an analysis of these data and found significant linear log-log relationships between percent methyl mercury and total mercury in sediment and between total mercury and clam bioaccumulation data and corresponding total mercury in sediment (Attachment A). However, the absence of sulfate data and the lack of corresponding locations between the sediment analysis and the tissue collection limited the extent of the evaluation and the relevance of the findings.

Response: In discussions with USFWS during the development of the Parcel F FS Data Gaps Investigation Work Plan, the decision was made not to analyze sulfate because it is abundant in the marine environment and is not likely to be a limiting factor for methylation. The 2003 sample stations did not exactly correspond with the Validation Study stations; however, many were located nearby. It should be noted that the DQOs for methylmercury data collection were not designed to support a detailed and in-depth characterization of mercury bioavailability because this information is not believed to be essential to the remedial decision-making process. Regardless of the outcome of such a study, a cleanup based on total mercury concentration is likely to be necessary given concerns about potential future mercury bioavailability, and the FS footprint based on total mercury concentrations is likely to encompass the stations with the highest methylmercury concentrations.

References Cited:

Miles, A. K. (2000) Surf scoter. In Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife, Olofson, P. R. ed. Goals Project,, Oakland, CA.

ARC ECOLOGY COMMENTS
DRAFT FINAL HUNTERS POINT SHIPYARD PARCEL F VALIDATION STUDY REPORT, SAN FRANCISCO, CA
November 30, 2004

General Comments

1. **According to the report, the primary objective of the Validation Study is to identify the areas of offshore sediment requiring evaluation in a Feasibility Study (FS) (Section 1.3, page 1-10). Having read the history of previous studies at Parcel F (Section 1.1.3), it is not clear why a Validation Study (VS) was required after the draft FS was submitted in 1998. How does the footprint that is being proposed in the VS differ from the low and high volume footprints that were presented in the draft FS? Please provide a more thorough explanation of how the analyses and conclusions in this report differ from those in previous ecological risk assessments.**

   Response: The high- and low-volume footprints provided in the 1998 Draft FS report were based on ER-L and ER-M values, as well as bioaccumulation criteria for DDT and PCBs. These footprints were not developed from site-specific, risk-based data. Because the FS footprint based on the Validation Study data has not yet been finalized, its similarity to the footprints in the 1998 FS report cannot yet be ascertained.

2. **In the identification of the Parcel F Feasibility Study (FS) study area (Section 10), the report explains that dose assessments based on field-collected invertebrate tissue data were given less weight in the risk evaluation because there is no data from reference stations to which these results can be compared. Arc Ecology does not believe this is a valid reason for discounting the risks associated with the field data. By discounting these risks, the proposed Feasibility Study (FS) footprint may be inadequate. Arc Ecology proposes taking a more conservative approach and including all identified risks in the footprint, from both field-collected tissues and laboratory bioaccumulation tests. Beginning with a footprint that includes all available data and the associated uncertainties, the community and regulatory agencies can then work with the Navy to determine an appropriate FS footprint.**

   Response: Please refer to the response to USEPA Specific Comment #1 regarding the use of field-collected tissue data and the proposed approach for developing the FS footprint.

3. **The report makes the argument that "Given the weak tidal circulation in South Basin, upstream transport of contaminated sediments from South Basin into Yosemite Creek is unlikely" (Section 1.2.5, page 1-10). While the data from the sediment transport indicated that currents are weak in South Basin, we do not believe there is sufficient evidence yet to determine whether or not the Navy is responsible for contamination in and around Yosemite Slough.**

   Response: The conclusion that transport of contaminated sediments into Yosemite Creek from South Basin due to sediment transport is unlikely due to weak currents does not refer to who is responsible for contamination in the creek, only to the fact that the contamination in the creek was unlikely to have originated from the Parcel E shoreline adjacent to the landfill. The Parcel F FS Data Gaps Draft Technical Memorandum discusses PCB distribution patterns in South Basin in more detail. Section 1.2.5 of the Validation Study Report has been revised to clarify this point.

a. **The evaluation to date of sediment transport in extreme tidal events and heavy storm periods is insufficient. While large storm events with heavy winds do not occur often, it is likely that this type of event has occurred numerous times since the PCB source material was deposited on the Shipyard. Until the transport of sediments in an extreme storm event is adequately assessed, statements about the potential for upstream transport are not adequately supported.**

Response: Additional analyses of sediment stability, sediment transport and potential effects of extreme events are provided in the Parcel F FS Data Gaps Draft Technical Memorandum (February 2005).

b. **Section 4.3.3, page 4-27, acknowledges that additional data is necessary to more clearly differentiate between differences due to multiple PCB sources and those due to weathering and dechlorination of Aroclor 1260. A more complete analysis of the PCB congeners found in South Basin is required before conclusions can be drawn about the relationship between sediments in the South Basin and Yosemite Slough. Plans for this type of study were included in the Parcel F FS Data Gaps Investigation Work Plan, however results of such a study are not presented in this report. The Data Gaps Investigation Work Plan also called for a comparison of onshore and offshore congeners. When will these studies be conducted and when and where will the results be documented?**

Response: Additional analysis of PCB composition and distribution in South Basin is provided in the Parcel F FS Data Gaps Draft Technical Memorandum.

4. **The Historical Radiological Assessment that was completed earlier this year by the Radiological Affairs Support Office indicated a potential for many areas of Parcel F to be radiologically impacted. An explanation of when sediments will be sampled for radionuclides should be provided in this report. Please include the program under which the sampling will be conducted, an explanation of how the data will be incorporated with chemical contamination data, and when an evaluation of the human health and ecological risks from radioisotopes in Parcel F will be conducted.**

Response: A survey of potential radiological contamination in Parcel F will be carried out following the recommendations in the Historical Radiological Assessment; however, details regarding the scope and schedule have not yet been determined. Remedial actions in response to the radiological survey will be incorporated into actions based on chemical contamination.

5. **The results from several studies conducted under the Parcel F FS Data Gaps Investigation are not included in the draft final Validation Study report or its addendum. For example, the data gaps investigation planned for more detailed radioisotope profile data to confirm the sediment accumulation rate as well as a PCB congener analysis to help determine the relationship between PCBs found in offshore sediments and along the Parcel E shoreline. When and where will the results of these investigations be presented? How will the results of these studies be incorporated into the evaluation of human health and ecological risk assessments?**

Response: This information is presented in the Parcel F FS Data Gaps Draft Technical Memorandum. The data are integrated with the risk assessment results in the refined conceptual site models presented in the technical memorandum. The conceptual site models will form the

basis for the evaluation of remedial alternatives, and will be refined throughout the rest of the RI/FS process as additional information becomes available.

6. **Not all data collected to date is used to determine the FS footprint. Please explain the rationale the Navy used in determining what data collected to date would be included in the determination of the FS footprint. If detected concentrations are similar or elevated compared to reference stations and a source area from the Shipyard is identified, the Navy should be held responsible for both stopping any ongoing contamination from the source and for reducing the resultant levels of contamination that originated with that source.**

   Response: The Navy proposes to develop the initial FS footprint based on detailed horizontal and vertical contaminant distribution data for primary risk drivers collected during the Parcel F Validation Study and FS Data Gaps investigation. This initial footprint will be evaluated to ensure that it is consistent with previous data and adjusted as necessary. Footprint development and refinement will take place during the FS scoping process in consultation with the BCT.

7. **Ongoing community concern has raised the issue of the synergistic effects of low-level exposure to multiple compounds. At the same time, scientific research is increasingly demonstrating that simultaneous exposure to multiple chemicals has a different or greater impact than exposure to a single substance (and that in many cases exposure to a single substance does not accurately reflect the real-world situation). How does the Navy's approach to risk assessment and development of remediation goals address both these community concerns and the growing body of scientific evidence that supports those concerns?**

   Response: Uncertainties regarding exposure to chemical mixtures that may cause additive, synergistic or antagonistic effects are discussed in Section 11 of the VS Report. The Navy recognizes the potential for these types of effects; however, these effects are poorly understood and the current state of the science does not allow these effects to be evaluated quantitatively. Uncertainties associated with the FS footprint will be discussed with the BCT during the FS scoping process to ensure that a technically defensible and protective footprint is developed.

<u>Specific Comments</u>

8. **Source Characterization: Section 1.2.4 – Area IX (Oil Reclamation): "The historical oil reclamation ponds (Site IR-03) are located approximately 1,000 ft east-southeast of Area IX. The ponds have been closed, sheet piling has been placed adjacent to the shoreline, and the shoreline has been stabilized in this area as part of onshore remediation activities." This statement suggests that the oil ponds are not a potential source for offshore contamination. While these activities may prevent this former oil reclamation area from acting as a current source for offshore contamination, this area may have contributed to offshore contamination in the past. Has Area IX been sampled for contaminants that would be associated with oil ponds in order to evaluate potential past migration of contaminants into the Bay and to assess whether the area is an ongoing source for offshore contamination?**

   Response: Area IX was sampled during field investigations conducted as part of the Environmental Sampling and Analysis Plan (ESAP) and the Phase 1B ERA. The 1997 Parcel F Feasibility Study developed the low volume footprint through a decision process which included an initial screening of analytical results against ER-Ms and bioaccumulation criteria for PCBs and

DDT. As a result of this evaluation, the oil reclamation pond area was not included in the low volume footprint.

9. **Section 4.3.3 – Composition of PCBs in South Basin: As mentioned in Comment #5, this section concludes with a paragraph stating that additional data are required to more clearly differentiate between differences due to multiple PCB sources and those due to weathering and dechlorination of Aroclor 1260. When does the Navy propose to do this sampling and where will the results be presented?**

   Response: This analysis is presented in the Parcel F FS Data Gaps Draft Technical Memorandum.

10. **The shoreline sampling that was recently conducted on Parcel E is mentioned several times in the report, particularly in reference to probable source areas. A figure showing the Parcel E Shoreline sampling locations and station numbers would be a useful addition to the report as a point of reference.**

    Response: A figure showing shoreline sample locations in Parcel E is included in the Parcel F FS Data Gaps Draft Technical Memorandum.

11. **Section 10.2 – Development of Preliminary Remediation Goals: In calculating the preliminary remediation goals for PCBs, mercury, and copper, the Navy has chosen to use the chemical concentration detected in the depurated, laboratory *M. nasuta* tissue. Would it not be more accurate to use the non-depurated field results, since this is more exemplary of what the birds will actually be eating? Please provide a better explanation of the rationale for using the depurated, laboratory concentrations versus the non-depurated field results.**

    Response: Please refer to the response to EPA Specific Comment #1 on the draft final Validation Study Report. Paired sediment and depurated laboratory *Macoma* tissue data are available for 59 stations throughout HPS, which provides a robust data set for the development of bioaccumulation factors. Only one non-depurated laboratory *Macoma* tissue sample, one hard-bodied invertebrate field-collected tissue sample, and one soft-bodied invertebrate field tissue sample are available for each of the five Validation Study areas. Additionally, paired sediment data are not available for the field-collected tissue samples. Please note that the food chain model used to develop the PRGs incorporates a term for incidental sediment ingestion.

12. **Section 10.2.3 – Qualitative Evaluation of Lead: Due to the uncertainties with assessing risk from lead, a qualitative evaluation of lead was conducted at Area X. By comparing the distribution of lead in Area X with the distribution of PCBs in the same area, it was determined that the highest concentrations of lead and PCBs generally co-occur and therefore, remediation based on PCB concentrations will also reduce lead concentrations. While this may be true of Area X, it does not seem as though the same is true for Area III (Point Avisadero), where lead was also detected at elevated concentrations in sediment samples. As stated in Section 4.3.1, "However, the horizontal and vertical distribution of chemicals in Area III sediments is patchy and discontinuous, […] and many COPECs do not co-occur." How does the Navy propose to evaluate lead in Area III to determine areas that require remediation?**

    Response: The highest concentrations of lead in Area III sediments fall within the footprint defined by elevated concentrations of mercury and copper; therefore, concerns about potential risk from lead will also be addressed.

RESPONSES TO U.S. EPA COMMENTS ON DISCUSSION DRAFT SUMMARY OF MAJOR COMMENTS ON THE DRAFT FINAL VALIDATION STUDY REPORT, MARCH 2005
March 23, 2005

Note: USEPA comments provided in the March 23, 2005 letter on the Draft Technical Memorandum, Hunters Point Shipyard Parcel F Feasibility Study Data Gaps Investigation, San Francisco Bay, California, February, 2005 will be addressed separately in the Draft Final Technical Memorandum).

1. **Response to EPA Specific Comments 1 and 6 (Issue 1): Navy Response to EPA Specific Comments 1 and 6 (Issue 1): There is a persistent technical disagreement between the Navy and the EPA regarding the use of field tissue in the validation study. The Navy continues to contend that the field tissue data are not appropriate for use in identifying areas for inclusion in the Parcel F Feasibility Study (FS). The Navy's rationale for this contention is technically flawed. The Navy maintains that the field tissue data were collected to evaluate uncertainty associated with the use of laboratory Macoma data in the food chain model. This is true. However, the food chain model is the basis for the calculation of preliminary remediation goals and, hence, the selection of areas for inclusion in the FS. Uncertainty in the food chain model directly relates to selection of these areas, so it is illogical to conclude that the field tissue data can not be used to identify areas for inclusion in the FS. The Navy should use the more protective of the bioaccumulation factors in modeling risks to upper trophic levels unless there is compelling evidence to support using a less protective value. At Parcel F, the more protective bioaccumulation factors (BAFs) are calculated from field tissue data. The areas selected for inclusion in the FS should result from the use of the more protective BAFs. The Navy should then present any uncertainties in the use of these protective BAFs.**

   Response: The Navy proposes to continue technical discussions regarding these disagreements during the Parcel F FS scoping process. The Navy is committed to developing remedial action objectives, preliminary remediation goals, and an FS footprint that are technically defensible and protective during the FS scoping process.

   There is compelling evidence that the field-collected tissue data should not be used to develop BAFs. This evidence is presented in the response to DTSC Specific Comment #56 on the Draft Validation Study Report (Appendix Q), and briefly summarized below. The data quality objectives (DQOs) and sampling design for field-collected tissues were not intended to support BAF development: paired sediment and field tissue samples were not collected, only one composite field tissue sample of each type was collected in each of the five study areas, and each composite sample only represents a portion of each area. The soft-bodied invertebrate field tissue samples were not depurated, and sediment on the surface or in the guts of the organisms introduces error into estimates of uptake. Scientific studies have cautioned against the use of non-depurated tissue data when developing bioaccumulation estimates, and bioaccumulation studies performed by the U.S. Army Corps of Engineers using sediment from South Basin at HPS indicated that BSAFs based on depurated *Neanthes* tissue data were lower than those based on depurated *Macoma* tissue data in the Validation Study. The strongest link between sediment and tissue at HPS is associated with the paired sediment and depurated *Macoma* tissue samples collected at 59 stations throughout the site.

   The Navy also plans to develop the initial FS footprint based on the primary risk drivers then evaluate whether other contaminants or areas identified based on the field tissue data have been addressed. A more transparent approach would be to develop more than one

footprint. The first footprint could be based on the modeling with the more protective of the BAFs and including all areas with chemicals posing a risk (HQ>1). The second footprint could be developed from the Navy's preferred BAF with rationale provided to support the contention that this footprint represents a better definition of the actual risks posed by Parcel F sediments.

Response: As described above, there are compelling technical arguments against developing BAFs from the field-collected tissue data set. All dose calculations for field-collected tissue data are based on a single tissue concentration and a site use factor of one, which is reasonable for a conservative, screening-level assessment. It is inappropriate to conclude that ecological risk is unacceptable based solely on dose assessment results for field-collected tissue (see the response to USEPA Specific Comment #1 on the Draft Final Validation Study Report for further discussion of this issue). However, as noted above, the Navy proposes to continue discussion of these technical issues with the BCT during the Parcel F FS scoping process in order to develop remedial action objectives, preliminary remediation goals, and an FS footprint that are technically defensible and protective.

2. **Response to EPA Specific Comment 2 (Issue 2): There is a persistent technical disagreement between the Navy and the EPA regarding the approach to establishing the FS footprint. The Navy continues to maintain that it is appropriate to develop the FS footprint based on preliminary remediation goals (PRGs) for chemicals of potential ecological concern (COPECs) driving risk in Areas III and IX/X despite risks being reported in other areas. Based on the weight-of-evidence (WOE) evaluation, the Navy has concluded that risks identified at Areas I, III, VIII, and X are insignificant. The EPA disagrees with the technical interpretation of the data that is reflected in the WOE evaluation (see comments on Navy's responses to EPA comments on Draft VSR). The Navy proposes to develop PRGs only for mercury, copper, and PCBs, the chemicals of concern (COCs) at Areas III and IX/X. This would result in no PRGs for other contaminants that pose risk in the remaining areas of Parcel F (e.g., lead). The Navy appears to suggest that the combination of applying the mercury, copper, and PCB PRGs and controlling onshore sources will be sufficient to address offshore contamination resulting in ecological risk at for Areas I, III, VIII, and X . This approach is akin to natural recovery (NR) without monitoring for offshore sediment risks (associated with lead and other contaminants) that the EPA considers significant. Applying NR without the benefit of considering other alternatives to address risks in these areas and without monitoring is inconsistent with the CERCLA FS process. Please revise the VSR to include PRGs for other contaminants posing risk, particularly lead, and include at least one footprint in the FS that is inclusive of areas with sediment concentrations greater than these PRGs.**

   Response: Section 10 of the Final Validation Study Report has been revised to remove language that implies that risk management decisions about specific areas (i.e., Areas I and VIII) have already been made. The final report indicates that all five areas (Area I, Area III, Area VIII, Area IX and Area X) will be evaluated in the FS, where the appropriate risk management decisions will be developed in consultation with the BCT. While it is the Navy's position that sediments in Areas I and VIII do not pose an unacceptable risk or hazard, decisions about remedial action will not be presupposed in the Validation Study. Please refer to the responses to USEPA Specific Comment #1 on the Draft Final VS Report and Comment #1 above regarding the proposed approach for resolving technical disagreements during the FS scoping process.

3. **Response to EPA Specific Comment 4 (Issue 6): The response does not address the comment. The Navy declines to explore possible relationships between metals toxicity to**

urchin larvae that was observed in the toxicity identification evaluation (TIE) ancillary study and the mortality observed in the amphipod bioassay. The Navy believes that the mortality observed in the amphipod bioassay is not significant and does not constitute toxicity.

Response: The amphipod bioassay test results were interpreted in accordance with the decision rules presented in the Validation Study Work Plan, which are based on reference envelope tolerance limits for San Francisco Bay developed by the State Water Resources Control Board. These criteria were developed in discussions with the Navy and agency technical group, as well as staff from the Bay Protection and Toxic Cleanup Program (BPTCP) and other local toxicity test experts. These discussions are summarized in technical conference call minutes from May 23 and June 1, 2000, which are provided in Appendix A of the Validation Study Work Plan. Based on these consensus-based decision criteria, unacceptable amphipod toxicity was not observed in any HPS sample. Given that toxicity was not observed in the amphipod test, the Navv does not believe that additional investigation of the relationship between amphipod survival and bulk sediment metals concentrations is warranted.

4. **Response to EPA Specific Comment 9 (Issue 7): The response is incomplete. The Navy declines to consider the adjacent contamination at Hunters Point Shipyard (HPS) for the site utilization factor (SUF) refinement. The Navy's rationale that the sizes of adjacent areas at HPS are very small compared to the foraging range of the scoter outside the low-volume footprint is not illustrated in the response. Further, the areas of Parcel F outside the low volume footprint have not been shown to be equivalent to background conditions for the Bay. Please revise Section 6.3 to include a calculation of the site-wide 95% upper confidence limit using data from all of Parcel F rather than just the low-volume footprint. Please include and discuss the resulting risk estimates.**

Response: The analysis provided in Section 6.3 currently includes evaluation of exposure to all five of the HPS study areas at a range of SUFs (see Table 6-12 of the final report), which accounts for the scenario where receptors forage in multiple contaminated areas of HPS as well as outside of HPS. Given that the five areas in the low volume footprint represent the areas of greatest ecological hazard based on previous studies, the site-wide estimates can be used to conservatively approximate risk for HPS as a whole. The technical aspects of this assessment can be discussed further with EPA during the FS scoping process.

5. **Navy Response to EPA Specific Comment 10 (Issue 8): The response partially addresses the comment. Please provide a rough schedule with major milestones that explains how and when the survey of potential radiological contamination in Parcel F will be conducted.**

Response: This schedule will be provided to EPA when it is available. Remedial actions to address any radiological contamination that is found in the survey will be incorporated into actions based on chemical contamination.