



Sediment Contamination in San Leandro Bay, CA

Ted Daum and Sarah Lowe, San Francisco Estuary Institute
Rob Toia, University of San Francisco
Greg Bartow, San Francisco Bay Regional Water Quality Control Board
Russell Fairey, Moss Landing Marine Laboratory
Jack Anderson and Jennifer Jones, Columbia Analytical Services, Inc.

San Francisco Estuary Institute (SFEI)
1325 S. 46th Street
Richmond, CA 94804

In cooperation with:
San Francisco Bay Regional Water Quality Control Board
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Executive Summary

San Leandro Bay is a shallow embayment, located south of Alameda Island, in the central part of San Francisco Bay. San Leandro Bay is formed by the confluence of four creek channels (East Creek, Damon, Elmhurst, and San Leandro Creek Channels) and the Oakland Inner Harbor and San Leandro Bay tidal channels. The open water channels of the bay cover approximately 690 acres at mean higher high-tide, and approximately 100 acres at low tide.

Contamination of sediments in San Leandro Bay by trace metals, PCBs, PAHs, and various synthetic biocides have been documented by several short term and continuing studies, including the Bay Protection and Toxic Cleanup Program (BPTCP) that listed it as a toxic hot spot). Recent analyses of 1997 BPTCP benthic community data suggest that several sites in San Leandro Bay have impacted benthic assemblages.

This study had 5 objectives; to evaluate the distribution of sediment contamination, determine if the contamination was relatively isolated or not, identify possible sources and pathways, investigate the depth of sediment contamination, and explore a method of sediment dating to see if it could be used to determine if the sediments are erosional or depositional within the embayment.

This study sampled surface and core sediments at a fine resolution to characterize the spatial distribution of the sediment contamination within San Leandro Bay and its immediate tributaries. Sixty sites were sampled for sediment in San Leandro Bay in August 1998. The stratified, random sampling design included 44 grab and 16 core sediment samples to address the question of how deep the sediment contamination penetrated below the surface and to evaluate erosion. Creek channels were sampled at successive sites upstream to evaluate potential contaminant pathways. Additionally, radionuclide analysis was performed on collected core samples as a sediment-dating tool to help determine if the sediments were depositional or erosional and to evaluate the analytical method. However, analytical difficulty in the laboratory resulted in poor sediment-dating results.

Chemical analyses were performed at all sites for trace elements, PAHs, and PCBs. Some of the sites were also analyzed for pesticides. Ancillary sediment quality analyses (grain size and total organic carbon (TOC)) were performed to help characterize the sites and augment

contaminant interpretation. A biomarker screening technique (the cytochrome P450 reporter gene system (P450 RGS)) was also performed to evaluate this less expensive analytical method for use as a screening tool for the presence of PAHs and dioxin-like compounds (i.e., coplanar PCBs, dioxins, and furans).

Although there currently are no regulatory criteria for sediment, several widely accepted local and national sediment quality guidelines exist. This study used the Effects Range Low and Effects Range Median (ERL and ERM, respectively) guidelines developed by Long et al. (1995) as predictive tools to evaluate the toxic potential of sediment. Some of the analytes were also compared to Ambient Sediment Concentrations (ASCs) for the San Francisco Bay, which were developed as a guideline for “background” contaminant levels in this highly urbanized Estuary. Pre-industrial, baseline trace metal concentrations for the San Francisco Bay determined from core samples were also used to evaluate sediment samples in this study.

Results of this study show surface and core samples of sediment collected in San Leandro Bay and its creek channels had elevated concentrations of trace metals and organic compounds compared to background and sediment guideline levels. Contaminants detected most frequently above ERM guideline levels were nickel, mercury, chlordanes, DDTs, and PCBs. In general, the highest concentrations of surface sample contaminants were found in East Creek Channel, Damon Creek Channel, and Elmhurst Creek Channel. Three sites in East Creek Channel and two sites in Elmhurst Creek Channel had over 75 % of the evaluated contaminants above ERL guidelines in surface samples.

Sediment grain size analysis showed that most of the surface samples in the open water channels of San Leandro Bay Channel, Airport Channel, and San Leandro Creek Channel, consisted of fine sediments (grain-size < 74 μm). The Oakland Channel sediments were coarser than the other channels. Samples from the upper portions of the creek channels in East Creek, Damon, Elmhurst, and San Leandro Creek Channels, consisted of sandier sediments, with the exception of one site on San Leandro Creek. The pattern of sandier sediments found at upstream sites and fine sediments found at the mouths of creek channels suggests the scouring of fine sediments from the upper portions of the creek channels into the mouths of the channels.

One open water site (B2c) and three sites in East Creek Channel had more than 75 % of the evaluated contaminants above the ERL in sub-surface samples. Core sites that had sub-surface samples of greater than 1 foot generally showed increasing concentrations of

contaminants with depth. This finding is consistent with other San Francisco Bay studies that have found higher concentrations associated with historic contamination since 1850, with decreasing loads over the last thirty years. The evaluation of subsurface sediment contamination was limited in this study because of sampling difficulties.

Within the entire study of both surface and core samples, three sites had mean ERM quotient (mERMq) values above 1 (A4c, B2c, and C6c), which indicated that sediments at these sites had a 92% probability of being toxic. Almost all of the creek channel sites and several open water sites had mERMq value > 0.5 , which indicated that sediments at these sites had an 82% probability of being toxic.

This study found that East Creek Channel, Elmhurst Creek Channel, and Damon Creek Channel had higher concentrations of many contaminants than most other sites. In general, creek channel sediments were more contaminated in sub-surface samples than on the surface. Open water sites B2c, B8c, and C6c were more contaminated than other open water sites, and more contaminated at depth than on the surface.

Regression analysis results from the organic wet chemistry and the P450 RGS analysis showed that the screening method significantly correlated to wet chemistry results for total PAHs and therefore is a good screening tool for future studies.

Introduction

San Leandro Bay is a shallow embayment, located south of Alameda Island, in the central part of San Francisco Bay. Formed by the confluence of four creek channels (East Creek, Damon, Elmhurst, and San Leandro Creek Channels), and the tidal channels of the Oakland Inner Harbor and San Leandro Bay channel, it covers 690 acres at mean higher high-tide (Figure 1). At mean lower low tides open water is reduced to channels covering about 100 acres (U.S. ACE, 1980). The directly associated watershed is approximately 42,000 acres, which is predominantly commercial, residential, and industrial land (U.S. ACE, 1980; ABAG, 1995). Over the past century the geomorphology and land use of San Leandro Bay and its watershed have changed drastically.

In 1902 the Oakland Channel was dredged to allow ship access between San Leandro Bay and the Oakland Harbor. By the mid-1970s the adjacent wetlands had been filled in by more than 96 percent (U.S. ACE, 1980). Sedimentation in San Leandro Bay also contributed to changes. Bathymetric and sedimentation studies have shown that San Leandro Bay is becoming progressively shallower. Sedimentation rates averaged 0.70 cm/yr between 1856 and 1984 (Nolan and Fuller, 1986), reducing water depths by up to 2.75 m in some areas since the early 1900's.

Contamination of sediments in San Leandro Bay by trace metals, PCBs, PAHs, and various synthetic biocides have been documented by several short term and continuing studies, including the Bay Protection and Toxic Cleanup Program (BPTCP) that listed it as a toxic hot spot (Hunt *et al.*, 1998). Recent analyses of 1997 BPTCP benthic community data suggest that several sites in San Leandro Bay have relatively impacted benthic assemblages (Lowe and Thompson, in preparation). Other local surveys and site assessments conducted in San Leandro Bay have contributed to a general understanding of the embayment (U.S. ACE, 1980; E.V.S., 1990; Uribe and Associates, 1993; SFBRWQCB, 1994).

Current and historical sources of contamination include metal plating, auto industries, lead manufacturing industries, storm water runoff, atmospheric deposition, and residential discharges. Transport of contaminants into the embayment can potentially occur via creek channels and/or tidal action from the Oakland Inner Harbor (Brown and Caldwell, 1979; see Figure 1). The relative contaminant contribution from these pathways, and the contaminant distribution within the sediments of San Leandro Bay are poorly understood.

To better understand the extent of sediment contamination within San Leandro Bay and its immediate tributaries, the objective of this study was to achieve the following:

1. Characterize the distribution of sediment contamination within San Leandro Bay in both surface sediments (top 5 cm) and at depth (up to ~1 meter).
2. Evaluate whether the contaminated sediments are relatively isolated areas amenable to cleanup, or large, dispersed areas where cleanup is unlikely to be feasible.
3. Investigate possible sources and pathways of sediment contamination by evaluating chemical signatures and identifying concentration gradients within the study area.
4. Investigate sediment contamination at various depths to identify possible sediment contamination "sinks".
5. Evaluate if sediment dating using radionuclide analyses can be used to determine if sediments at a contaminated site are erosional or depositional.

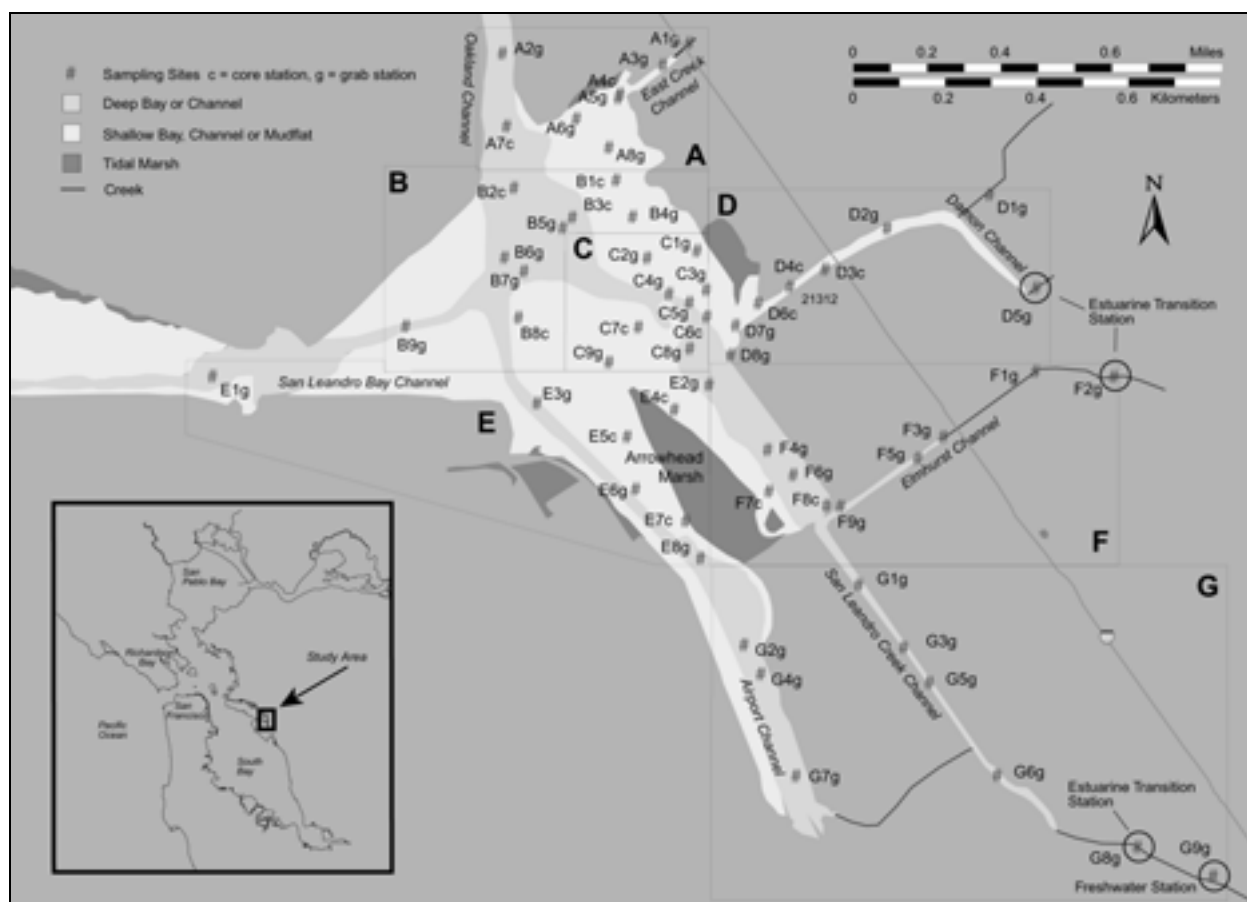


Figure 1. San Leandro Bay study area and sampling sites. Lower case letter indicates surface grab "g" or core "c" station. Sites were grouped by regions A - G for ease of organization. San Leandro Bay is bounded by the cities of Oakland to the east and south, and Alameda to the northwest and on both sides of San Leandro Bay Channel. The city of San Leandro begins at the far southeast corner. Oakland International Airport is adjacent to the Airport Channel. The map was generated from the SFEI Bay Area EcoAtlas (Goals Project, 1999). The habitat types shown are generalized from more detailed EcoAtlas habitat types in order to show deep/shallow embayment, shipping channel areas, and general wetland type.

To characterize the distribution of the sediment contamination, 60 sites were sampled for sediment in San Leandro Bay in August 1998. The sampling design included both grab and core sediment samples to characterize the depth of sediment contamination and to evaluate erosion. Creek channels were sampled at successive sites upstream to evaluate potential contaminant pathways. Chemical analyses were performed at all sites for 13 trace elements, 25 PAHs, 52 PCBs, and at a subset of sites for 24 pesticides, using similar analytical methods and QA procedures to the Regional Monitoring Program (RMP). Ancillary sediment quality analyses were performed at all sites to help characterize the sites and augment contaminant interpretation. A biomarker screening technique (the cytochrome P450 reporter gene system (RGS)) was also performed on all sediments to evaluate this less expensive analytical method for use as a screening tool for the presence of PAHs and dioxin-like compounds (coplanar PCBs, dioxins, and furans). Additional core samples were collected and radionuclide analysis was performed as a sediment-dating tool to help determine if the sediments were depositional or erosional and to evaluate the analytical method.

Sediment quality attributes (e.g. grain-size and total organic carbon (TOC)) can profoundly affect contaminant concentrations in sediment samples. Therefore, all sediment analyses included sediment analyses of grain-size and TOC. Finer sediments tend to naturally have higher contaminant concentrations because of surface-to-volume considerations (fine sediments have more exposed surfaces where contaminants can bind). Differences in the way that many contaminants adsorb and react with minerals and organic matter (organic carbon) also affect contaminant concentrations in sediment samples (Stumm and Morgan, 1981). Sediment grain size is a function of fluvial, wind, wave, and tidal energy. Therefore, coarser surface sediments were expected under erosional conditions and fine sediments were expected in depositional areas. It was also expected that erosional areas would not show an age gradient (using the radionuclide analysis method) whereas depositional sites would show increasing age with depth.

Although there currently are no regulatory criteria for evaluating sediment contaminants, several widely accepted local and national sediment quality guidelines exist and were used to evaluate contaminants in sediments in this study. The Effects Range Low and Effects Range Median (ERL and ERM, respectively) were developed as predictive tools for evaluating the potential of a sample to elicit toxic effects (Long *et al.*, 1998). Ambient Sediment Concentrations (ASCs) for the San Francisco Bay were developed in 1998 as a guide to what might be considered “background” contaminant levels for this highly urbanized estuary (Smith and Riege, 1998; Gandesbery, 1998). Pre-industrial, baseline trace metal concentrations for the San Francisco Bay have been determined from core samples (Hornberger *et al.*, 1999) and were also used to evaluate sediment samples in this study.

Methods

Sampling Design

The sampling design included both surface-grab and core sediment samples at a total of 60 sites (44 surface and 16 core samples) scattered throughout the 680 acres of San Leandro Bay. All samples were collected between August 15 and August 18, 1998. A stratified, random sampling design was chosen and as many sites as possible were sampled to provide sufficient coverage of the embayment. The aim of the study was to characterize the distribution of sediment contamination, and to gather samples from several creek channels and core samples for depth studies.

Sampling sites were determined with a grid overlaid on a USGS 1:24,000 scale quadrangle base map of the San Leandro Bay area using Arc View® Geographic Information System (GIS) software. The base map and grid were referenced to real world coordinates using GIS. Sample cells comprising the grid were 100 m², and were based on proximity to canal areas and mudflats. The grid resolution was approximately equal to the resolution of the initial Global Positioning System (GPS) navigation to the sites with no differential correction (i.e. satellite or benchmark corrected coordinates). Specific sampling sites within a grid cell were selected by hand plotting them on the base map. The GIS was used to identify their specific coordinates. A map of the selected sampling sites was produced for use in the field.

A Magellan NAV 5000 Global Positioning System (GPS) was used to navigate to within 100 m of each sampling site. Upon arriving at a site, differentially corrected GPS latitude and longitude coordinates, accurate to within 2 m of the actual location, were taken to document the exact location for future sampling efforts. The final map and graphics in this report were generated in ArcInfo® using these final, in-field, coordinates.

Sampling Equipment

Sediment samples were collected using either a 0.1m Young-modified van Veen grab sampling apparatus, polycarbonate plastic tubes 6 feet in length and 2 inches in diameter, or polycarbonate hand-held scoops. To avoid contamination of the sediment from the metal surface, a non-contaminating Kynar® coating covered the sample box and jaws, i.e., the parts in direct contact with the sediment. Regardless of the collection method used, each sediment sample was deposited in a 2 L polycarbonate plastic tub. The tub was covered with a Teflon® sheet, sealed with a polycarbonate

plastic lid, and stored on ice for transport back to Moss Landing Marine Laboratory. At the laboratory each sample was homogenized in its 2 L polycarbonate plastic container, using non-contaminating polycarbonate plastic stirring rods. This process was carried out in a positive pressure "clean" room to avoid sample contamination by airborne particles. Air supplied to the clean room was filtered. For subsequent analyses the bulk homogenized sample was subdivided. Samples were shipped in dry ice to the respective analytical laboratories by Moss Landing Marine Laboratory. Any unused sample material was maintained in a cold room at approximately 10°C.

Sampling Methods

Grab Samples

Forty-four surface grab samples were collected (Figure 1). Grab samples from a Boston Whaler were taken with the van Veen sampling apparatus noted above. The sampler was lowered to the Bay bottom from an armature extending off the side of the boat, via a winch and cable. After the sampler was raised and secured, the sample was carefully inspected to determine whether a set of acceptability criteria was met. If a sample did not meet all of the criteria, it was rejected and another sample was collected. The criteria were:

1. Grab sampler not over-filled (i.e., the sediment surface not pressed against the top of the grab).
2. Overlying water present, indicating minimal leakage.
3. Overlying water not excessively turbid, indicating minimal sample disturbance.
4. Sediment surface relatively flat, indicating minimal sample disturbance.
5. Sediment sample not washed-out due to an obstruction in the sampler jaws.
6. Desired penetration depth achieved (i.e., 10 cm).
7. Sample did not include excessive shell, organic, or man-made debris.

Sediment collection protocols from the van Veen grab followed those of the RMP (SFEI, 2000). For acceptable samples the top 5 cm of sediment was removed from the grab using a polycarbonate plastic scoop. Large stones (greater than approximately 2" in length), vegetation, or other miscellaneous debris not representative of the sediment was removed from the sample during the inspection. Such removals were noted on the field data sheet. Small rocks (less than 2" in length) and other small foreign material remained in the sample.

Core Samples

Sixteen core samples were collected (Figure 1). All core samples were taken from the Boston Whaler. Duplicate cores were taken at each site; one core was used for chemical analyses at varying depths, and the other core was used for sediment age determination by measuring radionuclides. Duplicate cores penetrated the sediment to within several inches of each other at all sites; the deeper core was used for sediment chemistry analyses.

In water less than 1.5 m in depth, the sampling device was pushed into the substrate by hand from the boat, using a pole with a cylindrical cup at one end which fit over the top of the sampling device. In water from 1.5 to approximately 2.5 m in depth, a diver using snorkel gear guided the device to the bottom and pushed it into the substrate. For the deepest channel sites, two divers using SCUBA gear took the device to the bottom and pushed it into the substrate. If the substrate was composed of high percentages of sand or gravel, a hammer was used to sink the apparatus into the sediment as deeply as possible. Once the device was sunk into the sediment, an airtight plastic cap was put over the top to create a vacuum when it was winched up. This reduced the likelihood of sediment material backsliding out of the device as it was taken to the surface. No losses occurred with any of the core samples. The same type of cap was placed on the bottom of the coring device immediately after it was taken into the boat to make an airtight seal.

The sediment cores were extruded from the sampling device using a polyethylene-covered plunger, which fit the internal diameter of the device. The top 5 cm of the core was discarded since it was usually distorted and/or compressed during the sampling procedure. The cores were sub-sampled by dividing them into 1 ft sections (except when the last section was less than 1 ft, in which case it was considered a single sample and the length recorded). The content of each section was extruded into a polycarbonate sample container, one section per container. The cores used for radionuclide samples were saved whole for transport to the analytical laboratory. At the laboratory they were cut into 4 cm segments, each segment comprising a single sample.

For sampling in canal areas too shallow for the Boston Whaler, sample collection gear and the GPS unit were carried by foot to the site, which was reached using landmarks from the hard copy map such as bridge overpasses and street intersections. Differentially corrected GPS latitude and longitude coordinates were taken at the sites. A polycarbonate plastic scoop was used to collect sample material from the canal sediment substrate and it was placed directly into the polycarbonate sample container.

Sample Handling and Treatment

All sampling equipment (i.e., containers, container liners, scoops, water collection bottles) was composed of pre-cleaned, non-contaminating materials which had been protectively packaged at Moss Landing Marine Laboratory prior to entering the field. The various analytical laboratories provided their own certified clean sampling containers. Only personnel wearing non-contaminating polyethylene gloves handled collection gear and samples.

All sample collection equipment not provided by the laboratories (excluding the sediment grab) was cleaned at the Moss Landing Marine Laboratory. The sediment grab was cleaned prior to entering the field and between sampling events by utilizing RMP sampling protocols (SFEI, 2000). First the sediment grab was scrubbed with seawater and then subjected to a vigorous Micro® detergent wash and scrub, followed by a seawater rinse. It was then rinsed with 10% HCl, and finally with methanol. The sediment grab was scrubbed with seawater between successive deployments at the same station to remove adhering sediments.

Laboratory Analysis Methods

Laboratory analytical methods were similar to those used by the RMP. Seventeen sites were not analyzed for organochlorine pesticides due to cost constraints. These sites were chosen on the basis of trace metal and PCB concentrations found at all sites, which were available before the pesticide analysis was performed. The analytical laboratories are listed on Appendix Table 1.

Sediment Quality and Salinity

Grain size was analyzed using the ASTM D422 protocol. Salinity was measured at each site using a temperature compensated refractometer (Leica, Inc.). Results are listed on Appendix Table 2.

Trace Element and Trace Organic Wet Chemistry

Trace metal samples were digested using EPA Method 3050B, a near total strong acid digestion method which dissolves almost all metals which could become biologically available, but is not designed to dissolve metals bound up in silicate structures as these are not usually mobile in the environment (EPA, 1996a). Thirteen metals (silver, aluminum, arsenic, cadmium, chromium, iron, manganese, nickel, lead, tin, selenium, and zinc) were analyzed using EPA Method 6010B, Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP). Mercury was analyzed using

EPA Method 7471A, manual cold vapor technique. Percent moisture was analyzed using EPA Method 160.3, and total organic carbon (TOC) using EPA Method 415.1. Trace element results are listed in Appendix Table 3.

EPA Method 3540C was used for organic contaminant sample extraction. Chlorinated pesticides were analyzed using EPA Method 8081A, and the polychlorinated biphenyls (PCBs) were analyzed using EPA Method 8082. Polycyclic aromatic hydrocarbons (PAHs) were analyzed using gas chromatography/mass spectrometry (GC-MS) in selected ion monitoring (SIM) mode (Denoux *et al.*, 1998). EPA Method 8070 was used for the P450 RGS biomarker screening process (APHA, 1996). Organic chemistry results are listed in Appendix Tables 4 – 6.

Cytochrome P450 Reporter Gene System (RGS)

In addition to wet chemistry analyses for trace organic contaminants, an additional analytical technique using the cytochrome P450 reporter gene system (RGS) biomarker was utilized. The Regional Water Quality Control Board wanted to evaluate the technique as a low cost screening tool. The P450 RGS can detect the presence or absence of dioxins, furans, coplanar PCBs, and high molecular weight PAHs. Although this technique is well established and has been used in a number of projects (Anderson *et al.*, 1995; Anderson and Jones, 1999), it had not been used in the San Francisco Bay Area. Using the relatively inexpensive P450 RGS analyses, large areas can be screened for the above-mentioned organic contaminants to locate potential hot spots where more focused, wet chemistry analyses could be implemented. The following is a brief overview of this method and was taken from APHA (1996) and Anderson and Jones (1999).

Cytochrome P450 enzymes play a key role in a number of biological reactions, including the metabolism of toxic chemicals. In mammalian cells the induction of the CYP1A1 gene within this group normally produces the enzyme P4501A1 in response to exposure to dioxins, furans, coplanar PCBs and high molecular weight PAHs. In the P450 RGS, a cell line was derived from the human liver cancer cell line HepG2, into which the P4501A1 gene modified with a firefly plasmid was integrated. This new cell line, called 101L, now produces an additional enzyme, the luminescent enzyme luciferase, when exposed to the same CYP1A1 inducing compounds. The luciferase activity can be quantified by a simple assay that measures relative light units with a luminometer. There is a concentration-response relationship between luciferase and dioxins, five coplanar PCBs, and eight high molecular weight PAHs. Cytochrome P450 RGS can be used to distinguish between the PAHs and chlorinated compounds (PCBs, dioxins, and furans) by the ratio of the response at 6 hours (when

the peak response to the PAHs occurs) and 16 hours (when the peak response to the chlorinated compounds occurs).

All P450 RGS samples in this study were analyzed at 6 hours (when the peak response to the PAHs occurs), and a subset of 10 samples was analyzed at 16 hours (when the peak response to the chlorinated compounds occurs). Results of the P450 RGS analyses are expressed as benzo(a)pyrene (B[a]P) and dioxin equivalents (B(a)Peq and TEQ respectively (see Appendix Table 7).

Quality Assurance/Quality Control

All sediment analyses data from the analytical laboratories were generated under detailed quality assurance/quality control (QA/QC) scrutiny. A cover letter transmitting the data report and actual tabulated results was submitted by the laboratories, and included information on how QA/QC samples and field samples were associated, reported units, all collection and analysis dates, wet/dry sample weights and units, and a description of the procedures and instrumentation used. Information consisted of the type and frequency of QA sample runs, sample size extracted (in general), method detection limits (MDLs), indication of whether the data were adjusted (e.g., blank or recovery corrected), the compounds associated with each surrogate, a list of any samples not analyzed, a list of definitions used for qualifying the results, and indication as to whether qualified results included uncensored results or not. All data from sediment analyses were reported in mg/kg dry weight for trace elements and µg/kg dry weight for trace organics. All information was submitted in both hard copy and electronic format (i.e., word processing and spreadsheet).

For metals, several of the laboratory batches had recoveries lower than the data quality objectives (DQO), however the standard reference material (SRM), lab control sample (LCS), and relative percent difference (RPD) results were all within DQOs. In one batch (20 samples) for silver, the SRM recovery was below DQOs but LCS and RPD results were within limits. Recoveries of naphthalene and biphenyl from the SRM in one batch (20 samples) were outside of DQOs, and so should be considered estimates. Similarly for PCBs, the SRM recovery of PCBs 18 and 87 in one batch were outside of control estimates, and so should be considered estimates. However, all PAH and PCB samples were within DQOs for laboratory spike and surrogate recoveries. See Appendix Tables 8 & 9 for QA/QC summaries.

Data Analysis Methods

The general distribution of contaminants within the San Leandro Bay was evaluated by creating histograms for the sediment quality and contaminant results for each site, and by plotting the results on maps. Sediment quality guidelines were used to evaluate the severity of sediment contamination. Multivariate analyses were performed to investigate potential contaminant pathways and sources.

Sediment Quality Guidelines and Other Reference Concentrations

Although there are currently no regulatory guidelines for sediment contaminant concentrations in the Estuary, there are a number of sediment quality guidelines that may be used as informal screening tools for sediment contaminant concentrations. Several types of sediment guidelines were used to evaluate San Leandro Bay data (Table 1).

Sediment quality guidelines developed by Long *et al.* (1995) are based on data compiled from numerous studies in the United States that included sediment contaminant and biological effects information. The guidelines were developed to identify concentrations of contaminants that were associated with biological effects in laboratory, field, or modeling studies. The effects range-low (ERL) value is the concentration equivalent to the lower 10th percentile of the compiled study data, and the effects range-median (ERM) is the concentration equivalent to the 50th percentile of the compiled study data. Sediment concentrations below the ERL are interpreted as being “rarely” associated with adverse effects. Concentrations between the ERL and ERM are “occasionally” associated with adverse effects, and concentrations above the ERM are “frequently” associated with adverse effects. The chlordane sediment quality guidelines are from Long and Morgan (1990). There are no ERL/ERM guidelines for selenium. ERMs have been used to develop a mean ERM quotient (mERMq) which has been shown to be another useful predictor of cumulative toxic effect, using local San Francisco Bay specific studies (Thompson *et al.*, 1999).

Table 1. Guidelines to evaluate chemical concentrations in sediment (in dry weight).**Effects Range-Low (ERL) and Effects Range-Median (ERM) values from Long et al., 1995**

Effects Range-Low; values between this and the ERM are in the possible effects range.

Effects Range-Median; values above this are in the probable effects range.

San Francisco Bay Ambient Sediment Criteria (ASC). Smith et al., 1998

Ambient sediment levels from background sediments in the Estuary allows one to assess whether a site has elevated levels or is "degraded"

Baseline sediment concentrations for selected trace elements in the SF Bay, from Hornberger et al., 1999

Chromium and Nickel ranges were seen throughout the core. All TEs, except Ag, measured by ICAPES. Ag measured by GFAAS.

Parameter	unit	ERL	ERM	ASC-sandy <40% fines	ASC-muddy >40% fines	Baseline Concentrations (Bay wide ranges)	
						Total	Near Total
Arsenic	mg/Kg	8.2	70	13.5	15.3	.	.
Cadmium	mg/Kg	1.2	9.6	0.25	0.33	.	.
Chromium	mg/Kg	81	370	91.4	112	110-170	70-120
Copper	mg/Kg	34	270	31.7	68.1	20 - 55	20 - 41
Mercury	mg/Kg	0.15	0.71	0.25	0.43	.	0.05 - 0.05
Nickel	mg/Kg	20.9	51.6	92.9	112	70-100	50-100
Lead	mg/Kg	46.7	218	20.3	43.2	20 - 40	10 - 20
Selenium	mg/Kg			0.59	0.64		
Silver	mg/Kg	1	3.7	0.31	0.58	0.1 - 0.1	0.1 - 0.1
Zinc	mg/Kg	150	410	97.8	158	60 - 70	50 - 100
Total HPAHs (SFEI)	µg/Kg	1700	9600	256	3060		
Fluoranthene	µg/Kg	600	5100	78.7	514		
Perylene	µg/Kg			24	145		
Pyrene	µg/Kg	665	2600	64.6	665		
Benz(a)anthracene	µg/Kg	261	1600	15.9	244		
Chrysene	µg/Kg	384	2800	19.4	289		
Benzo(b)fluoranthene	µg/Kg			32.1	371		
Benzo(k)fluoranthene	µg/Kg			29.2	258		
Benzo(a)pyrene	µg/Kg	430	1600	18.1	412		
Benzo(e)pyrene	µg/Kg			17.3	294		
Dibenz(a,h)anthracene	µg/Kg	63.4	260	3	32.7		
Benzo(g,h,i)perylene	µg/Kg			22.9	310		
Indeno(1,2,3-c,d)pyrene	µg/Kg			19	382		
Total LPAHs (SFEI)	µg/Kg	552	3160	37.9	434		
1-Methylnaphthalene	µg/Kg			6.8	12.1		
1-Methylphenanthrene	µg/Kg			4.5	31.7		
2,3,5-Trimethylnaphthalene	µg/Kg			3.3	9.8		
2,6,-Dimethylnaphthalene	µg/Kg			5	12.1		
2-Methylnaphthalene	µg/Kg	70	670	9.4	19.4		
Naphthalene	µg/Kg	160	2100	8.8	55.8		
Acenaphthylene	µg/Kg	44	640	2.2	31.7		
Acenaphthene	µg/Kg	16	500	11.3	26.6		
Fluorene	µg/Kg	19	540	4	25.3		
Phenanthrene	µg/Kg	240	1500	17.8	237		
Anthracene	µg/Kg	85.3	1100	9.3	88		
Total PAHs (SFEI)		4022	44792	211	3390		
p,p'-DDE	µg/Kg	2.2	27				
Total DDTs (SFEI)	µg/Kg	1.58	46.1	1.58	46.1		
Total Chlordanes (SFEI)	µg/Kg	0.5	6	0.42	1.1		
Dieldrin	µg/Kg	0.02	8	0.18	0.44		
TOTAL PCBs (NIST 18)	µg/Kg			5.9	14.8		
Total PCBs (SFEI)	µg/Kg	22.7	180	8.6	21.6		

The mERMq is calculated by taking each of 9 trace metals (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) and 4 organics values (total low-molecular-weight PAHs, total high-molecular-weight PAHs, total PCBs, and total DDTs) and dividing them each by the ERM guideline value (Table 1), summing these together, and then dividing by the total number of contaminants measured:

$$\text{mERMq} = \frac{\sum [\text{contaminant}] / \text{ERM}}{\text{Number of contaminants}}$$

Based on RMP and BPTCP data, sediment samples with mERMq values above 0.5 have an 82% probability of being toxic in a ten-day amphipod survival bioassay (SFEI, unpublished). mERMq values above 1.0 show a 92% probability of being toxic.

Ambient sediment quality guidelines for the San Francisco Bay have been developed by the San Francisco Bay Regional Water Quality Control Board (Table 1). The Ambient Sediment concentrations (ASC) are based on the 85th percentile of reference (or ambient) Bay concentrations (Smith and Riege, 1998). Concentrations above the ASC are considered elevated. Pre-anthropogenic (baseline) sediment concentrations were determined by Hornberger *et al.* (1999) for the following metals—silver: 0.09 +/- 0.02 µg/g; mercury: 0.06 +/- 0.01 µg/g; lead: 5.2 +/- 0.7 µg/g; and copper, with the widest range: 16–55 µg/g.

Multivariate Analyses

Principal component analysis (PCA) was conducted to examine patterns of contaminant distributions and covariance. PCBs, PAHs, and some trace elements were evaluated using samples that had detectable contaminant levels (values above the method detection limit (MDL)) as a way to investigate potential contaminant sources and pathways. The PCAs were expected to show patterns in contaminant ratios, which would indicate if sediments were being mixed or not. For example, if sediment resuspension and deposition was the process most responsible for the PCB contamination in San Leandro Bay, one would expect the ratio of the various PCB congeners to vary uniformly among the samples (concentrations would be similar in both the creek channels and in the open waters of San Leandro Bay). If PCBs were being transported into the embayment through the creek channels, one might expect to find consistent PCB congener ratios within one or more creek channels that could indicate a pathway of a specific set of congeners, which might be different from congener ratios in the open waters of San Leandro Bay itself.

It was anticipated that the PCA would also help to group samples based on similarities in PCB congener ratios and thus help to characterize the original industrial use of the PCB

contamination. Various Aroclors (mixtures of PCB congeners) were historically manufactured for specific industrial uses as they had different physical properties. For example, Aroclors 1254 and 1260 were manufactured and used in electrical capacitors and transformers and other industrial applications (Brinkman and de Kok, 1980).

Regression analyses were performed to evaluate covariance among contaminants, grain-size and TOC. If contaminants varied with grain-size or TOC, then the trace element data might need to be normalized to these parameters in order to see true contaminant gradients within the sampling area. Regression analyses were also performed for contaminant results from the P450 RGS and the organic wet chemistry to examine how well the two analytical methods compared. Regression analysis between contaminants (e.g., PCBs and PAHs) indicated whether the contaminants had similar spatial distributions or similar relationships to other parameters.

Data Management

All statistical analyses were performed using SAS software (SAS Institute, 1990). Data were stored and managed within a Microsoft Access® relational database.

Results and Discussion

Sample Collection

A number of core samples were only partially captured because the substrate at depths below 1 foot at a number of the sites was too compacted and could not be penetrated with the sampling equipment. Therefore most of the cores did not reach the target depth of three feet. Of the sixteen core samples taken, only three could be pushed into the third foot of substrate (B2c, B8c, C7c), eight cores reached the second foot level (B1c, B3c, D3c, D6c, E4c, E5c, E7c, F7c), and five cores penetrated the first foot of substrate only (A4c, A7c, C6c, D4c, F8c).

Sediment Quality and Salinity

Most of the surface samples in the open water channels (Oakland Channel, San Leandro Bay Channel, Airport Channel, and San Leandro Creek Channel) consisted mostly of fine sediments (grain-size $< 74 \mu\text{m}$), with the exception of the Oakland Channel sediments, which were coarser than other channels (Figure 2c). Samples from the upper portions of the creek channels (East Creek, Damon, Elmhurst, and the upper portions of San Leandro Creek Channels), consisted of sandier sediments, with the exception of site G9g on San Leandro Creek. This site was located farthest up the watershed, and consisted of a high percentage of fine sediments. The Creek at this point was a concrete channel with deposited sediment partially covering the surface.

The pattern of sandier sediments found at upstream sites and fine sediments found at the mouths of creek channels suggests that fine sediments are transported from the upper portions of the creek channels into the mouths of the channels. This movement of fine sediments may occur during high flow periods or may be a result of tidal action. This study was not able to determine the mechanisms by which the sediments may be transported down stream. The only freshwater station, G9g, contained primarily fine sediments. Since it was above the tidal prism, this suggests that tidal action could aid in the transport of fine sediments into the San Leandro Bay. To support this hypothesis, one would need to sample above the tidal prism of all the creek channels to see if those samples also consisted of mostly fine sediments.

Sites D5g, F2g, and G8g had salinities of 5 ppt or less and may be considered estuarine stations. All the other sites had salinities ranging from 7 – 26 ppt. Site E1g served as a representative sample for the San Leandro Bay channel, west of the Doolittle Drive Bridge.

Sediment Contamination

Contaminant concentration histograms for surface sampling sites are shown in Figures 3a-h, with ERL and ERM levels shown on the charts where applicable. Maps showing contaminant distributions and concentration ranges for surface samples are shown in Figures 2a-e. Histograms of contaminant concentrations at increasing depth for the core sample results are shown in Figures 4a-d. Table 2 summarizes the results of the ERL-ERM and the ASC guideline evaluation, and lists the calculated mERMq for each sample.

Surface sediment site G2g was not analyzed for PAHs and sites G7g and G9g were not analyzed for PCBs, due to low percent solids in the samples. As mentioned above, the core samples penetrated to variable depths, so chemistry results at all depths are not available.

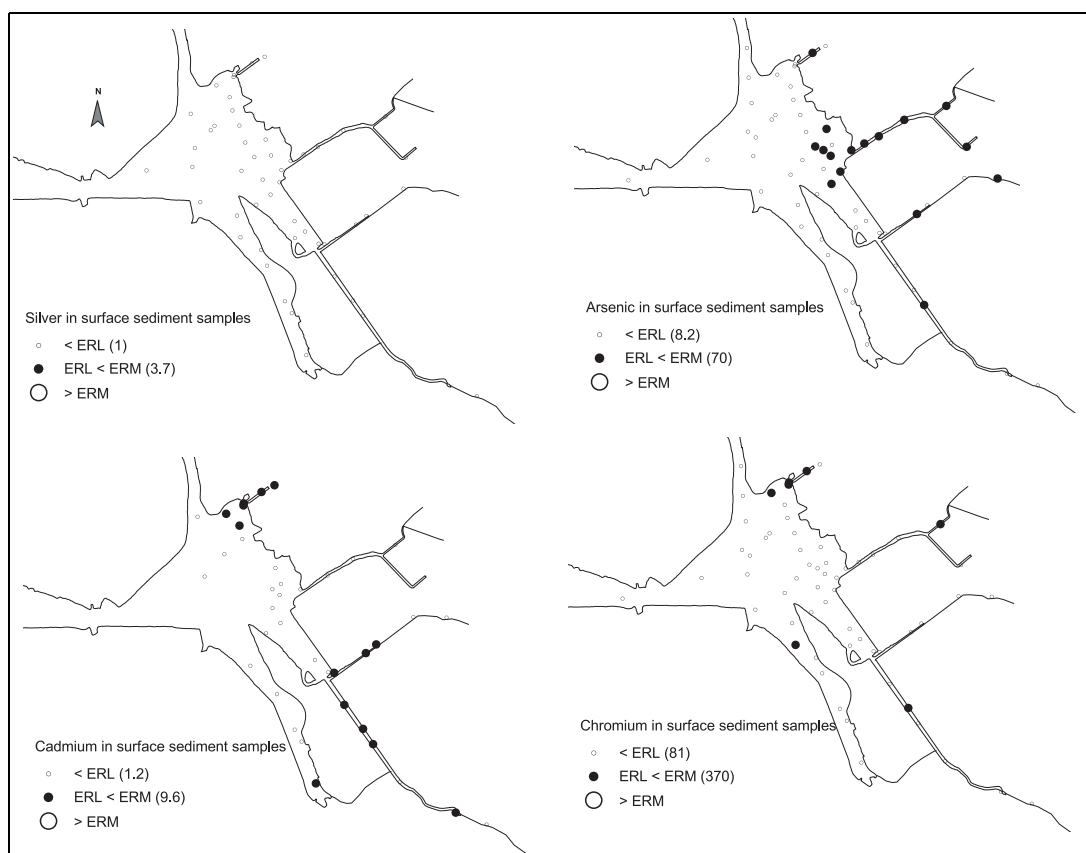


Figure 2a. Concentration distributions for the San Leandro Bay project study area. Concentration ranges are based on Long, et. al. (1995) sediment quality guidelines. Trace elements are in mg/Kg dry weight.

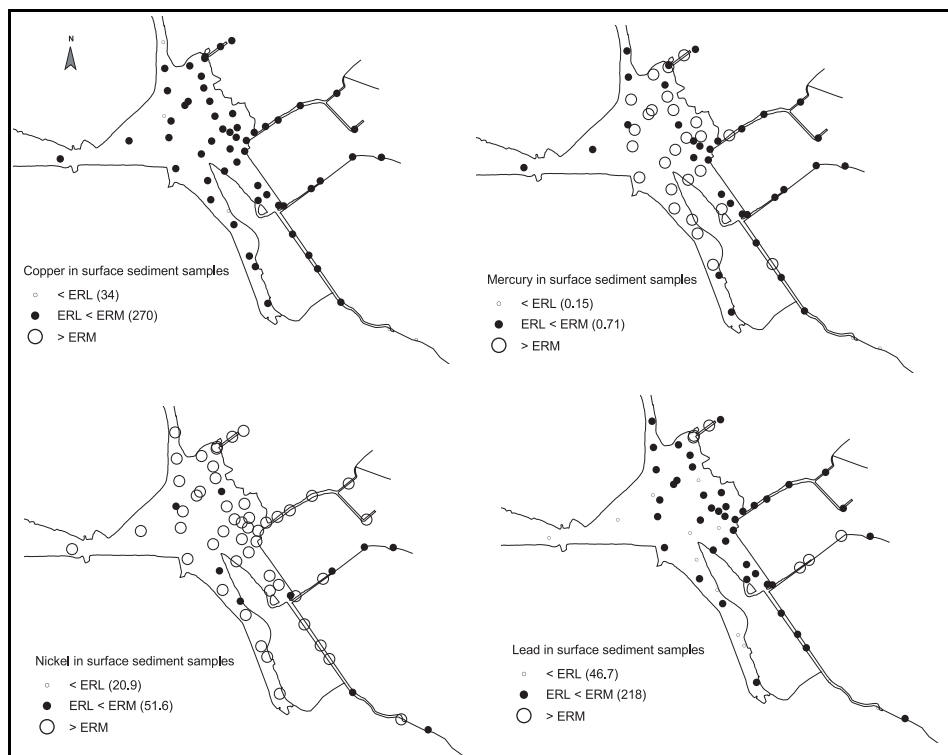


Figure 2b. Concentration distributions for the San Leandro Bay project study area. Concentration ranges are based on Long, et. al. (1995) sediment quality guidelines. Trace elements are in mg/Kg dry weight.

Guideline Evaluation (Surface Sediments)

Trace element contamination exceeded sediment quality guidelines in many samples (Table 2). The numbers of ERL exceedances in a total of 60 surface samples were as follows: arsenic (16), cadmium (14), chromium (7), copper (55), mercury (58), nickel (60), lead (48), silver (0), and zinc (42). The number of PAH exceedances in 59 samples were as follows: LPAHs (11), HPAHs (25), and total PAHs (13). There were 39 out of 58 PCB samples that exceeded ERL guidelines. The number of ERL exceedances for DDTs was 46 of 56 surface samples, and for chlordanes 28 of 56 surface samples. The numbers of ERM exceedances were as follows: mercury (26), nickel (50), lead (6), zinc (6), HPAHs (3), PCBs (9), DDTs (22), and chlordanes (27).

Trace metals were generally found to be somewhat elevated over a widespread distribution. Copper, nickel, mercury, lead, and zinc concentrations were above the ERL in most surface samples throughout the study area. However, copper concentrations did not exceed the ERM. Nickel exceeded both the ERL and ERM at most sites, although it should be mentioned that the Bay Area's geology is such that much of the sediments in the estuary are naturally high in nickel and the RMP Status and Trends sites show similar, elevated levels of nickel (SFEI, 2000). Lead and zinc exceeded

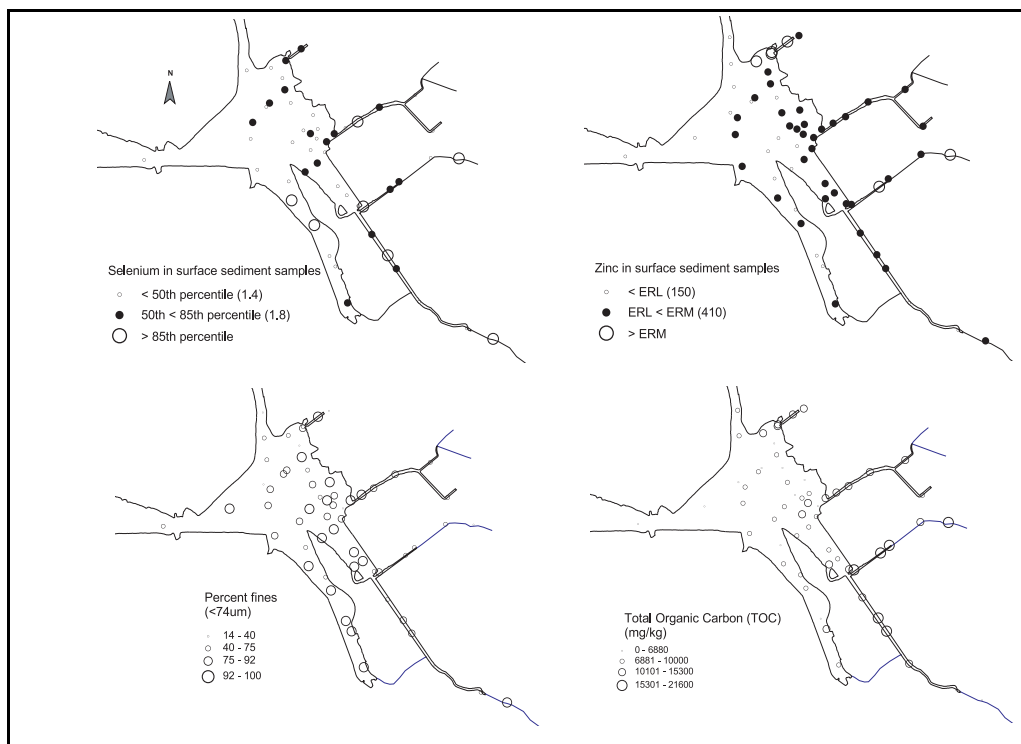


Figure 2c. Concentration distributions for the San Leandro Bay project study area. Concentration ranges are based on Long, et. al. (1995) sediment quality guidelines. Trace elements are in mg/Kg dry weight.

the ERM in East Creek and Elmhurst Creek channels. There are no ERL or ERM guidelines for selenium.

Total PAHs exceeded the ERL at 13 sites, including the mouth of East Creek Channel and all sites in Elmhurst Creek Channel. None of the surface samples were above the ERM guideline for total PAHs. Three sites in Elmhurst Creek Channel (F3g, F5g and F9g) had the highest *surface* concentrations of total HPAHs in the study and were above the ERM guideline. Total PCB concentrations in surface sediments were above the ERL at most of the sites in the study, and above the ERM at one site in Damon Channel (D5g), and at many sites of the East Creek (A1g, A4c, A5g, A6g) and Elmhurst Creek (F1g, F3g, F5g, F9g) channels. Total DDTs exceeded the ERL at all but 10 of the sites sampled. Total DDTs exceeded the ERM in all of the East Creek and Elmhurst Channel surface samples, and in three surface samples within both Damon (D3cz0, D4cz0, D5g) and San Leandro Creek Channels (G1g, G3g, G5g). Total DDTs were also above the ERM at several open water sites along the eastern side of San Leandro Bay (A8g, B1zc0, C1g, C6cz0), and at increasingly higher concentrations in the second and third foot depths of the deep channel site B2c (286 and 426 $\mu\text{g/Kg}$ respectively), and the first foot depth at site C6c (401 $\mu\text{g/Kg}$). Core samples from the creek

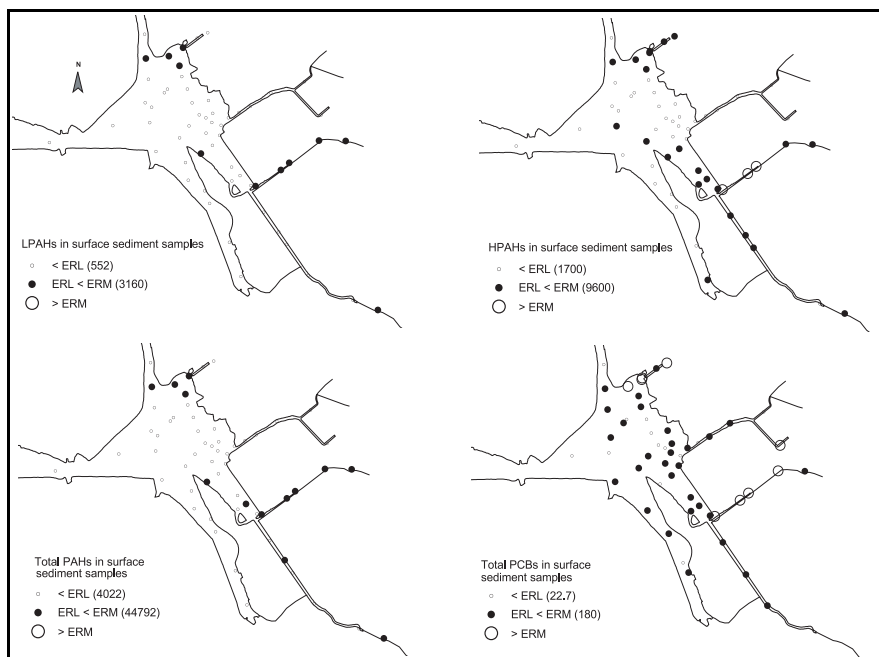


Figure 2d. Concentration distributions for the San Leandro Bay project study area. Concentration ranges are based on Long, et. al. (1995) sediment quality guidelines. Units are in $\mu\text{g/Kg}$ dry weight.

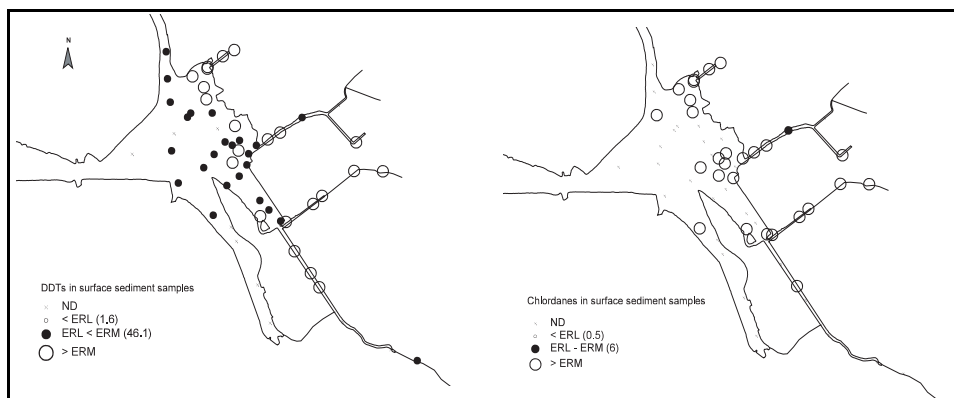


Figure 2e. Concentration distributions for the San Leandro Bay project study area. Concentration ranges are based on Long, et. al. (1995) sediment quality guidelines. Units are in $\mu\text{g/Kg}$ dry weight.

channels also showed an increase in DDT concentrations with depth with a subsurface sample at site A4c having the highest concentration of total DDTs (see below). Total chlordanes exceeded the ERM at all East Creek, Damon, and Elmhurst Channel sites except two, although most open water stations were below detection limits. Dieldrin was detected at only four sites throughout the sample area, all surface samples; however all concentrations exceeded the ERM of 8 ppb. Chlorpyrifos likewise was found at four surface sites localized at or near Elmhurst Channel. There are no sediment quality guidelines for chlorpyrifos.

The numbers of ASC exceedances in a total of 60 surface samples were as follows: cadmium (36), copper (27), mercury (49), nickel (3), lead (52), selenium (51), and zinc (44). The number of exceedances in 59 PAH samples were as follows: LPAHs (16), HPAHs (18), and total PAHs (18). There were 39 out of 52 PCB surface samples that exceeded ASC guidelines. The ASC guidelines for total DDTs are the same as the ERM for > 40% fines and the ERL for <40% fines.

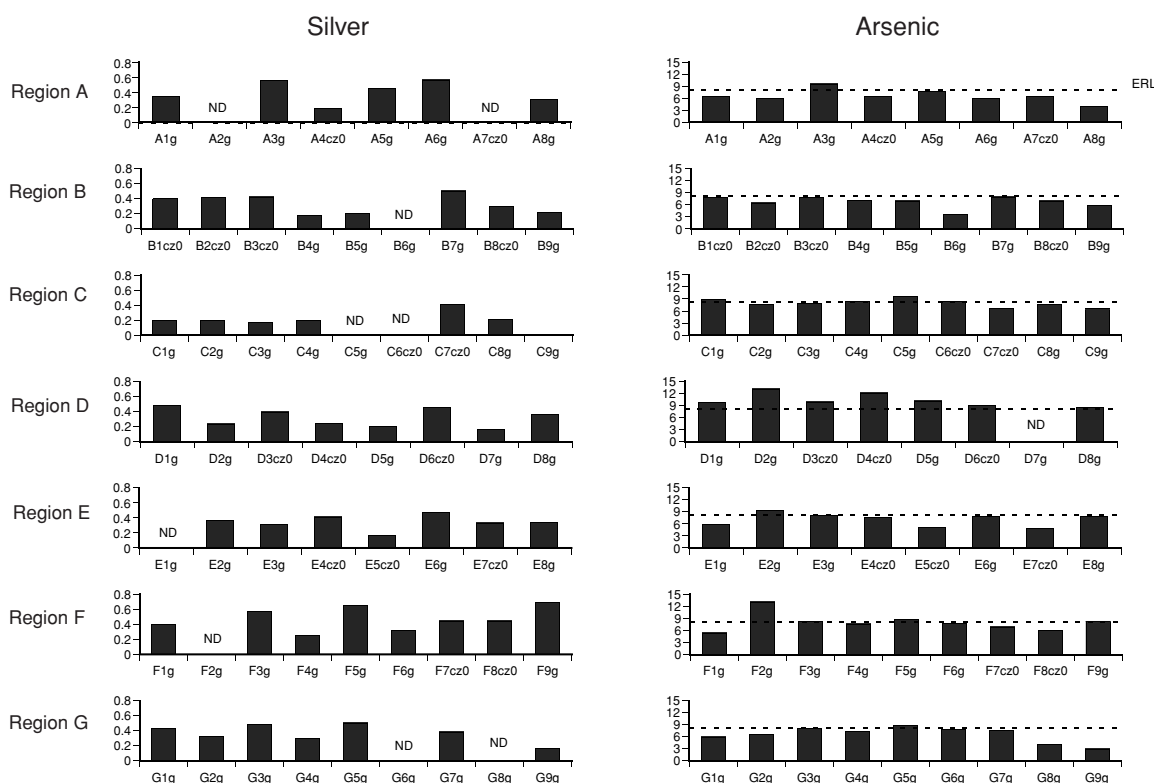


Figure 3a. Concentrations of silver and arsenic in sediment grab samples. All units are in parts per million (ppm) dry weight. All values for silver were below the Effects Range Low (ERL) sediment quality guideline of 1 ppm. The ERL for arsenic, shown by the dotted line, is 8.2 ppm. Samples are grouped by the regions shown in Figure 1. Values below the detection limit are indicated by "ND". ASC values for silver are 0.31 ppm (<40% fines) and 0.58 (>40% fines). ASC values for arsenic are 13.5 ppm (<40% fines) and 15.3 ppm (>40% fines).

Guideline Evaluation (Sub-surface Core Sediments)

All of the cores that had sub-surface samples of greater than 1 foot showed variable concentration gradients over depth for one or more of the contaminants. Site B2c, a deep channel site in the southern part of the Oakland Channel, contained higher concentrations at sub surface levels for all contaminants measured. The only exceedances of the ERL values for silver found in this study occurred at the second and third foot depths of this site. Contaminant concentrations increased to the two-foot depth interval and decreased at the three-foot interval for silver, arsenic, cadmium, lead

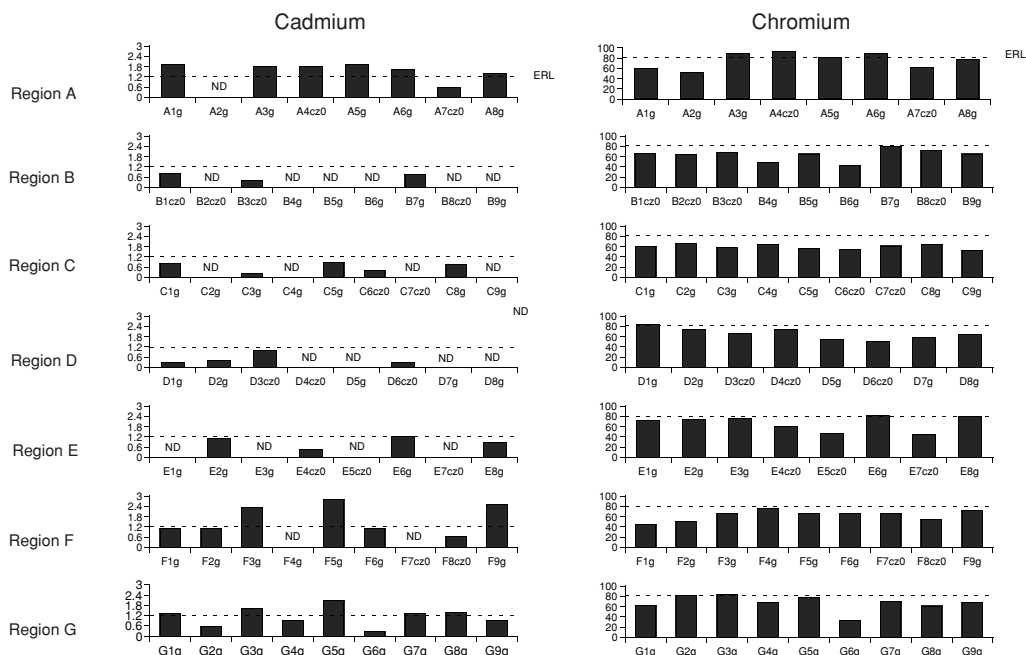


Figure 3b. Concentrations of cadmium and chromium in sediment grab samples. All units are in parts per million (ppm) dry weight. Effects Range Low (ERL) sediment quality guidelines are represented by the dotted lines. The ERL is 1.2 for cadmium and 81 for chromium. Samples are grouped by the regions shown in Figure 1. Values below the detection limit are indicated by "ND". ASC values for cadmium are 0.25 ppm (<40% fines) and 0.33 (>40% fines). ASC values for chromium are 91.4 ppm (<40% fines) and 112 (>40% fines).

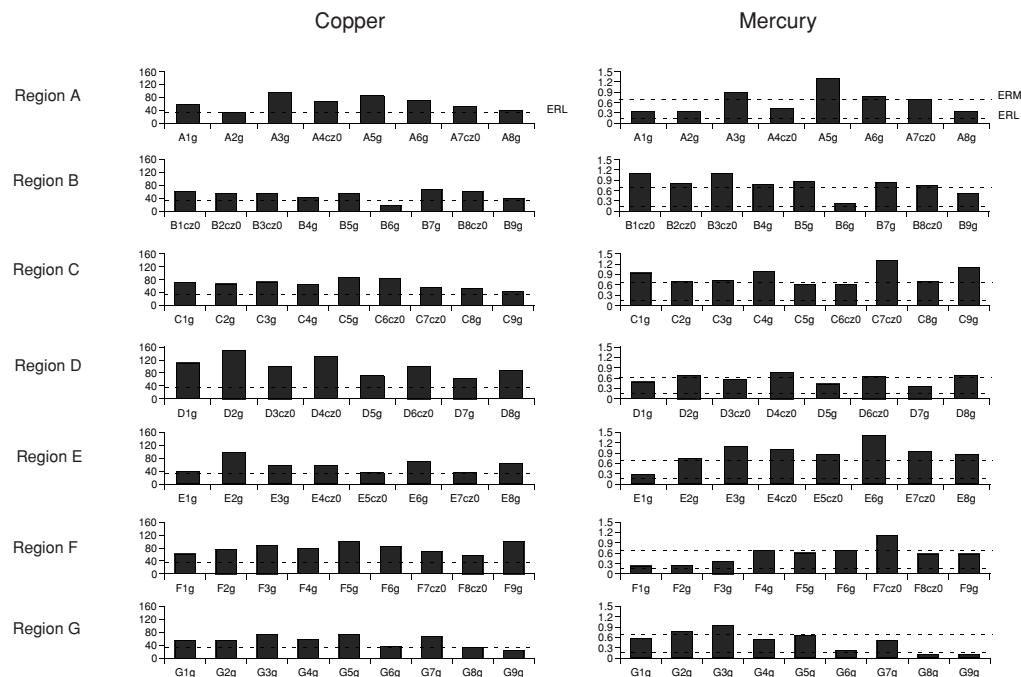


Figure 3c. Concentrations of copper and mercury in sediment grab samples. All units are in parts per million (ppm) dry weight. Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality guidelines are represented by the dotted lines. The ERL is 34 for copper and 0.15 for mercury. The ERM is 0.71 for mercury. None of the copper concentrations exceeded the ERM value of 270 ppm. Samples are grouped by the regions shown in Figure 1. ASC values for copper are 31.7 (<40% fines) and 68.1 (>40% fines). ASC values for mercury are 0.25 (<40% fines) and 0.43 (>40% fines).

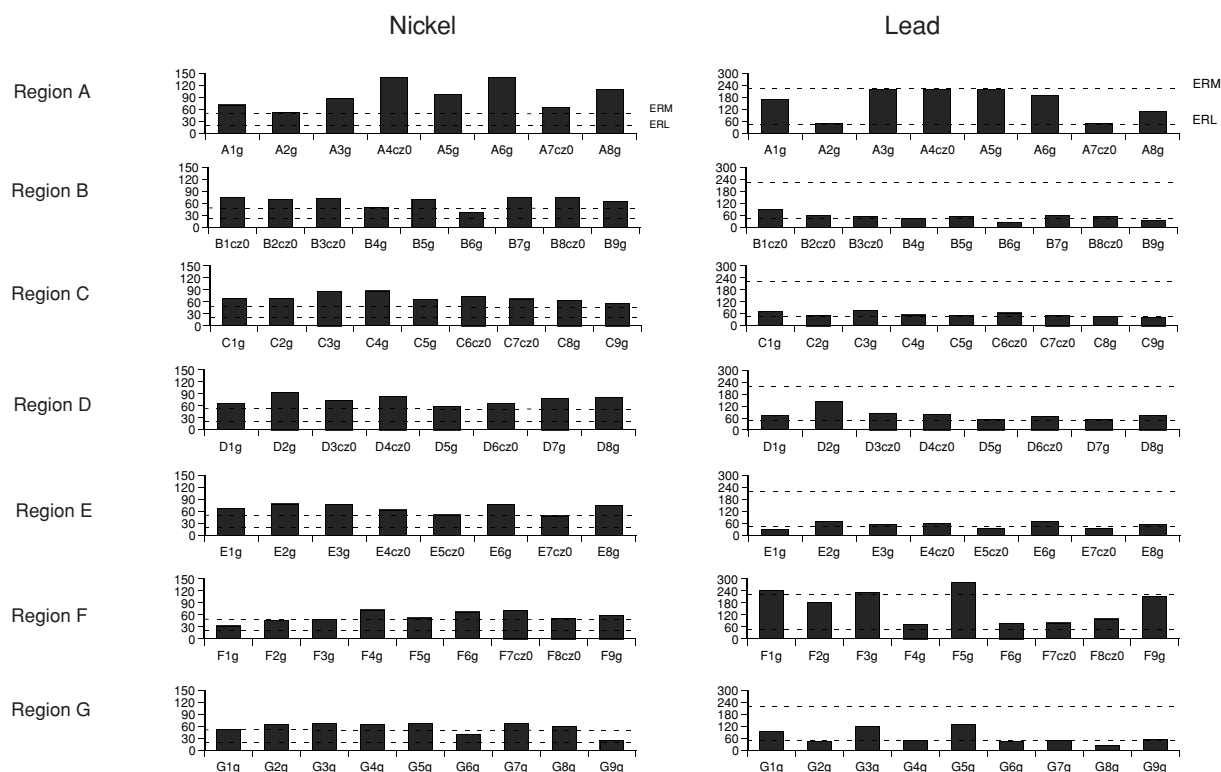


Figure 3d. Concentrations of nickel and lead in sediment grab samples. All units are in parts per million (ppm) dry weight. Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality guidelines are represented by the dotted lines. The ERL is 20.9 for nickel and 46.7 for lead. The ERM is 51.6 for nickel and 218 for lead. Samples are grouped by the regions shown in Figure 1. ASC values for nickel are 92.9 ppm (<40% fines) and 112 (>40% fines). ASC values for arsenic are 20.3 ppm (<40% fines) and 43.2 ppm (>40% fines).

(slight), mercury, zinc (slight), and total PAHs at this site. This suggests a discernible pollutant “lens” for these contaminants. Mercury levels in the two and three foot interval samples were extremely high (11 and 7 mg/Kg respectively), the highest concentration in the entire study, and more than 15 fold above the ERM (0.71 mg/Kg). Constant concentrations between the second and third foot depth intervals were seen for arsenic, chromium, copper, and selenium. Increasing concentrations between the second and third foot intervals were seen for nickel, total DDTs, total chlordanes, and total PCBs, all of which were above the ERM guidelines. Total PCB concentrations (2645 µg/Kg) in the deepest core interval (three foot), at B2c were more than 50% higher than B8c, and were the highest in the study. A deeper core sample would be needed to measure the extent of those contaminant gradients.

Site B8c located in the open waters of San Leandro Bay, on a shallow shoal near the junction of the San Leandro Bay channel and Airport Channel, showed increasing contamination with depth similar to site B2c though trace element concentrations were not as high. Trace element analyses at the three-foot depth were not evaluated due to insufficient sample material, so it could not be

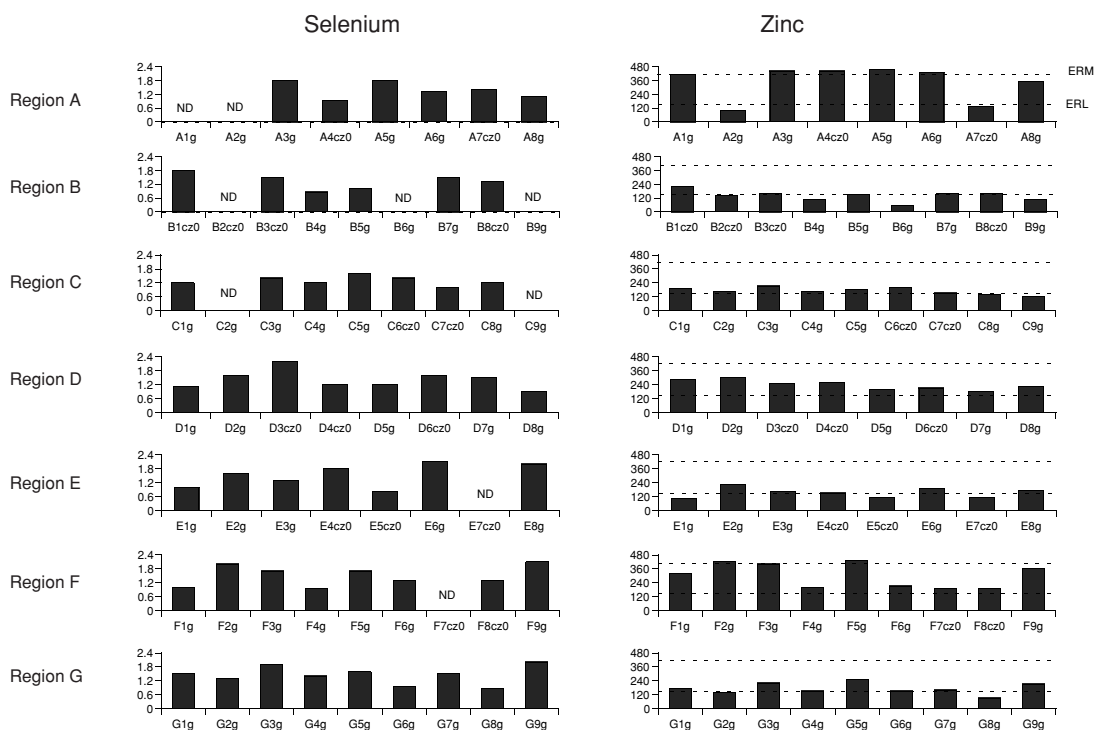


Figure 3e. Concentrations of selenium and zinc in sediment grab samples. All units are in parts per million (ppm) dry weight. Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality guidelines are represented by the dotted lines. For zinc the ERL is 150 ppm and the ERM is 410 ppm. There are no ERL or ERM guidelines for selenium. Samples are grouped by the regions shown in Figure 1. Values below the detection limit are indicated by "ND". ASC values for selenium are 0.59 ppm (<40% fines) and 0.64 (>40% fines). ASC values for zinc are 97.8 ppm (<40% fines) and 158 ppm (>40% fines).

determined if trace element contamination showed a similar pollutant ‘lens’. Mercury concentrations were well above the ERM, reaching 3.9 mg/Kg in the second foot interval. Total organic compounds were measured through the three-foot interval at this site. Total PAHs (12592 $\mu\text{g/Kg}$) and total PCBs (1716 $\mu\text{g/Kg}$) were five and seven times higher in sample B8cz3 than sample B8cz2. Total HPAHs were above the ERM guideline, and the highest *subsurface* concentration of total PAHs in the study was measured in the three-foot interval.

Sites A4c in East Creek Channel and F8c in Elmhurst Creek Channel showed increases between the surface and first foot levels for a number of contaminants. However, these cores were only penetrated through the first foot interval. Deeper core depths would be needed to measure the extent of the contaminated sediment gradients at those sites. A4cz1 had the highest measured subsurface core concentrations of Cd, Cr, Ni, Pb and total DDTs in this study. Ni, Pb, Zn, total DDTs, and total PCBs were above the ERM guideline values in both surface and subsurface samples at this site. Total DDTs (1040 $\mu\text{g/Kg}$) in first foot interval at this site were the highest measured in the study, and were fifteen times higher than the study average (omitting B2cz3 and C6cz1 where

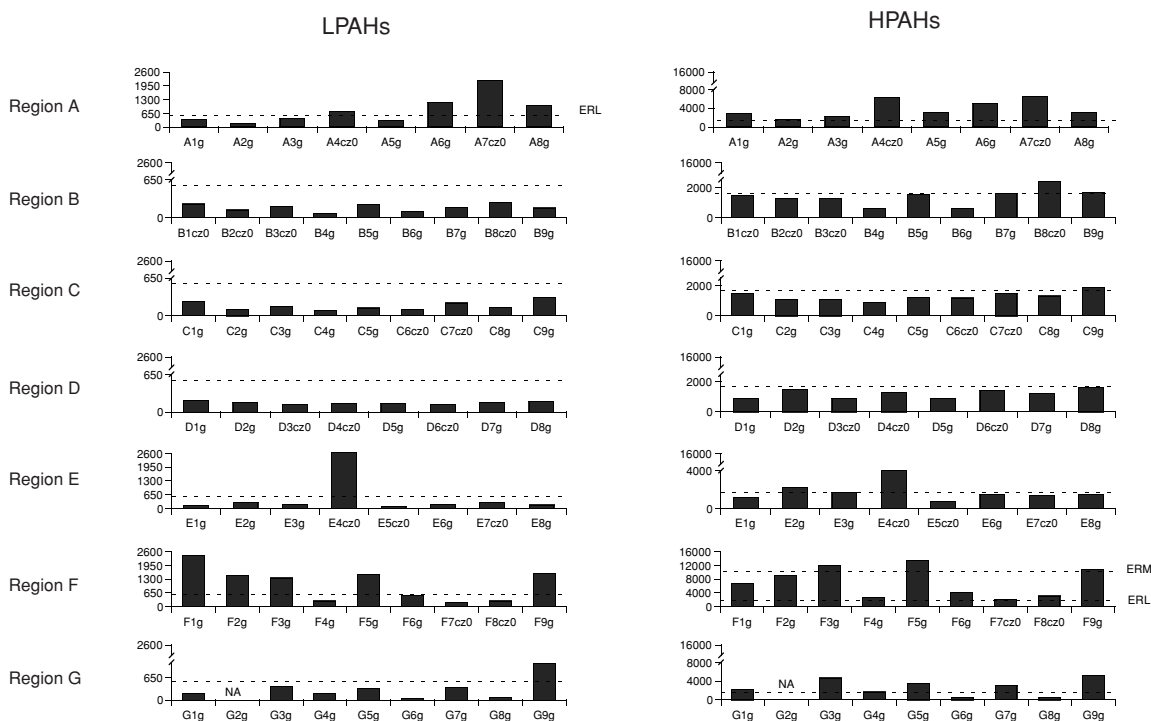


Figure 3f. Concentrations of LPAHs and HPAHs in sediment grab samples. All units are in parts per billion (ppb) dry weight. Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality guidelines are represented by the dotted lines. For LPAHs the ERL is 552 ppb. No LPAH values exceeded the ERM value of 3160 ppb. For HPAHs the ERL is 1700 ppb and the ERM is 9600 ppb. Samples are grouped by the regions shown in Figure 1. Stations not analyzed are indicated by "NA". ASC values for LPAHs are 37.9 ppm (<40% fines) and 434 (>40% fines). ASC values for HPAHs are 256 ppm (<40% fines) and 3060 ppm (>40% fines).

concentrations were above 400 µg/Kg). Total DDTs concentrations above the ERM guideline value were also found in two of three subsurface core samples in Damon Creek Channel (D3cz and D4cz). D3cz2 and D4cz1 had concentrations reaching above 200 µg/Kg. The second foot interval of sites D6c and E5c were not analyzed due to insufficient sample material in the core sections for analysis of the entire suite of parameters.

Based on the Hornberger *et al.* (1998) baseline sediment concentrations for trace elements, (pre-anthropogenic concentrations), silver concentrations in core samples B1c, B3c, C6c, C7c, D4c, E4c, E5c, E7c, and F7c were at baseline levels of 0.09 +/- 0.02 µg/g at the one-foot depth range or deeper. Mercury concentrations in cores B1c, B3c, C7c, E4c, and E7c were at baseline levels of 0.06 +/- 0.01 µg/g at the second foot range. All of the lead concentrations were above baseline concentrations of 5.2 +/- 0.7 µg/g at the one-foot depth range or deeper. The copper range was very wide (16–55 µg/g); 12 core samples of one-foot depth or more, were above this range.

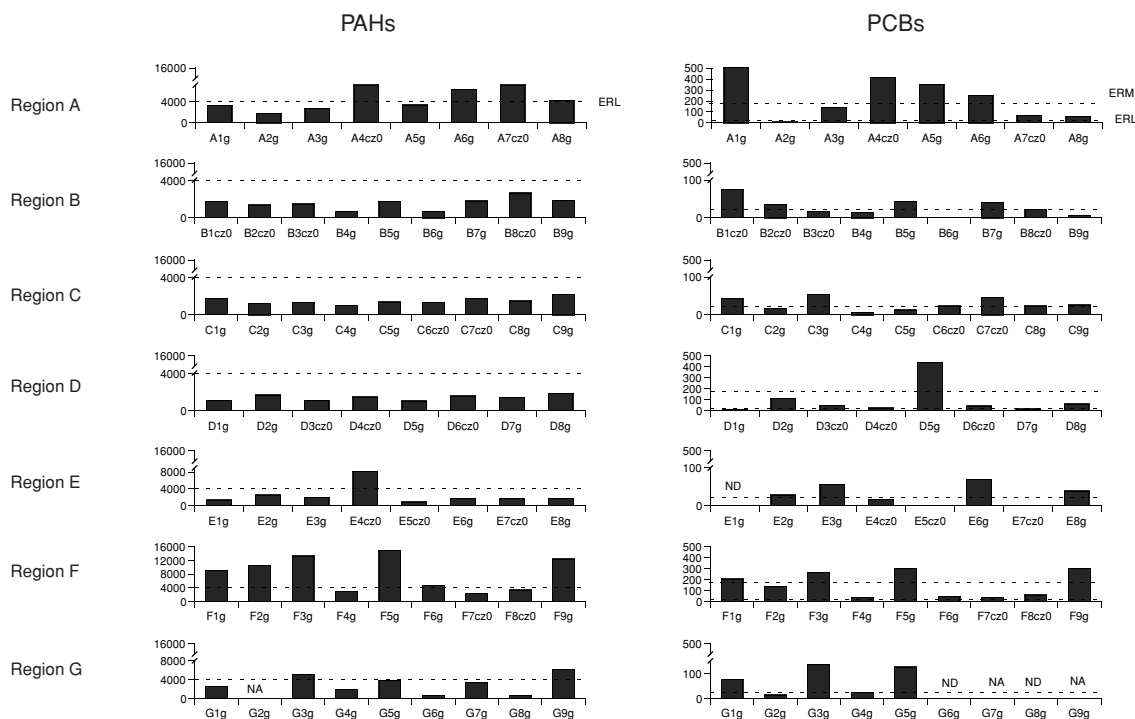


Figure 3g. Concentrations of PAHs and PCBs in sediment grab samples. All units are in parts per billion (ppb) dry weight. Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality guidelines are represented by the dotted lines. For PAHs the ERL is 4022 ppb. No PAH values exceeded the ERM value of 44792 ppb. For PCBs the ERL is 22.7 ppb and the ERM is 180 ppb. Samples are grouped by the regions shown in Figure 1. Values below the detection limit are indicated by "ND". Stations not analyzed are indicated by "NA". ASC values for PAHs are 211 ppm (<40% fines) and 3390 (>40% fines). ASC values for PCBs are 8.6 ppm (<40% fines) and 21.6 ppm (>40% fines).

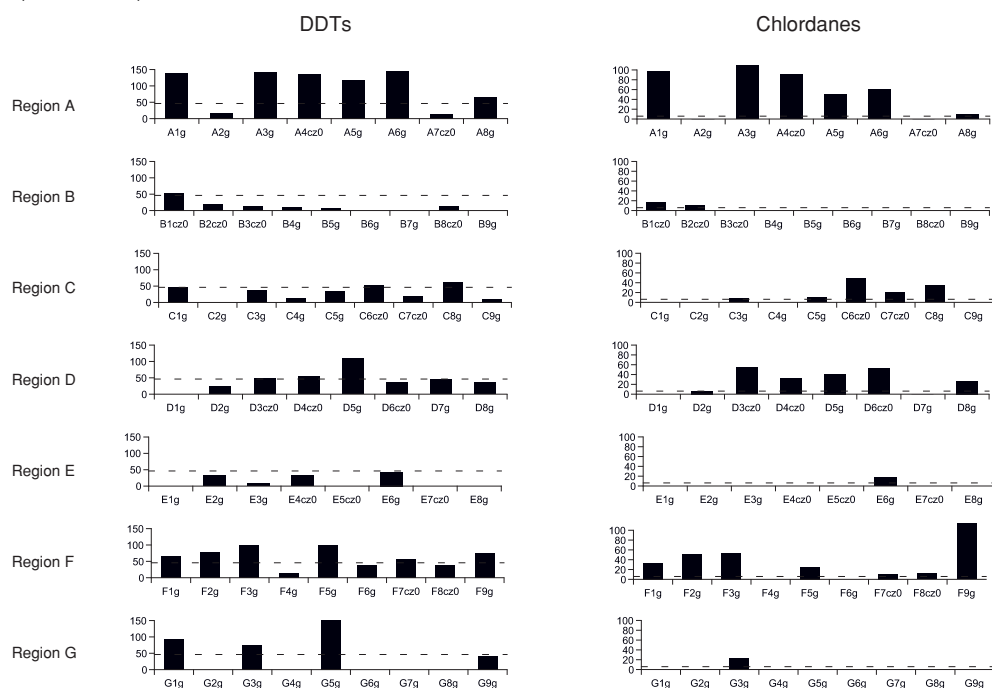


Figure 3h. Concentrations of total DDTs and total chlordanes in sediment grab samples. All units are in parts per billion (ppb) dry weight. Effects Range Low (ERL) and Effects Range Median (ERM) sediment quality guidelines are represented by the dotted lines. For DDTs the ERL is 1.58 ppb and the ERM 46.1 ppb. The ERL is 0.5 ppb and the ERM 6 ppb for chlordanes. There were 22 ERM exceedances for DDTs and 37 for chlordanes. Samples are grouped by the regions shown in Figure 1. Values below the detection limit are indicated by "ND". Stations not analyzed are indicated by "NA".

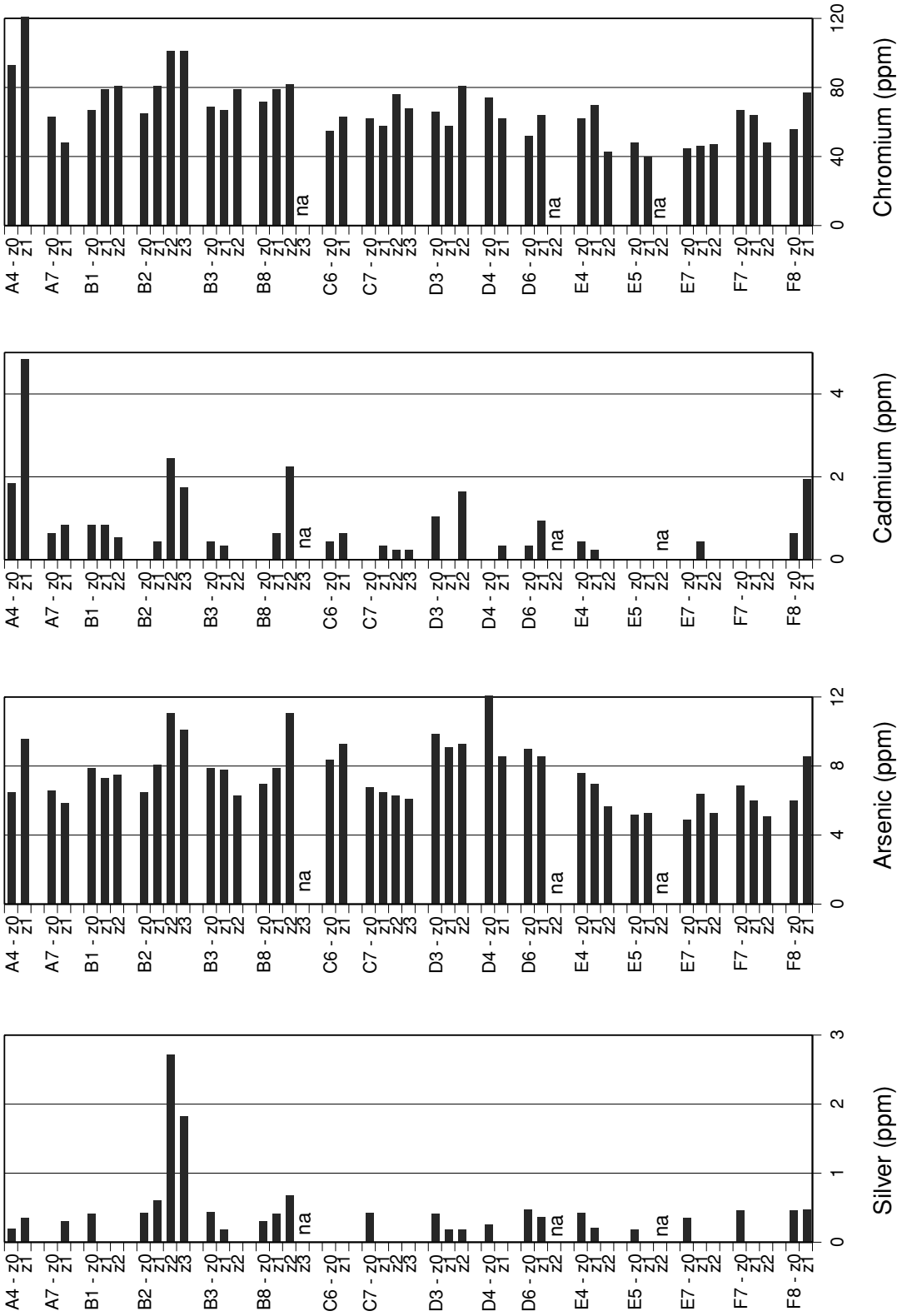


Figure 4a. Silver, arsenic, cadmium and chromium core sample concentrations. z0 = surface, z1 = first foot depth, z2 = second foot depth, z3 = third foot depth. Core depth varies with sample site. Blank areas indicate concentrations below detection limits. A "na" indicates a section not analyzed. Sediment quality guidelines are found on Table 7. All units are in dry weight.

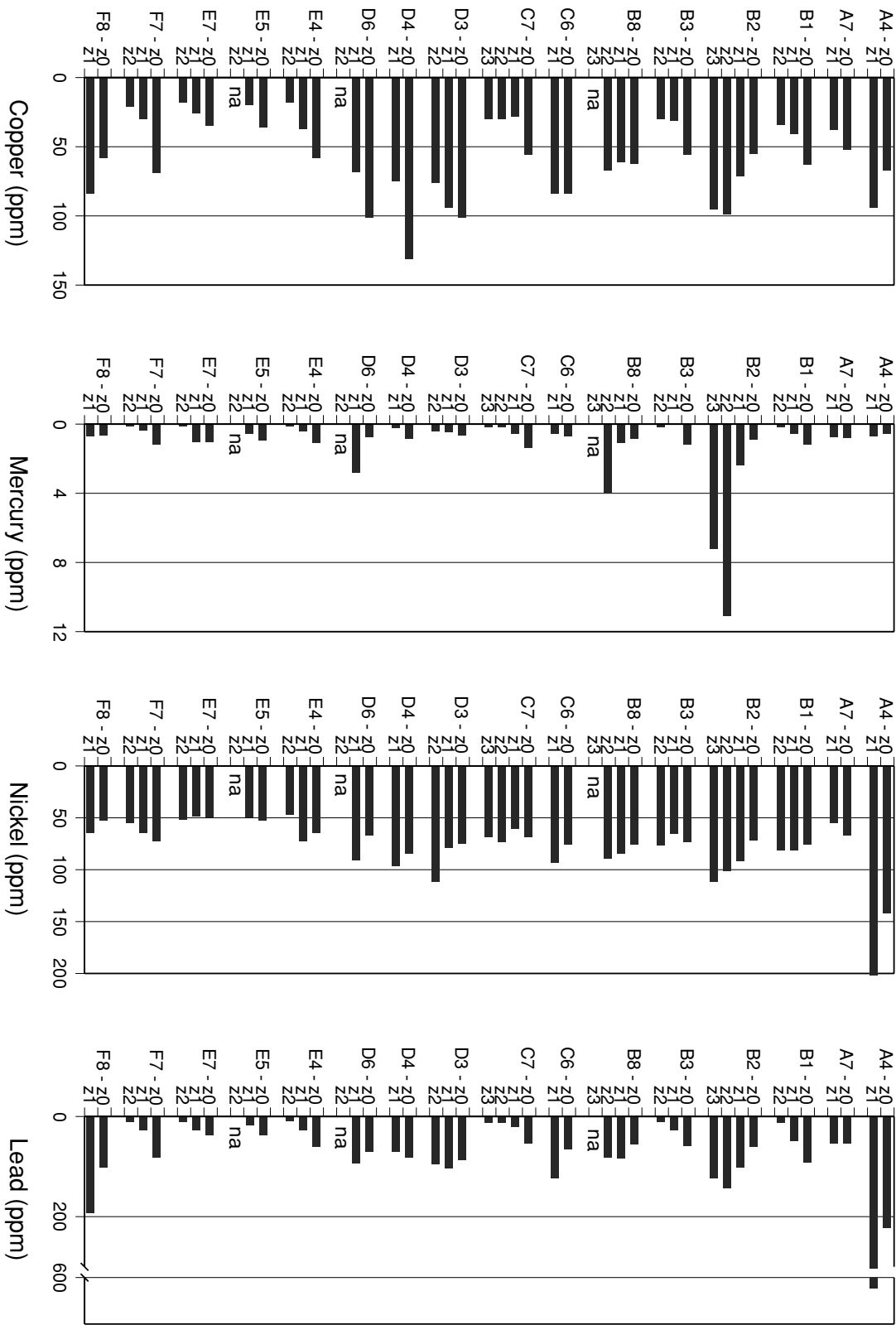


Figure 4b. Copper, mercury, nickel and lead core sample concentrations. z0 = surface, z1 = first foot depth, z2 = second foot depth, z3 = third foot depth. Core depth varies with sample site. Blank areas indicate concentrations below detection limits. A "na" indicates a section not analyzed. Sediment quality guidelines are found on Table 7. All units are in dry weight.

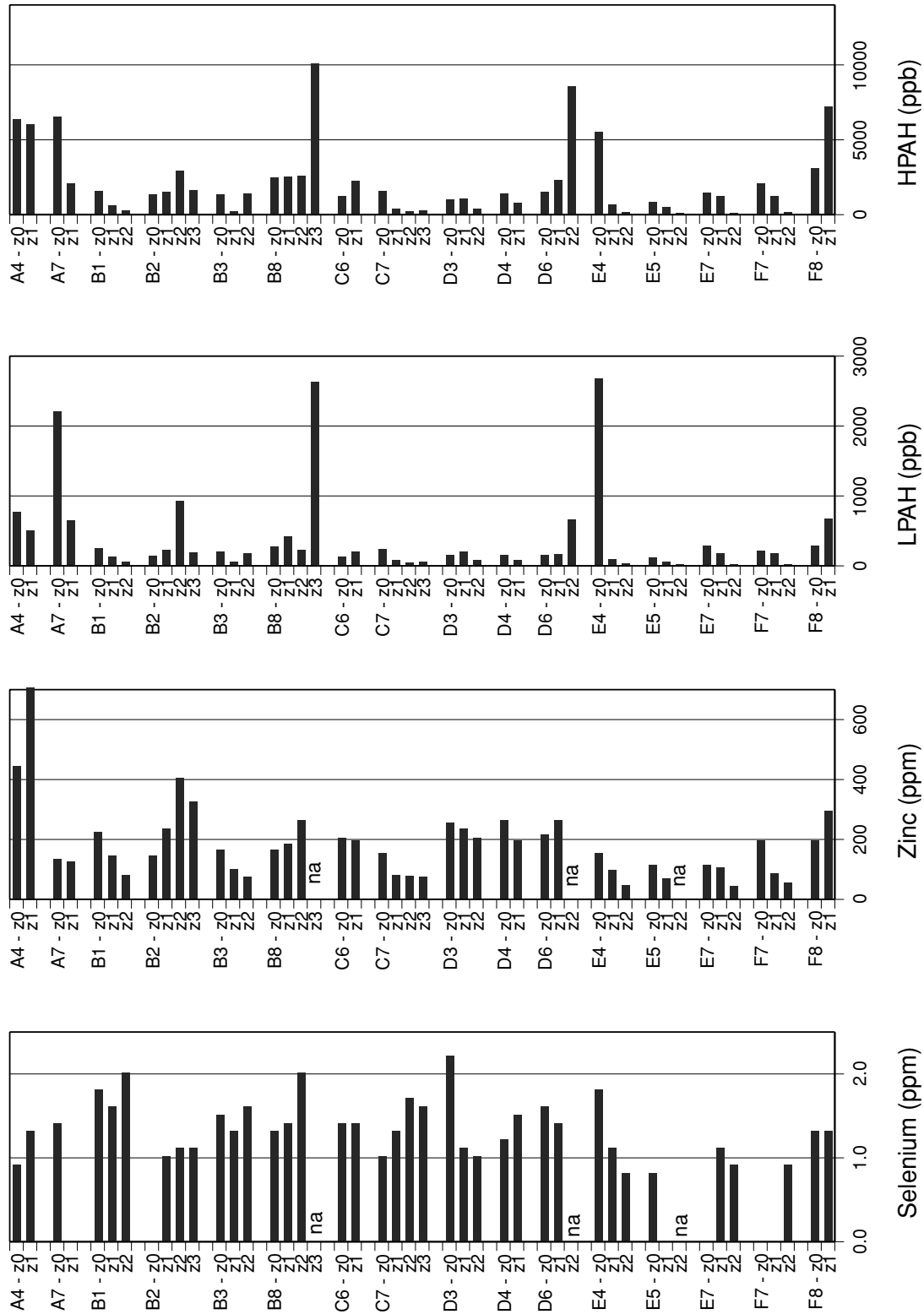


Figure 4c. Selenium, zinc, low and high molecular weight PAHs (LPAH and HPAH) core sample concentrations. z0 = surface, z1 = first foot depth, z2 = second foot depth, z3 = third foot depth. Core depth varies with sample site. Blank areas indicate concentrations below detection limits. A "na" indicates a section not analyzed. Sediment quality guidelines are found on Table 7. All units are in dry weight.

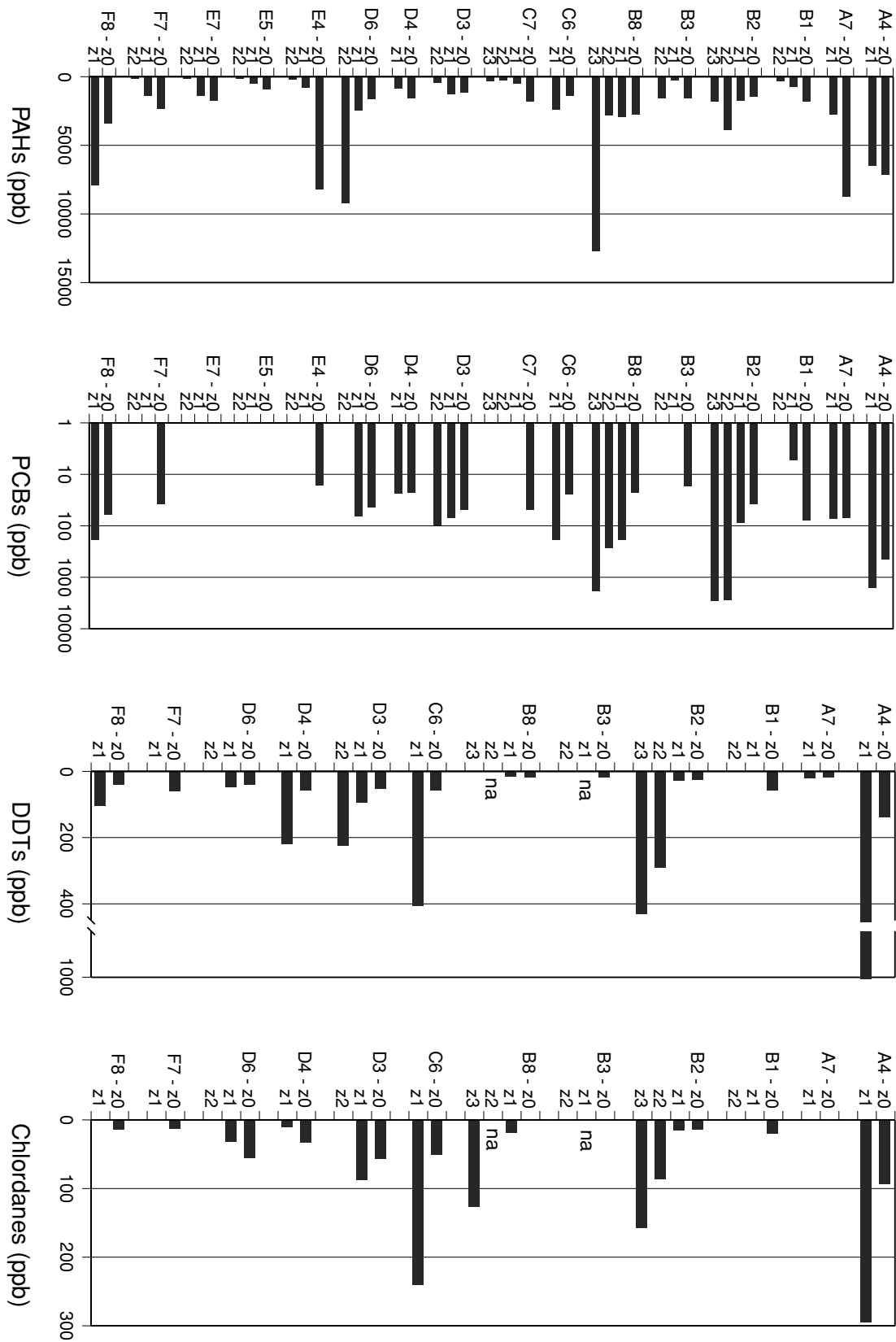


Figure 4d. Total PAHs, Total PCBs, DDT and Chlordane core sample concentrations. z0 = surface, z1 = first foot depth, z2 = second foot depth, z3 = third foot depth. Core depth varies with sample site. Blank areas indicate concentrations below detection limits. A "na" indicates a section not analyzed. Sediment quality guidelines are found on Table 7. All units are in dry weight.

Site Contamination Summary and Mean ERM quotient (mERMq)

Based on this study, sediment contamination in San Leandro Bay and its immediate tributaries appears to be most severe in three Creek Channels and at a few sites within the open waters of the embayment (Table 2 and Figure 5). East Creek Channel was the most contaminated and showed contaminant levels above ERM values for 6 contaminants at several sites with the highest total DDT levels found in the study at site A4c. Elmhurst Creek Channel also showed contaminant levels above ERM values for 6 contaminants at several sites with the highest total PAHs levels found in the study at sites F3g, F5g and F9g. Damon Creek Channel was less contaminated, although sites D3c and D4c had high total DDT levels at depth and total PCBs were above the ERM at D5g. The open water San Leandro Bay sites were generally less contaminated, but were above ERM levels at many sites for Hg and total DDTs. Sites B2c and B8c, in the southerly portions of the Oakland Channel, were the most contaminated open water sites. B2c had the highest levels of Hg and total PCBs in the study in the deeper subsurface samples, and had high total DDT concentrations. Site B8c had very high levels of Hg, total PAHs, and total PCBs. Site C6c had a high total DDT concentration under the surface sediments. Three sites (G1g, G3g, and G5g) in San Leandro Creek Channel had total DDT concentrations above the ERM. Hg concentrations were high in the San Leandro Bay Channel and the northern portions of Airport Channel reaching 1.4 mg/Kg at E6g.

Calculated mERMq values (for samples with more than 9 measured contaminants) in the study ranged from 0.136 – 3.258, with an average mERMq of 0.546. The mERMq is a useful contaminant summary measure to evaluate the probability that sediment samples will be toxic in laboratory bioassays (see Data Analysis Methods). Based on concurrent sediment and toxicity data from the RMP and the BPTCP, when mERMq values are > 0.5, then the probable toxic effect in a sediment bioassay is 82% (Thompson *et al.* 1999). One third of the sediment samples had mERMq values above 0.5. All the creek channel sites had mERMq values above 0.5 with the exception of D1g (in the upper portions of Damon Creek), and G6g, G8g, G9g in the upper portions of San Leandro Creek Channel. In general, the open water regions of San Leandro Bay had mERMqs < 0.5 with the exception of samples from B2c, B8c, and C6c.

Three sites had mERMq values above 1. mERMq values above 1 have a 92% probability of being toxic in laboratory bioassays (Thompson *et al.* 1999). Site A4c in East Creek channel was the only surface sample with a mERMq above 1. This site also had highest subsurface mERMq value in the study (3.258 in the first foot interval sample (A4cz1)). Although the mERMq in the surface sample of site B2c was not above 0.5 (B2cz0=0.347), the deeper samples had the second highest

mERMq values in the second and third foot intervals (3.201, 3.003 respectively). C6cz1 also had a mERMq above 1 in the first foot interval (no deeper sample results are available at this site).

Table 2. Sediment contamination summary for each sample. A total of 14 contaminants were evaluated: Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Se, and Zn; Total DDTs, Total HPAHs, Total LPAHs, and Total PCBs. Included here are: % Fine sediment, mERMq, the number of evaluated contaminants measured in each sample, the percent of contaminants that were above the ERL, ERM, and ASC sediment guidelines in each sample, and the actual number of contaminants measured that were above the guideline value for the four contaminant groups (PAHs, PCBs, Pesticides, Trace elements (TE)). Flags (+) were used to highlight samples that were above the mERMq values where toxicity was likely, and to flag samples with a large percentage of contaminants above the various guidelines (see footnote for details). Grey highlights are sub-surface samples, missing values mean data not available.

SCODE	CDATE	%Fines	mERMq ¹	# Contam. measured	%ERL ²	ERL PAH	ERL PCB	ERL PEST	ERL TE	%ERM ³	ERM PAH	ERM PCB	ERM PEST	ERM TE	%ASC ⁴	ASC PAH	ASC PCB	ASC PEST	ASC TE
A1g	9/17/98	28	0.876 +	13	69	1	1	1	6	23	0	1	1	1	38	0	1	1	3
A2g	9/15/98	30	0.236	14	29	0	0	1	3	7	0	0	0	1	57	0	0	0	1
A3g	9/15/98	99	0.789 +	14	79 +	1	1	1	8	36	0	0	1	4	7	0	1	1	6
A4cz0	9/18/98	49	1.023 + +	12	92 +	2	1	1	7	42 +	0	1	1	3	75 +	2	1	1	5
A4cz1	9/17/98	74	3.258 + +	14	79 +	1	1	1	8	36	0	1	1	3	86 +	2	1	1	8
A5g	9/15/98	89	0.898 +	14	71	1	1	1	7	43 +	0	1	1	4	57	0	1	1	6
A6g	9/15/98	59	0.925 +	14	79 +	2	1	1	7	36	0	1	1	3	79 +	2	1	1	7
A7cz0	9/15/98	61	0.420	14	57	2	1	1	4	7	0	0	0	1	50	2	1	0	4
A7cz1	9/17/98	38	0.336	13	62	2	1	1	4	8	0	0	0	1	38	1	1	0	3
A8g	9/15/98	22	0.578 +	12	83 +	2	1	1	6	17	0	0	1	1	58	2	1	1	3
B1cz0	9/15/98	92	0.528 +	13	54	0	1	1	5	23	0	0	1	2	54	0	1	1	5
B1cz1	9/17/98	96	0.294	13	23	0	0		3	8	0	0		1	31	0	0		4
B1cz2	9/17/98	99	0.231	12	8	0			1	8	0			1	17	0			2
B2cz0	9/15/98	63	0.347	14	43	0	1	1	4	14	0	0	0	2	21	0	1	0	2
B2cz1	9/17/98	79	0.615 +	14	50	0	1	1	5	14	0	0	0	2	57	0	1	0	7
B2cz2	9/17/98	93	3.201 + +	14	93 +	2	1	1	9	29	0	1	1	2	71 +	1	1	1	7
B2cz3	9/17/98	99	3.003 + +	14	79 +	0	1	1	9	29	0	1	1	2	64 +	0	1	1	7
B3cz0	9/15/98	85	0.369	14	43	0	0	1	5	14	0	0	0	2	36	0	0	0	5
B3cz1	9/17/98	89	0.227	10	10	0			1	10	0			1	20	0			2
B3cz2	9/17/98	99	0.227	12	8	0			1	8	0			1	8	0			1
B4g	9/15/98	64	0.275	12	33	0	0	1	3	8	0	0	0	1	8	0	0	0	1
B5g	9/15/98	79	0.359	13	46	0	1	1	4	15	0	0	0	2	31	0	1	0	3
B6g	9/15/98	17	0.159	12	17	0			2	0	0			0	0	0		0	
B7g	9/18/98	91	0.373	13	46	0	1		5	15	0	0		2	46	0	1		5
B8cz0	9/15/98	92	0.345	14	50	1	0	1	5	14	0	0	0	2	29	0	0	0	4
B8cz1	9/17/98	89	0.466	14	57	1	1	1	5	14	0	0	0	2	43	0	1	0	5
B8cz2	9/17/98	93	0.910 +	13	69	1	1	1	7	23	0	1		2	54	0	1		6
B8cz3	9/17/98	94		3		2	1				1	1				2	1		
B9g	9/15/98	92	0.260	13	23	0	0		3	8	0	0		1	8	0	0		1
C1g	9/18/98	93	0.463	13	62	0	1	1	6	23	0	0	1	2	62 +	0	1	1	6
C2g	9/15/98	92	0.339	12	42	0	0		5	8	0	0		1	25	0	0		3
C3g	9/15/98	88	0.448	13	54	0	1	1	5	15	0	0	0	2	46	0	1	0	5
C4g	9/15/98	69	0.394	13	54	0	0	1	6	15	0	0	0	2	31	0	0	0	4
C5g	9/18/98	97	0.356	14	50	0	0	1	6	7	0	0	0	1	43	0	0	0	6
C6cz0	9/15/98	91	0.406	14	57	0	1	1	6	14	0	0	1	1	57	0	1	1	6
C6cz1	9/17/98	91	1.090 + +	14	64	1	1	1	6	14	0	0	1	1	57	0	1	1	6
C7cz0	9/15/98	96	0.426	12	50	0	1	1	4	17	0	0	0	2	25	0	1	0	2
C7cz1	9/17/98	92	0.239	12	17	0			2	8	0			1	17	0			2
C7cz2	9/17/98	100	0.225	10	10	0			1	10	0			1	0	0			0
C7cz3	9/17/98	100	0.198	12	8	0			1	8	0			1	8	0			1
C8g	9/18/98	84	0.415	13	38	0	1	1	3	15	0	0	1	1	46	0	1	1	4
C9g	9/15/98	89	0.334	14	43	1	1	1	3	14	0	0	0	2	14	0	1	0	1
D1g	9/16/98	54	0.339	13	54	0	0		7	8	0	0		1	38	0	0		5
D2g	9/16/98	82	0.500 +	14	57	0	1	1	6	7	0	0	0	1	50	0	1	0	6
D3cz0	9/16/98	75	0.451	13	62	0	1	1	6	15	0	0	1	1	62 +	0	1	1	6
D3cz1	9/16/98	54	0.511 +	13	62	0	1	1	6	15	0	0	1	1	46	0	1	1	4
D3cz2	9/16/98	76	0.802 +	12	75 +	0	1	1	7	17	0	0	1	1	50	0	1	1	4
D4cz0	9/15/98	97	0.466	14	50	0	0	1	6	21	0	0	1	2	43	0	0	1	5
D4cz1	9/17/98	22	0.647 +	14	43	0	0	1	5	14	0	0	1	1	43	0	1	1	4
D5g	9/16/98	42	0.668 +	13	62	0	1	1	6	23	0	1	1	1	46	0	1	1	4
D6cz0	9/15/98	99	0.381	14	57	0	1	1	6	7	0	0	0	1	43	0	1	0	5
D6cz1	9/17/98	78	0.731 +	13	69	1	1	1	6	15	0	0	0	2	46	0	1	0	5
D6cz2	9/17/98	100		2		2					0					2			
D7g	9/18/98	40	0.431	11	55	0	0	1	5	9	0	0	0	1	27	0	0	0	3
D8g	9/15/98	82	0.443	12	67	0	1	1	6	8	0	0	0	1	42	0	1	0	4
E1g	9/15/98	74	0.256	11	27	0			3	9	0			1	0	0			0
E2g	9/18/98	100	0.423	14	64	1	1	1	6	14	0	0	0	2	50	0	1	0	6
E3g	9/15/98	90	0.387	14	50	0	1	1	5	14	0	0	0	2	36	0	1	0	4

Table 2 continued on next page

Table 2 Continued from previous page

SCODE	CDATE	%Fines	mERMq ¹	# Contam. measured	%ERL ²	ERL PAH	ERL PCB	ERL PEST	ERL TE	%ERM ³	ERM PAH	ERM PCB	ERM PEST	ERM TE	%ASC ⁴	ASC PAH	ASC PCB	ASC PEST	ASC TE
E4cz0	9/15/98	99	0.499	13	54	2	0	1	4	15	0	0	0	2	46	2	0	0	4
E4cz1	9/16/98	100	0.271	11	27	0			3	9	0		1	9	0	0		1	
E4cz2	9/16/98	72	0.136	11	9	0			1	0	0		0	0	0			0	
E5cz0	9/15/98	66	0.308	10	30	0			3	10	0		1	10	0			1	
E5cz1	9/16/98	53	0.205	12	17	0			2	0	0		0	8	0			1	
E5cz2	9/16/98	44		2		0					0				0				
E6g	9/18/98	96	0.508 +	14	57	0	1	1	6	14	0	0	0	2	43	0	1	0	5
E7cz0	9/15/98	69	0.323	11	18	0			2	9	0		1	9	0			1	
E7cz1	9/16/98	51	0.292	11	18	0			2	9	0		1	18	0			2	
E7cz2	9/16/98	44	0.142	11	9	0			1	0	0		0	0	0			0	
E8g	9/18/98	99	0.370	13	46	0	1		5	15	0	0		2	46	0	1		5
F1g	9/16/98	42	0.614 +	12	75 +	2	1	1	5	25	0	1	1	1	58	2	1	1	3
F2g	9/16/98	23	0.595 +	14	71	2	1	1	6	14	0	0	1	1	64 +	2	1	1	5
F3g	9/16/98	55	0.752 +	14	71	2	1	1	6	29	1	1	1	1	64 +	2	1	1	5
F4g	9/15/98	100	0.362	14	57	1	1	1	5	7	0	0	0	1	43	0	1	0	5
F5g	9/16/98	69	0.849 +	14	79 +	2	1	1	7	43 +	1	1	1	3	79 +	2	1	1	7
F6g	9/18/98	100	0.429	14	57	1	1	1	5	7	0	0	0	1	64 +	2	1	0	6
F7cz0	9/15/98	97	0.470	14	57	1	1	1	5	21	0	0	1	2	36	0	1	1	3
F7cz1	9/16/98	95	0.240	12	17	0			2	8	0		1		0	0		0	
F7cz2	9/16/98	80	0.153	11	9	0			1	9	0		1		0	0		0	
F8cz0	9/15/98	66	0.374	14	57	1	1	1	5	0	0	0	0	0	43	0	1	0	5
F8cz1	9/17/98	91	0.670 +	14	79 +	2	1	1	7	14	0	0	1	1	71 +	2	1	1	6
F9g	9/15/98	91	0.758 +	14	71	2	1	1	6	29	1	1	1	1	79 +	2	1	1	7
G1g	9/15/98	58	0.466	14	64	1	1	1	6	14	0	0	1	1	50	0	1	1	5
G2g	9/15/98	100	0.361	11	27			0	3	18			0	2	27			0	3
G3g	9/15/98	82	0.584 +	14	71	1	1	1	7	21	0	0	1	2	64 +	1	1	1	6
G4g	9/18/98	100	0.302	13	31	0	1		3	8	0	0		1	38	0	1		4
G5g	9/18/98	91	0.819 +	14	71	1	1	1	7	14	0	0	1	1	64 +	1	1	1	6
G6g	9/15/98	14	0.200	11	27	0			3	0	0		0		9	0			1
G7g	9/15/98	100	0.347	12	58	1			6	8	0		1		42	0			5
G8g	9/17/98	69	0.209	11	18	0			2	9	0		1		9	0			1
G9g	9/16/98	96	0.296	13	46	2			3	0	0		0	0	46	2		0	4

1 + = mERMq value is ≥ 0.5 , ++ = mERMq ≥ 1 , the level above which there is an 82% and 91% probability of a toxic affect respectively.

2 + means more than 75% of the evaluated contaminants were above the ERL guideline.

3 + means more than 40% of the evaluated contaminants were above the ERM guideline.

4 + means more than 60% of the evaluated contaminants were above the ASC guideline.

Regression Analysis Results

Correlations of Contaminants with TOC and Grain size

TOC was not significantly correlated with grain size. All trace elements were significantly correlated with TOC with the exception of Ni. As, Cd, Cu, Pb, and Zn had the best fits ($p < 0.0001$ and $R^2 = 0.23 - 0.39$), and Cr, Hg, and Se had p values ranging from 0.001 to 0.02 and $R^2 = 0.06 - 0.12$. The sums of several organic compound groups were evaluated: total PAHs, ($p < 0.0001$, $R^2 = 0.33$), total PCBs ($p = 0.0005$, $R^2 = 0.17$), total DDTs ($p = 0.006$, $R^2 = 0.13$), and total chlordanes ($p = 0.03$, $R^2 = 0.13$) were significantly correlated to TOC. These results suggest that analyses of spatial variation could benefit from normalizing the trace element and trace organic data to TOC. Cr was the only trace element that was significantly correlated with grain size ($p < 0.0001$, $R^2 = 0.19$). None of the total organic compounds were significantly correlated with grain size.

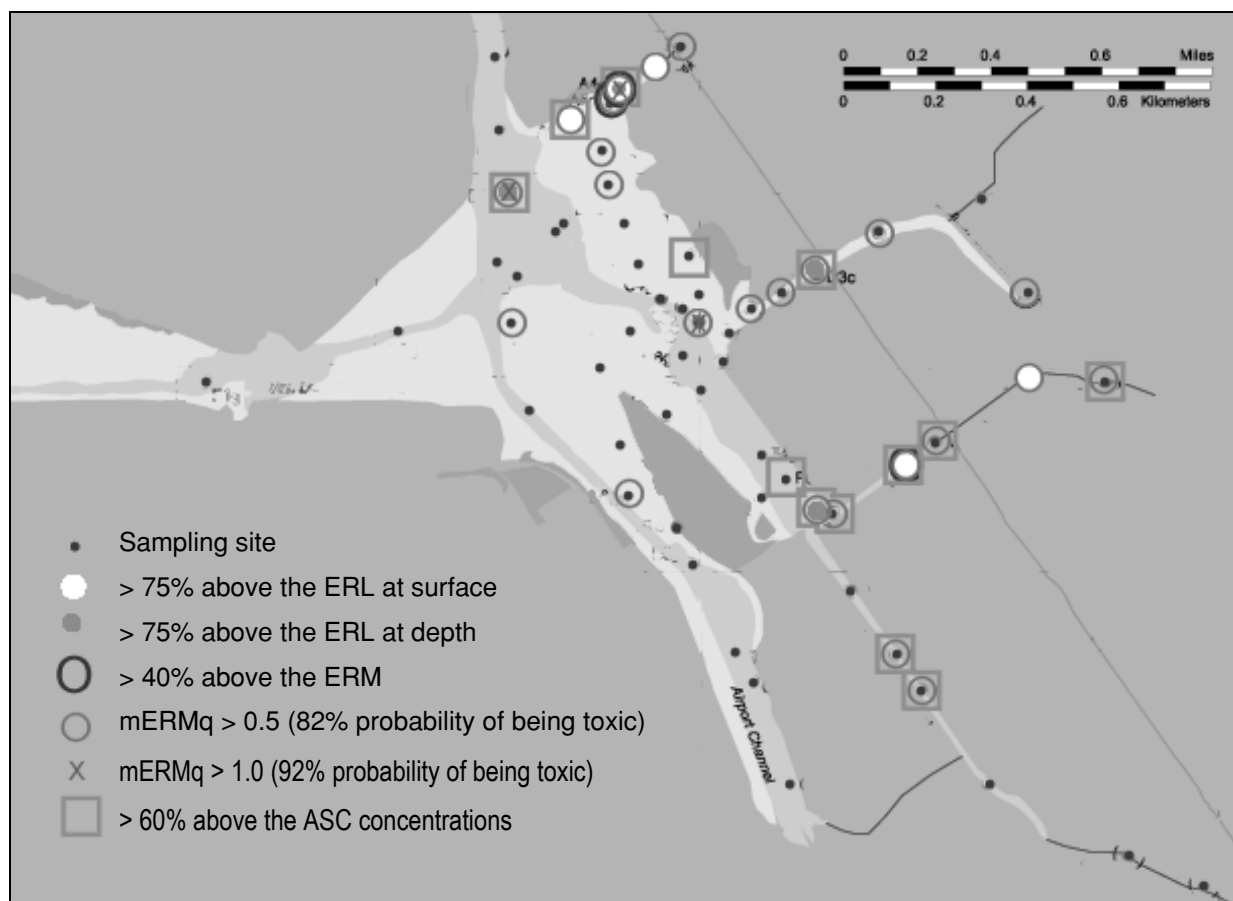


Figure 5. Summary of the percentage of evaluated contaminants that were above sediment quality guidelines in the San Leandro Bay study (Effects Range Low (ERL), Effects Range Medium (ERM), mean ERM quotient (mERMq), and Ambient Sediment Concentrations (ASC). See text for guideline descriptions. A total of 14 contaminants were evaluated against the guidelines: Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Se, and Zn; Total DDTs, Total HPAHs, Total LPAHs, and Total PCBs. The creek channels showed the most contamination with East Creek (1) being the most contaminated, then Elmhurst Creek (3), then Damon Creek (2) and finally San Leandro Creek Channel (4). Several open channel sites were highly contaminated (B2c, C6c, B8c, and E6g).

Cytochrome P450 RGS Versus Wet Chemistry Regression Analysis

P450 RGS versus wet chemistry regressions were generated using the San Leandro Bay data to see how well the less costly P450 RGS analytical method correlated with wet chemistry results. Total PAHs were significantly correlated to benzo(a)pyrene equivalents measured at 6 hours (P450 RGS measure for PAHs); $p = <0.0001$, $R^2 = 0.80$ (see Figure 6). Although the P450 RGS analyses were not carried out to the full 16 hours (when the response to PCBs and other dioxin like compounds would have been the greatest), a regression of TPCBs and TEQs measured at 6 hours (the P450 RGS measure for dioxin like compounds) showed that they were significantly correlated: $p = <0.0001$, $R^2 = 0.46$. This is partly a result of the fact that TPCB and TPAH concentrations covaried in this study (TPAH and TPCB were significantly correlated: $p = <0.0001$, $R^2 = 0.29$). However, the

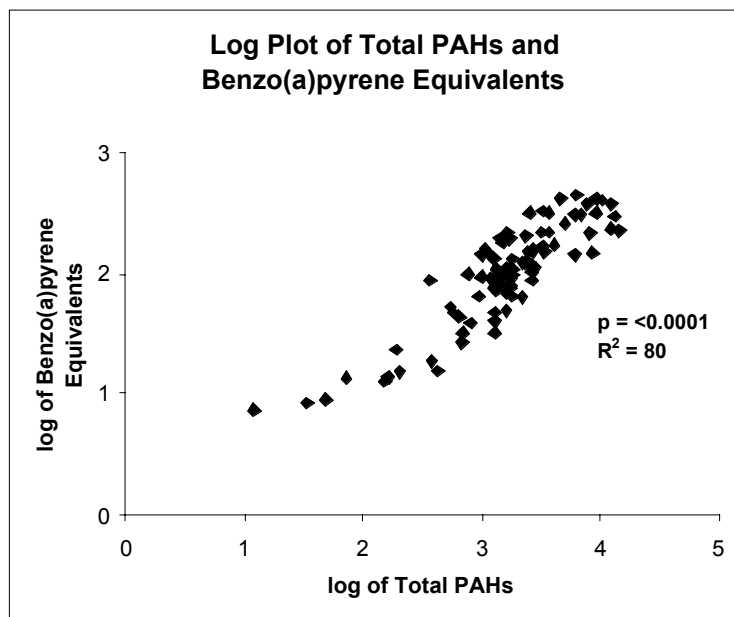


Figure 6. Log plot of total PAHs vs. benzo(a)pyrene equivalents showing a high correlation between wet chemistry methods and P450 RGS screening methods.

fact that this explains only 29% of the variation and that 46% of the variation is explained by the TPCB/TEQ regression is surprising since the 6 hour RGS results are considered to be an index of PAH contamination. A real test of the RGS method for PCB screening would require the 16 hour RGS data. Due to cost limitations, only a few 16 hour results were obtained in this study (data not shown).

Principal Components Analysis

PCB fingerprints were analyzed using principal components analysis to evaluate sources of sediment contamination in this study (see Data Analysis Methods). PCB fingerprints (PCB congener ratios) in both the Creek Channels and open waters of San Leandro Bay were examined for those samples that had sufficient PCB congener values above the MDL. Figure 7a shows 3 distinct groupings, two of them defined by the first principal component (which accounted for 70% of the variability). The second principal component accounted for an additional 14% of the variability. Sites D5g, B2cz2, and B2cz3 were characterized by high relative concentrations of PCBs 110 and 118, which are major components of Aroclor 1254 (Frame *et al.*, 1996). All of the sub-surface, open water San Leandro Bay samples showed a congener pattern higher in Aroclor 1254 congeners than samples from the surface, East Creek and Elmhurst Creek Channel samples. Most of the East Creek and Elmhurst Channel samples grouped together along principal component 1 axis. These samples contained higher relative concentrations of congeners found in Aroclor 1260 (Frame *et al.*, 1996).

Principal components analysis showed fewer distinct groupings based on individual PAH groupings (Figure 7b). There was some separation of samples from East Creek and Elmhurst Channels shown by the first principal component, and site F1g by the second, but in general there was much more similarity in individual PAH patterns throughout the sample area compared to the PCBs.

An alternative approach to assessing contaminant sources would be to compare surface grab samples from the sampling strata of deep water/channel, shallow water, and estuarine transition. The conceptual model underlying this analysis would be that the sites closer to the watershed would reflect the influence of local sources more than the sites further out in San Leandro Bay. This analysis would help to identify contaminant gradients within the study area, but was beyond the scope of this report.

Radionuclide Analysis

Results were inconclusive due to analytical difficulty with the sediment dating method and it was not possible to evaluate the depositional environment.

Conclusions

This study had 5 objectives; to evaluate the distribution of sediment contamination, determine if the contamination was relatively isolated or not, identify possible sources and pathways, investigate the depth of sediment contamination, and explore a method of sediment dating to see if it could be used to determine if the sediments are erosional or depositional within the embayment.

Surface and core samples of sediment collected in San Leandro Bay and its tributaries showed elevated concentrations of metals and organic compounds compared to Bay-wide ambient sediment concentrations and other sediment guidelines.

In August of 1998, 45 surface and 16 core samples were collected in order to characterize the distribution of sediment contamination within San Leandro Bay in both surface sediments (top 5 cm) and at depth (up to ~1 meter).

The highest concentrations of surface sample contamination were found in three creek channels (East Creek, Damon Creek, and Elmhurst Creek Channels) thus indicating that the sources are from point and nonpoint inputs within the watershed (see Table 2 and Figure 5). One exception is that the mercury source appears to be within San Leandro Bay itself since the surface samples showed higher concentrations in open water areas compared to the tributaries. Contaminants detected most frequently above ERM guidelines were nickel, mercury, chlordanes, DDTs, and PCBs. Elevated levels of lead and zinc were detected in two creek channels.

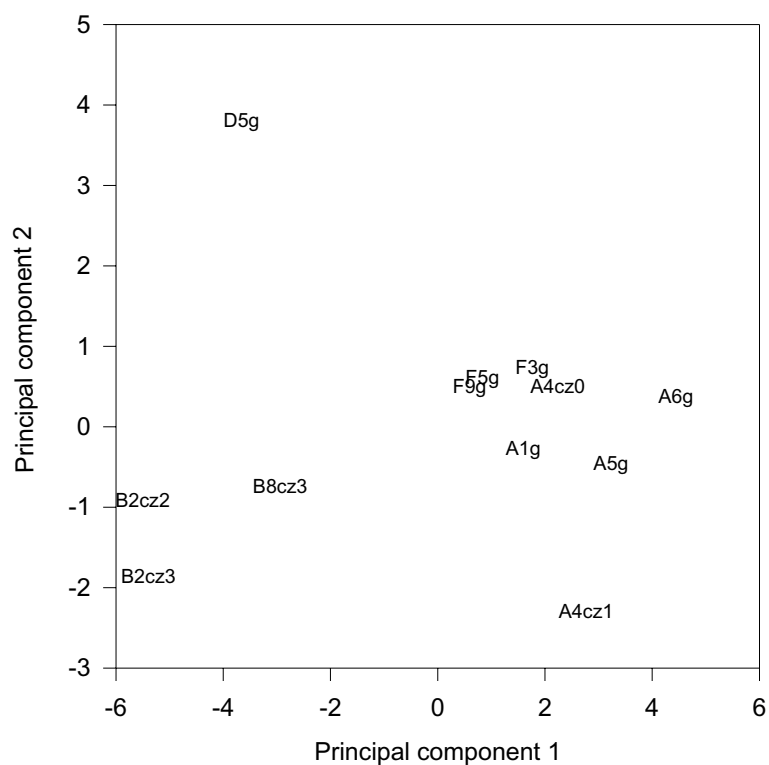


Figure 7a. Principal component 1 (70 %) and principal component 2 (14%) cross plot from principal components analysis on PCB congeners from a subset of surface and core sites.

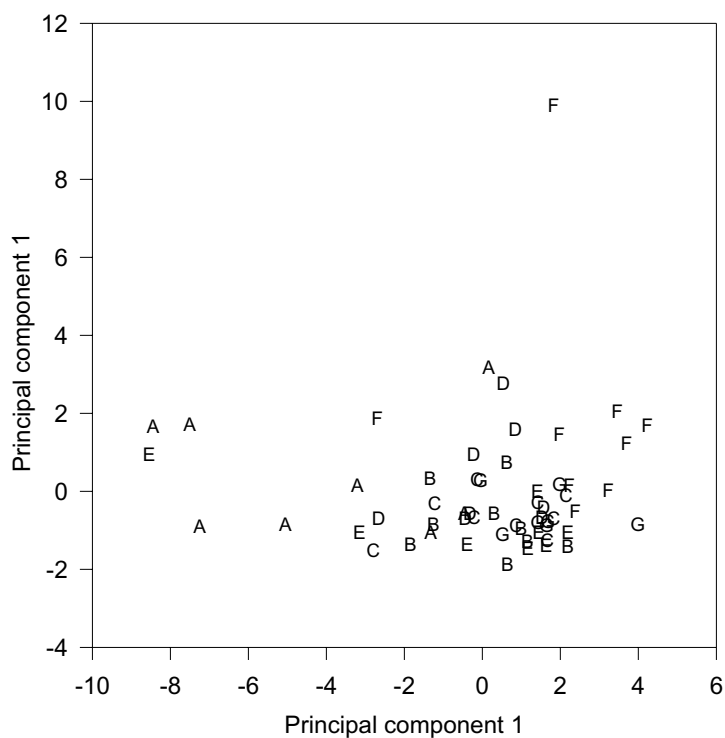


Figure 7b. Principle component 1 (41 %) and principle component 2 (15%) cross plot from principle components analysis on total PAHs from a subset of surface and core sites. Site names were generalized by area for chart presentation purposes.

Although contamination in the creek channels is relatively dispersed, the most contaminated sampling sites within the three creek channels were: A4c, A5g in East Creek, D3c in Damon Creek, and F3g, F5g, and F9g in Elmhurst Creek. Almost all the samples from these three creek channels had mERMq values > 0.5 indicating an 82% potential for toxic effects in laboratory bioassays.

Five sites in the open water regions were particularly contaminated: three sites were located at creek mouths; A6g (East Creek), C6c (Damon Creek), and F9g (Elmhurst Creek); one site was located in the southern portion of the deeper Oakland Channel (B2c, subsurface), and one site (B8c, subsurface) in the shallows at the confluence of San Leandro Bay Channel and Airport Channel.

PCBs and PAHs were evaluated using principal components analyses to address possible sources and pathways of contaminant loadings. Using results from both the creek channels and open waters of San Leandro Bay, 3 distinct groupings resulted, two of them defined by the first principal component (which accounted for 70% of the variability). The second principal component accounted for an additional 14% of the variability. Sites D5g, B2cz2, and B2cz3 were characterized by high relative concentrations of PCBs 110 and 118, which are major components of Aroclor 1254. All of the subsurface, open water San Leandro Bay samples showed a congener pattern higher in Aroclor 1254 congeners than surface samples from East Creek and Elmhurst Creek Channels. Most of the East Creek Channel and Elmhurst Creek Channel samples grouped together along principal component 1 axis. These samples contained higher relative concentrations of congeners found in Aroclor 1260.

Although there are clear indications of subsurface contamination at several of these sites, this study could not definitively answer questions pertaining to the extent of subsurface sediment contamination because of the limited depth of core penetration at many sites. However, of the core samples obtained, the study results showed increasing contamination with depth at several sites. B2c had a 'lens' of increasing concentration of 10 trace elements, total PAHs, total PCBs, and total DDTs with depth. B8c had increasing concentrations of 10 trace elements, total PAHs, total PCBs, with depth (DDT data were not available). A4c had increasing concentrations of 9 trace elements, total PCBs, and total DDTs with depth. F8c had increasing concentrations of 7 trace elements, total PAHs, total PCBs, and total DDTs with depth. D6c had increasing concentrations of 5 trace elements, total PAHs, total PCBs, and total DDTs with depth. Deeper cores are needed to gain a better understanding on the depth of sediment contamination within this embayment.

In other areas of the Bay, vibracores have been used to collect deeper core samples than can be taken by hand-pushed cores. However, the shallow water of much of San Leandro Bay, even at high tide, precludes the use of vessels large enough to carry the vibracorer equipment. There are

special platform rigs now available which are able to access very shallow waters (to 1.5 ft depth) with vibracorer equipment. This option should be considered in future sediment core collection efforts in San Leandro Bay or other embayments in order to capture the entire contaminant profile.

The radionuclide analysis (Pb210, Ra226, and Cs137) results were inconclusive because Pb210, Ra226, and Cs137 concentrations were too low for the analytical method (detection limits were too high). Therefore it was not possible to evaluate the depositional environment using this sediment dating technique. Sediment dating could be used to answer the question of whether the sediments were depositional or erosional, but cores would have to be taken on a more limited basis, due to a significantly higher analytical cost per core using lower detection limits.

The cytochrome P450 RGS analysis method appeared to be a valuable, relatively inexpensive screening technique to detect PAHs.

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Appendix Tables

Appendix Table 1. Analytical Laboratories

Laboratory	Analysis
Moss Landing Marine Lab	Sample Collection
Caltest	Trace metals Percent Moisture
Columbia Analytical Services	PCBs PAHs Chlorinated Pesticides Organophosphorus Pesticides P450 RGS
Sequoia Analytical	TOC (originally did pesticides, but re-analyzed by Columbia Analytical)
Battelle	Grain size (as % gravel, sand, silt, clay)
Davi Laboratories	Cs 137, Pb 210, Ra 226 (core samples only)

Appendix Table 2. Concentrations of Sediment Quality parameters in San Leandro Bay samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth.

Site Code	Temperature (C)	Salinity (o/oo)	% Gravel+Shell (>4-76mm)	% Sand (74µm-76mm)	% Silt (5µm-74µm)	% Clay (<5µm)	% Fines (<74µm)	TOC (mg/kg)
A1g	22	10	0	72.07	10.54	17.39	27.93	12700
A2g	22	25	9.74	59.78	4.86	25.62	30.48	7490
A3g	22	20	0	1.02	19.27	79.71	98.98	12300
A4cz0	22	25	0	50.72	29	20.28	49.28	15000
A4cz1	.	.	0.19	25.95	46.69	27.17	73.86	18400
A5g	21	25	0	10.65	33.92	55.43	89.35	15000
A6g	22	25	0.37	40.65	32.9	26.08	58.98	12100
A7cz0	22	24	5.24	33.61	15.14	46.01	61.15	8210
A7cz1	.	.	6.16	55.58	5.29	32.97	38.26	6260
A8g	21	25	0.74	77.54	5.07	16.66	21.73	4890
B1cz0	22	25	0.23	7.55	44.76	47.46	92.22	7630
B1cz1	.	.	0	3.92	29.06	67.02	96.08	7630
B1cz2	.	.	0	1.15	29.65	69.2	98.85	9580
B2cz0	22	25	4.71	32.43	11.04	51.81	62.85	10100
B2cz1	.	.	0.24	20.67	20.04	59.05	79.09	8180
B2cz2	.	.	0.37	6.16	19.92	73.55	93.47	18400
B2cz3	.	.	0	1.33	20.05	78.62	98.67	15500
B3cz0	22	26	0.27	14.94	37.33	47.46	84.79	6600
B3cz1	.	.	0	10.51	38.77	50.72	89.49	8970
B3cz2	.	.	0	1.3	21.89	76.81	98.7	8360
B4g	21	25	0.35	36.09	34.58	28.98	63.56	6650
B5g	22	26	0.5	20.22	36.89	42.39	79.28	7600
B6g	22	25	0	82.76	3.11	14.13	17.24	4130
B7g	21	25	2.25	6.87	26.75	64.13	90.88	8610
B8cz0	22	26	1.15	7.31	30.68	60.86	91.54	8180
B8cz1	.	.	0.15	11.01	38.13	50.72	88.85	8980
B8cz2	.	.	0	6.7	33.52	59.78	93.3	12000
B8cz3	.	.	0	5.74	32.31	61.95	94.26	15200
B9g	22	25	0	7.83	37.5	54.67	92.17	6880
C1g	22	25	1.2	5.57	51.57	41.66	93.23	5090
C2g	21	24	0	8.5	42.59	48.91	91.5	9180
C3g	21	25	0.14	11.82	61.96	26.08	88.04	8260
C4g	20	25	0.6	29.93	34.34	35.14	69.48	4590
C5g	21	25	0.46	2.05	40.61	56.88	97.49	9780
C6cz0	21	24	0.39	8.72	64.81	26.08	90.89	11100

Appendix Table 2 (Cont'd.). Concentrations of Sediment Quality parameters in San Leandro Bay samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth.

Site Code	Temperature (C)	Salinity (o/oo)	% Gravel+Shell (>4-76mm)	% Sand (74µm-76mm)	% Silt (5µm-74µm)	% Clay (<5µm)	% Fines (<74µm)	TOC (mg/kg)
C6cz1	.	.	0	8.93	58.82	32.25	91.07	8770
C7cz0	21	25	0.88	2.97	47.97	48.18	96.15	8970
C7cz1	.	.	0.75	6.89	42.73	49.63	92.36	11300
C7cz2	.	.	0	0.35	38.42	61.23	99.65	10500
C7cz3	.	.	0	0.35	31.54	68.11	99.65	13500
C8g	21	26	1.76	14.74	44.38	39.13	83.51	11900
C9g	21	25	0.76	10.05	54.77	34.42	89.19	8450
D1g	26	20	16.64	29.23	12.11	42.02	54.13	11400
D2g	24	15	0	18.26	34.28	47.46	81.74	14500
D3cz0	23	21	0	24.63	37.69	37.68	75.37	11300
D3cz1	.	.	3.69	42.71	20.63	32.97	53.6	9950
D3cz2	.	.	0	23.59	25.69	50.72	76.41	8180
D4cz0	22	24	0.48	3	34.21	62.31	96.52	12400
D4cz1	.	.	0.58	77.5	10.69	11.23	21.92	6180
D5g	25	5	0.72	56.89	9.42	32.97	42.39	8840
D6cz0	21	25	0.26	0.85	50.7	48.18	98.88	15300
D6cz1	.	.	0	21.72	36.25	42.03	78.28	10900
D6cz2	.	.	0	0.31	27.59	72.1	99.69	13700
D7g	21	26	0.16	60.02	27.42	12.39	39.81	6650
D8g	21	24	0.55	17.02	47.29	35.14	82.43	8650
E1g	23	25	3.2	22.39	28.04	46.37	74.41	5310
E2g	21	25	0	0.23	34.56	65.21	99.77	9980
E3g	22	26	0	9.71	29.06	61.23	90.29	8060
E4cz0	20	24	0	1.08	47.11	51.81	98.92	9180
E4cz1	.	.	0	0.48	40.1	59.42	99.52	11200
E4cz2	.	.	0.71	27.78	37.08	34.42	71.5	9580
E5cz0	22	25	0.68	32.97	42.8	23.55	66.35	6180
E5cz1	.	.	0.47	46.27	29.71	23.55	53.26	3990
E5cz2	.	.	0	55.67	22.96	21.37	44.33	7780
E6g	22	25	0	4.48	40.81	54.71	95.52	8610
E7cz0	21	26	0.07	31.07	38.42	30.43	68.85	8380
E7cz1	.	.	0.29	48.91	29.07	21.73	50.8	6980
E7cz2	.	.	0	55.87	20.37	23.76	44.13	4390
E8g	22	26	0.38	0.38	28.23	71.01	99.24	8800
F1g	25	7	0	57.73	9.3	32.97	42.27	14500
F2g	22	5	16.1	60.68	8.4	14.82	23.22	21600
F3g	23	18	4.44	40.59	29.97	25	54.97	19000
F4g	21	25	0	0.09	25.64	74.27	99.91	9040
F5g	23	20	2.44	28.15	27.94	41.46	69.4	16100
F6g	21	23	0	0.16	24.12	75.72	99.84	8020
F7cz0	21	24	0	2.59	46.69	50.72	97.41	13000
F7cz1	.	.	0	5.04	47.5	47.46	94.96	11400
F7cz2	.	.	0	19.59	39.47	40.94	80.41	9380
F8cz0	21	23	0.8	33.69	27.83	37.68	65.51	13800
F8cz1	.	.	0.74	8.69	45.28	45.29	90.57	24900
F9g	21	23	0	9.13	39.79	51.08	90.87	19300
G1g	21	23	3.56	38.11	28.25	30.07	58.32	13600
G2g	23	25	0	0.04	17.72	82.24	99.96	5900
G3g	21	22	0.46	17.61	38.81	43.12	81.93	17100
G4g	23	25	0	0.26	24.38	75.36	99.74	15100
G5g	21	24	0	9.39	44.23	46.38	90.61	17800
G6g	19	17	20.78	65.03	3.32	10.87	14.19	12000
G7g	24	26	0	0.48	37.2	62.32	99.52	9390
G8g	24	5	3.36	27.82	22.07	46.74	68.81	3730
G9g	22	0	0	3.68	6.28	90.04	96.32	4520

Appendix Table 3. Concentrations of trace elements (mg/Kg dry wt.) in San Leandro Bay sediment samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. "." = below detection limit, na = not analyzed due to insufficient sample material in the core section

Site code	Ag	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Zn
A1g	0.34	11000	6.3	1.9	59	56	19000	0.34	170	71	170	.	.	410
A2g	.	12000	6.0	.	51	33	21000	0.33	380	53	50	.	.	98
A3g	0.55	25000	9.5	1.8	88	95	37000	0.88	370	88	220	.	1.8	440
A4cz0	0.18	14000	6.4	1.8	92	66	22000	0.44	170	140	220	.	0.9	440
A4cz1	0.33	17000	9.5	4.8	120	93	27000	0.60	220	200	620	.	1.3	700
A5g	0.45	19000	7.6	1.9	82	85	31000	1.30	220	98	220	.	1.8	450
A6g	0.56	14000	5.8	1.6	89	70	24000	0.77	180	140	190	.	1.3	430
A7cz0	.	17000	6.5	0.6	62	51	25000	0.69	510	65	51	.	1.4	130
A7cz1	0.29	11000	5.8	0.8	47	37	18000	0.64	230	53	51	.	.	120
A8g	0.30	9500	3.9	1.4	77	39	18000	0.35	170	110	110	.	1.1	350
B1cz0	0.40	17000	7.8	0.8	66	62	28000	1.10	240	74	88	.	1.8	220
B1cz1	.	24000	7.2	0.8	78	40	33000	0.45	270	80	45	.	1.6	140
B1cz2	.	26000	7.4	0.5	80	33	35000	0.07	280	80	10	.	2.0	76
B2cz0	0.41	18000	6.4	.	64	54	25000	0.80	310	70	58	.	.	140
B2cz1	0.59	20000	8.0	0.4	80	70	31000	2.30	250	90	98	.	1.0	230
B2cz2	2.70	24000	11.0	2.4	100	98	38000	11.00	240	100	140	.	1.1	400
B2cz3	1.80	25000	10.0	1.7	100	94	39000	7.10	280	110	120	.	1.1	320
B3cz0	0.42	19000	7.8	0.4	68	55	27000	1.10	320	72	55	.	1.5	160
B3cz1	0.17	20000	7.7	0.3	66	30	29000	NA	NA	64	24	.	1.3	96
B3cz2	.	24000	6.2	.	78	29	33000	0.06	290	75	8	.	1.6	71
B4g	0.17	15000	7.0	.	48	41	21000	0.77	220	50	41	.	0.9	110
B5g	0.20	18000	6.9	.	65	53	28000	0.87	280	69	53	.	1.0	150
B6g	.	9000	3.5	.	42	17	14000	0.23	150	37	23	.	.	51
B7g	0.50	22000	7.9	0.8	79	67	35000	0.82	350	74	57	.	1.5	160
B8cz0	0.29	20000	6.9	.	71	61	32000	0.74	320	74	53	.	1.3	160
B8cz1	0.39	18000	7.8	0.6	78	60	29000	0.97	190	83	81	.	1.4	180
B8cz2	0.66	19000	11.0	2.2	81	66	31000	3.90	240	88	79	.	2.0	260
B8cz3	na	na	na	na	na	na	na	na	na	na	na	na	na	na
B9g	0.21	18000	5.8	.	65	40	27000	0.50	330	65	31	.	.	110
C1g	0.20	19000	8.8	0.8	60	70	30000	0.94	220	68	70	.	1.2	190
C2g	0.20	20000	7.6	.	66	66	31000	0.70	250	68	51	.	.	160
C3g	0.17	15000	7.9	0.2	59	72	28000	0.73	210	86	75	.	1.4	210
C4g	0.20	18000	8.3	.	63	65	30000	0.99	220	87	53	.	1.2	160
C5g	.	25000	9.5	0.9	56	86	36000	0.61	250	65	50	.	1.6	180
C6cz0	.	15000	8.3	0.4	54	83	31000	0.61	220	74	63	.	1.4	200
C6cz1	.	16000	9.2	0.6	62	83	28000	0.45	200	92	120	.	1.4	190
C7cz0	0.41	18000	6.7	.	61	55	26000	1.30	240	67	51	.	1.0	150
C7cz1	.	19000	6.4	0.3	57	27	30000	0.47	270	59	17	.	1.3	76
C7cz2	.	23000	6.2	0.2	75	29	35000	0.06	330	72	9	.	1.7	74
C7cz3	.	20000	6.0	0.2	67	29	33000	0.08	310	67	9	.	1.6	69
C8g	0.21	23000	7.6	0.7	64	52	29000	0.70	290	64	45	.	1.2	140
C9g	.	15000	6.5	.	52	43	24000	1.10	220	56	41	.	.	120
D1g	0.48	18000	9.6	0.3	84	110	31000	0.48	370	65	70	.	1.1	280
D2g	0.23	23000	13.0	0.4	73	150	36000	0.68	320	93	140	.	1.6	300
D3cz0	0.39	20000	9.8	1.0	65	100	33000	0.55	270	73	84	.	2.2	250
D3cz1	0.16	18000	9.0	.	57	93	31000	0.36	210	77	100	.	1.1	230
D3cz2	0.17	18000	9.2	1.6	80	75	30000	0.33	230	110	92	.	1.0	200
D4cz0	0.24	26000	12.0	.	73	130	43000	0.76	330	83	78	.	1.2	260
D4cz1	.	16000	8.5	0.3	61	74	30000	0.13	250	95	67	.	1.5	190
D5g	0.20	19000	10.0	.	55	71	40000	0.42	570	59	53	.	1.2	200
D6cz0	0.45	15000	8.9	0.3	51	100	31000	0.65	220	65	67	.	1.6	210
D6cz1	0.34	15000	8.5	0.9	63	67	27000	2.70	200	89	90	.	1.4	260
D6cz2	na	na	na	na	na	na	na	na	na	na	na	na	na	na
D7g	0.16	14000	.	.	57	63	29000	0.36	230	78	53	.	1.5	180

Appendix Table 3 (Cont'd.). Concentrations of trace elements (mg/Kg dry wt.) in San Leandro Bay sediment samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. "." = below detection limit, na = not analyzed due to insufficient sample material in the core section

Site code	Ag	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Zn
D8g	0.36	18000	8.4	.	64	86	33000	0.66	240	80	71	.	0.9	220
E1g	.	21000	5.9	.	71	40	31000	0.29	310	67	27	.	1.0	99
E2g	0.36	28000	9.4	1.1	74	97	42000	0.74	290	78	68	.	1.6	220
E3g	0.31	21000	8.0	.	75	57	34000	1.10	340	77	54	.	1.3	160
E4cz0	0.41	18000	7.5	0.4	61	57	30000	1.00	200	63	57	.	1.8	150
E4cz1	0.19	22000	6.9	0.2	69	36	30000	0.34	220	71	24	.	1.1	92
E4cz2	.	12000	5.6	.	42	17	22000	0.05	230	45	6	.	0.8	43
E5cz0	0.16	13000	5.1	.	47	35	19000	0.85	180	51	34	.	0.8	110
E5cz1	.	11000	5.2	.	39	19	18000	0.45	150	48	14	.	.	65
E5cz2	na	na	na	na	na	na	na	na	na	na	na	na	na	na
E6g	0.47	23000	7.9	1.2	82	68	33000	1.40	260	77	68	.	2.1	190
E7cz0	0.33	12000	4.8	.	44	34	20000	0.93	160	48	34	.	.	110
E7cz1	.	13000	6.3	0.4	45	25	19000	0.92	150	47	25	.	1.1	100
E7cz2	.	16000	5.2	.	46	17	20000	0.03	270	50	7	.	0.9	40
E8g	0.34	25000	7.7	0.9	80	63	37000	0.85	400	74	54	.	2.0	170
F1g	0.39	10000	5.3	1.1	45	61	17000	0.22	260	32	240	.	1.0	320
F2g	.	19000	13.0	1.1	51	76	28000	0.23	310	45	180	.	2.0	420
F3g	0.57	17000	8.2	2.3	65	88	25000	0.36	250	48	230	.	1.7	400
F4g	0.25	25000	7.5	.	75	78	34000	0.66	250	72	72	.	0.9	200
F5g	0.65	18000	8.6	2.8	67	99	28000	0.60	260	52	280	.	1.7	430
F6g	0.32	23000	7.7	1.1	67	83	35000	0.67	240	67	77	.	1.3	210
F7cz0	0.44	20000	6.8	.	66	68	33000	1.10	240	71	79	.	.	190
F7cz1	.	18000	5.9	.	63	29	29000	0.29	250	63	25	.	.	82
F7cz2	.	14000	5.0	.	47	20	23000	0.05	220	53	7	.	0.9	50
F8cz0	0.44	18000	5.9	0.6	55	57	24000	0.57	220	51	99	.	1.3	190
F8cz1	0.45	21000	8.5	1.9	76	83	29000	0.63	360	63	190	.	1.3	290
F9g	0.69	21000	8.2	2.5	72	100	31000	0.57	250	59	210	.	2.1	360
G1g	0.43	17000	5.9	1.3	63	54	26000	0.57	240	52	93	.	1.5	170
G2g	0.32	22000	6.5	0.6	81	55	31000	0.77	240	65	42	.	1.3	140
G3g	0.48	23000	8.0	1.6	83	72	35000	0.94	320	67	120	.	1.9	220
G4g	0.29	23000	7.2	0.9	67	58	29000	0.55	230	64	46	.	1.4	150
G5g	0.50	23000	8.7	2.1	77	74	34000	0.66	340	66	130	.	1.6	250
G6g	.	19000	7.7	0.3	32	35	29000	0.21	500	40	45	.	1.0	150
G7g	0.38	26000	7.5	1.3	70	66	33000	0.52	250	66	47	.	1.5	160
G8g	.	22000	4.1	1.4	61	32	27000	0.10	580	59	22	.	0.9	90
G9g	0.16	6600	2.9	0.9	67	25	9100	0.10	380	24	54	.	2.0	210

Appendix Table 4. Concentrations of PAHs (µg/Kg dry wt.) in San Leandro Bay sediment samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. "." = below detection limit, na = not analyzed due to low % solids in sample.

Site code	Total Low Mol Wt PAHs	Biphenyl	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	2,6-Dimethylnaphthalene	2,3,5-Trimethylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Dibenzothiophene	Fluorene	Phenanthrene	1-Methylphenanthrene	Total High Mol Wt PAHs	Benzo(a)anthracene	Chrysene	Fluoranthene	Pyrene	Benzo(a)pyrene	Benzo(e)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Dibenz(a,h)anthracene	Perylene	Benzo(ghi)perylene	Indeno(1,2,3-cd)pyrene	Total PAHs
A1g	354	5	16	18	14	22	19	12	19.0	41	18	170	2850	230	320	410	480	230	200	240	210	38	72	200	220	3204		
A2g	173	2	6	2	4	3	3	10	10.0	32	5	14	73	9	1562	130	190	370	270	110	74	120	110	16	29	58	85	1735
A3g	415	8	75	8	18	150	4	7	11.0	22	7	8	97	2	2147	140	210	290	270	190	170	230	170	32	55	180	210	2562
A4cz0	750	13	17	7	15	26	20	22	27.0	93	26	28	420	36	6270	500	600	820	830	510	380	620	440	110	130	630	700	7020
A4cz1	482	8	31	9	28	31	18	17	19.0	63	13	15	230	5	5910	500	530	530	990	540	470	610	420	80	140	540	560	6392
A5g	298	6	16	5	12	22	12	9	11.0	32	10	10	140	13	3003	220	270	410	430	250	240	300	230	43	80	250	280	3301
A6g	1141	6	14	12	15	26	25	25	57.0	130	33	96	640	62	5023	450	490	790	870	480	320	420	370	63	110	290	370	6164
A7cz0	2182	11	51	19	26	25	13	82	14.0	230	79	150	1400	82	6419	610	680	1400	1100	510	350	500	450	79	130	240	370	8601
A7cz1	629	6	25	8	15	8	7	33.0	90	25	51	320	33	1996	180	190	320	360	210	120	140	150	25	41	110	150	2625	
A8g	1017	6	23	10	16	15	7	38	8.0	100	37	70	650	37	3116	310	350	670	440	250	180	250	230	42	64	130	200	4133
B1cz0	232	4	8	4	7	7	3	4	13.0	29	8	14	120	11	1460	100	140	210	200	150	110	130	120	22	38	120	120	1692
B1cz1	112	3	38	2	6	9	2	2	4.0	13	2	5	23	3	526	29	40	46	45	51	32	45	42	7	110	34	45	638
B1cz2	38.8	1	25	1	2	2	1	0.2	1	0.2	1	2	1	161	1	2	2	2	2	2	2	2	2	150	1	1	200	
B2cz0	124	5	7	2	5	12	2	3	8.0	20	4	7	45	4	1229	69	97	120	150	130	91	110	93	19	40	140	170	1353
B2cz1	203	4	30	3	7	17	3	5	11.0	25	6	11	81	1	1435	76	92	150	180	160	110	140	110	25	52	150	190	1638
B2cz2	905	8	20	5	18	49	52	120	19.0	73	41	120	380	1	2863	200	240	590	470	230	170	190	150	33	110	220	260	3768
B2cz3	165	3	19	3	7	18	5	4	5.0	19	6	6	70	1	1546	110	140	210	180	140	110	160	110	24	42	150	170	1711
B3cz0	184	4	37	4	8	8	1	4	8.0	24	5	11	64	7	1264	85	120	130	160	130	85	110	92	21	41	130	160	1448
B3cz1	38	2	2	2	3	15	1	1	1	1	1	4	8	1	123	1	3	2	2	2	2	2	2	110	2	1	161	
B3cz2	154	5	10	3	7	14	4	8.0	27	5	10	61	1	1334	81	110	130	160	140	97	120	100	23	43	150	180	1488	
B4g	71	2	3	2	3	4	1	2	4.0	9	2	5	31	3	590	38	53	81	72	59	45	57	49	8	19	47	62	661
B5g	223	3	7	3	5	9	3	5	16.0	36	7	15	100	14	1507	120	150	210	200	160	110	150	120	17	43	97	130	1730
B6g	98	1	6	3	6	5	2	2	5.0	13	3	7	40	5	591	36	52	86	88	56	37	47	39	9	19	56	66	689
B7g	173	5	13	3	9	11	1	5	9.0	35	4	11	61	6	1603	100	160	170	190	160	110	140	120	25	58	170	200	1776
B8cz0	258	6	13	4	9	22	3	8	15.0	51	7	13	94	13	2376	150	200	260	260	240	170	230	170	29	77	270	320	2634
B8cz1	399	6	11	8	11	23	4	10	30.0	51	10	24	180	31	2422	180	190	280	310	280	160	230	180	33	59	230	290	2821
B8cz2	203	8	17	3	9	28	1	9	18.0	26	8	8	68	1	2524	130	120	220	370	270	200	230	170	34	130	300	350	2727
B8cz3	2613	19	31	24	14	120	75	130	170.0	360	110	120	1300	140	9979	900	840	1700	2100	900	540	600	590	89	310	620	790	12592
B9g	162	3	9	2	5	7	1	4	10.0	30	1	9	72	10	1659	110	140	200	200	180	110	130	110	22	57	180	220	1821
C1g	241	4	8	4	8	14	7	3	11.0	27	8	18	110	19	1444	110	130	180	170	150	110	150	110	24	40	120	150	1685
C2g	112	2	5	3	4	8	2	3	6.0	18	3	6	46	6	1093	74	100	120	120	110	86	110	88	18	37	100	130	1205
C3g	153	2	6	3	5	8	4	5	6.0	21	1	9	77	7	1095	80	100	150	140	99	73	97	82	18	26	110	120	1248
C4g	90	2	4	2	4	5	2	2	4.0	12	1	6	43	4	848	58	76	110	99	77	69	88	59	16	24	81	91	938
C5g	133	4	9	4	9	16	5	4	5.0	15	5	10	47	1	1195	75	110	140	120	110	91	110	89	23	47	130	150	1328
C6cz0	108	2	7	2	5	9	4	3	4.0	11	4	4	49	4	1164	76	100	140	120	110	75	120	89	20	34	130	150	1272
C6cz1	186	4	12	5	11	19	10	5	9.0	20	8	9	74	1	2136	110	160	200	220	220	200	200	180	45	81	250	270	2322
C7cz0	220	4	37	3	8	9	1	4	11.0	28	6	11	86	12	1491	110	140	190	190	150	106	130	130	23	42	120	160	1711
C7cz1	59	1	5	1	3	7	1	1	2.0	7	2	3	25	2	316	20	24	31	42	34	19	24	21	5	24	33	39	375
C7cz2	26	1	4	1	2	3	1	0.3	5	1	1	3	5	1	125	1	2	2	2	2	3	2	2	110	2	1	151	
C7cz3	33.5	2	5	1	3	6	1	0.5	1	1	1	3	9	2	159	3	5	5	5	3	3	4	2	1	120	4	4	192
C8g	141	3	8	3	7	14	9	4	5.0	15	5	7	53	8	1298	87	120	160	140	120	100	130	96	25	40	130	150	1439
C9g	314	3	7	2	4	8	2	4	13.0	51	10	17	180	13	1854	150	170	270	260	190	110	130	120	27	47	170	210	2168
D1g	198	4	8	4	9	81	13	4	5.0	10	5	55	5	889	57	87	120	99	78	73	84	74	17	28	79	93	1087	
D2g	155	3	8	4	7	15	8	5	7.0	14	1	7	70	7	1496	99	140	210	210	120	130	160	110	18	39	120	140	1651
D3cz0	131	3	30	2	7	13	4	3	4.0	10	4	5	43	3	895	56	86	110	110	82	70	85	70	15	25	87	99	1026
D3cz1	183	2	16	25	35	17	4	2	4.0	12	4	5	57	3	982	62	69	120	120	95	83	100	80	18	25	100	110	1165
D3cz2	59	1	23	2	4	7	1	1	2.0	4	2	1	13	1	303	17	26	29	40	31	24	32	29	6	11	28	30	362
D4cz0	139	3	7	3	6	16	4	5	5.0	16	5	8	56	5	1306	89	120	150	130	120	86	120	96	28	37	160	170	1445
D4cz1	55.9	1	2	1	2	4	3	1	2.0	7	2	3	28	1	711	47	58	96	120	61	47	56	48	12	28	63	75	767
D5g	153	2	5	2	5	31	2	6	3.0	17	1	11	60	9	854	59												

Appendix Table 4 (Cont'd.). Concentrations of PAHs (µg/Kg dry wt.) in San Leandro Bay sediment samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. "." = below detection limit, na = not analyzed due to low % solids in sample.

Site code	Total Low Mol Wt PAHs	Biphenyl	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	2,6-Dimethylnaphthalene	2,3,5-Trimethylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Dibenzothiophene	Fluorene	Phenanthrene	1-Methylphenanthrene	Total High Mol Wt PAHs	Benz(a)anthracene	Chrysene	Fluoranthene	Pyrene	Benzo(a)pyrene	Benzo(e)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Dibenz(e,h)anthracene	Perylene	Benzo(ghi)perylene	Indeno(1,2,3-cd)pyrene	Total PAHs	
E7cz2	1.5	.	1	.	.	.	.	.	.	.	.	.	.	.	10	1	1	1	1	1	1	.	1	.	2	1	1	12
E8g	149	4	10	3	7	9	3	3	8.0	26	5	9	55	7	1464	91	140	130	160	150	110	140	110	26	47	160	200	1613	
F1g	2416	89	270	160	340	280	550	37	23.0	140	.	130	330	67	6670	470	600	580	740	720	530	620	660	150	180	550	870	9086	
F2g	1451	25	100	66	120	110	77	46	20.0	130	.	91	590	76	9070	760	1200	1300	1300	880	680	720	700	130	200	540	660	10521	
F3g	1353	43	120	71	130	110	200	39	39.0	96	31	74	400	.	11880	770	990	1100	1000	1400	900	1200	1100	230	290	1300	1600	13233	
F4g	261	8	18	7	15	36	13	8	10.0	27	.	16	88	15	2504	150	200	270	310	260	190	250	220	47	67	240	300	2765	
F5g	1495	50	140	86	160	120	240	39	33.0	100	29	72	370	56	13310	820	1100	1100	1200	1500	1100	1500	1200	260	330	1400	1800	14805	
F6g	524	19	51	21	47	93	46	14	19.0	48	12	24	130	.	4041	260	350	460	430	390	330	420	300	71	110	410	510	4565	
F7cz0	198	4	13	5	11	17	7	5	9.0	19	6	7	86	9	2014	130	170	230	200	210	150	180	160	39	55	220	270	2212	
F7cz1	156	3	10	4	8	10	5	3	8.0	17	4	5	70	9	1148	77	92	120	130	130	79	98	92	19	61	110	140	1304	
F7cz2	2.6	.	1	.	.	1	.	.	.	.	.	.	1	.	47	.	1	1	1	2	2	2	1	.	33	2	2	49
F8cz0	263	5	17	9	17	34	23	10	9.0	22	6	9	94	8	3022	210	300	250	260	300	240	290	240	69	73	350	440	3285	
F8cz1	656	17	53	30	58	79	84	19	33.0	75	17	21	170	.	7130	400	500	880	730	700	470	650	590	180	180	850	1000	7786	
F9g	1546	51	140	80	150	130	240	38	38.0	110	30	73	410	56	10820	690	940	1000	1000	1200	870	1200	970	250	300	1000	1400	12366	
G1g	178	3	8	4	8	17	12	4	10.0	16	4	6	78	8	2275	130	170	210	250	240	190	240	190	54	61	250	290	2453	
G2g	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
G3g	394	5	15	8	15	22	21	11	18.0	30	12	11	210	16	4638	300	390	530	610	480	350	430	390	98	110	430	520	5032	
G4g	196	5	12	4	8	30	3	4	9.0	52	4	10	55	.	1645	110	190	160	170	180	120	180	150	27	58	130	170	1841	
G5g	325	6	21	8	20	30	17	8	25.0	28	9	10	130	13	3457	290	280	350	380	340	280	330	280	68	79	350	430	3782	
G6g	53	.	2	2	2	5	2	1	1.0	4	2	3	27	2	491	30	44	56	61	47	38	46	46	10	14	43	56	544	
G7g	358	8	12	5	14	110	6	8	24.0	50	8	23	90	.	2991	270	240	340	350	290	210	260	220	52	99	300	360	3349	
G8g	68	.	2	1	3	15	2	2	1.0	5	2	2	33	.	514	36	50	69	66	45	35	46	42	10	15	45	55	582	
G9g	1064	.	24	.	.	670	31	14	18.0	37	.	.	270	.	5110	290	500	530	610	450	400	460	470	110	180	540	570	6174	

Appendix Table 5. Concentrations of PCBs (µg/Kg dry wt.) in San Leandro Bay sediment samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. "." = below detection limit, na = not analyzed due to low % solids in sample.

Site code	Total PCBs	PCB 008	PCB 018	PCB 029/31	PCB 033	PCB 044	PCB 049	PCB 052	PCB 055	PCB 060	PCB 066/95	PCB 070	PCB 074	PCB 077	PCB 081	PCB 087	PCB 090	PCB 097	PCB 099	PCB 101	PCB 105	PCB 110	PCB 114	PCB 118	PCB 123	PCB 126	PCB 128	PCB 132	PCB 138	PCB 141	PCB 149	PCB 151	PCB 153	PCB 156	PCB 157	PCB 158	PCB 166	PCB 167	PCB 169	PCB 170	PCB 174	PCB 177	PCB 180	PCB 183	PCB 184	PCB 187	PCB 189	PCB 194	PCB 195	PCB 201	PCB 203	PCB 206	PCB 209	Total PCBs
A1g	505	.	.	5	.	6	6	13	5	.	25	7	.	.	.	13	.	6	13	39	8	24	.	18	.	.	6	14	49	13	35	14	48	18	17	9	34	10	.	22	.	6	.	7	9	.	.	505	
A2g	6	6	6		
A3g	137	7	.	.	5	8	11	.	5	11	.	7	.	6	20	14	.	19	8	7	.	16	.	11	137			
A4cz0	415	6	7	19	9	6	10	26	7	22	15	5	14	43	11	32	12	37	16	16	9	32	9	19	415		
A4cz1	1505	8	.	23	13	19	15	29	.	60	28	14	.	24	.	14	45	61	14	68	36	12	29	150	39	130	35	160	9	.	.	.	50	83	25	120	29	91	.	22	11	24	8	10	1505					
A5g	351	5	8	15	5	.	8	.	10	15	14	12	9	38	6	28	10	37	.	.	.	10	14	9	33	11	21	.	11	351				
A6g	251	6	13	5	.	9	12	11	11	8	31	10	21	8	27	11	10	6	25	8	14	5	251					
A7cz0	64	7	5	6	12	7	10	10	.	7	64							
A7cz1	68	9	7	8	14	9	10	6	5	68							
A8g	54	6	6	.	6	11	8	10	7	6	54							
B1cz0	74	5	9	.	7	.	6	14	8	12	7	6	74							
B1cz1	5	5							
B1cz2							
B2cz0	35	5	7	10	6	8	35					
B2cz1	81	9	5	7	18	11	14	7	81				
B2cz2	2531	13	.	.	.	37	110	180	11	11	210	75	27	.	71	.	57	140	240	66	280	260	36	44	250	130	13	170	18	.	.	.	11	.	17	8	23	.	.	6	11	2531								
B2cz3	2660	5	.	.	.	48	100	200	9	.	230	130	26	.	67	.	64	150	230	58	290	240	31	48	230	22	140	18	170	16	.	.	.	6	8	.	18	14	9	26	.	19	6	7	7	6	12	2660		
B3cz0	16	9	.	7	16				
B3cz1						
B3cz2						
B4g	14	7	6	7	6	7	14				
B5g	43	6	10	6	8	43					
B6g						
B7g	41	7	6	10	5	7	41				
B8cz0	21	9	5	7	21				
B8cz1	171	5	.	6	13	6	.	.	.	7	.	7	16	5	15	14	23	13	18	10	.	8	171					
B8cz2	247	6	9	12	.	.	19	9	.	.	10	.	10	13	25	8	24	20	7	27	15	19	8	6	247					
B8cz3	1716	8	.	.	.	26	43	93	.	28	120	60	.	53	.	46	64	100	57	150	130	27	42	160	27	93	17	120	14	.	.	.	6	.	25	24	11	50	18	36	13	5	11	16	8	15	1716		
B9g	5	5	5			
C1g	42	6	5	10	6	10	5	42					
C2g	16	9	.	7	16				
C3g	53	8	13	8	11	6	53					
C4g	6	6	6				
C5g	12	7	.	5											

Appendix Table 5 (Cont'd.). Concentrations of PCBs (µg/Kg dry wt.) in San Leandro Bay sediment samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. " ." = below detection limit, na = not analyzed due to low % solids in sample.

		Total PCBs	PCB 008	PCB 018	PCB 028/31	PCB 033	PCB 044	PCB 049	PCB 052	PCB 055	PCB 060	PCB 066/95	PCB 070	PCB 074	PCB 077	PCB 081	PCB 087	PCB 090	PCB 097	PCB 099	PCB 101	PCB 105	PCB 110	PCB 114	PCB 118	PCB 123	PCB 126	PCB 128	PCB 132	PCB 138	PCB 141	PCB 149	PCB 151	PCB 153	PCB 156	PCB 157	PCB 158	PCB 166	PCB 167	PCB 169	PCB 170	PCB 174	PCB 177	PCB 180	PCB 183	PCB 184	PCB 187	PCB 189	PCB 194	PCB 195	PCB 201	PCB 203	PCB 206	PCB 209	Total PCBs
Site code																																																							
F1g	204	.	.	7	.	6	6	11	.	.	19	9	16	6	19	.	13	6	24	.	15	.	19	204			
F2g	136	7	14	12	5	17	.	9	5	21	5	11	.	13	136			
F3g	263	8	.	.	17	7	8	.	.	6	21	.	16	.	13	.	.	.	8	30	7	21	7	26	10	9	5	20	5	.	13	.	.	6	.	.	263				
F4g	36	6	.	5	11	.	6	.	8	36					
F5g	300	.	.	6	.	6	.	10	.	.	19	8	9	.	6	7	22	6	19	.	16	.	.	9	34	6	21	7	27	10	9	6	19	.	.	13	.	.	.	5	300						
F6g	42	7	.	5	10	.	6	.	8	42						
F7cz0	35	6	.	5	10	.	6	.	8	35						
F7cz1					
F7cz2					
F8cz0	57	6	8	.	7	.	5	11	.	7	.	8	57					
F8cz1	174	6	7	14	8	.	.	.	6	.	.	.	7	14	.	13	.	12	.	.	.	6	21	.	12	.	17	.	.	.	6	6	.	11	.	.	8	174					
F9g	302	.	.	6	.	5	.	10	.	.	20	8	9	.	5	7	24	6	19	.	16	9	33	6	20	7	28	.	.	.	10	5	5	19	5	.	13	7	302				
G1g	76	6	5	7	8	.	7	.	7	13	.	7	.	10	10	.	.	6	76					
G2g	13	7	.	.	.	6	13					
G3g	136	6	6	11	6	.	.	.	6	10	.	12	.	10	.	.	.	19	.	12	.	14	5	.	.	11	.	.	8	136					
G4g	23	9	.	6	.	8	23					
G5g	125	9	6	11	6	13	.	12	.	10	.	.	.	18	.	10	.	14	9	.	.	7	125						
G6g		na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na				
G7g		na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na				
G8g		na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na				
G9g		na	a	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na				

Appendix Table 6. Concentrations of Pesticides (µg/Kg) in San Leandro Bay sediment samples.
 All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. "." = below detection limit

Station Code	DDTs							Chlordanes							Cyclopentadienes			HCHs				Other		
	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	Total DDT	alpha-Chlordane	gamma-Chlordane	cis-Nonachlor	trans-Nonachlor	Heptachlor	Heptachlor Epoxide	Oxychlordane	Total Chlordanes	Aldrin	Dieldrin	Endrin	alpha-HCH	beta-HCH	delta-HCH	gamma-HCH	Hexachlorobenzene	Chlorpyrifos
A1g	.	.	.	140	.	.	140	22	.	75	.	.	.	.	97	.	.	.	.	.	.	.	.	.
A2g	.	.	.	7	.	9	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A3g	14	11	.	67	25	24	141	17	25	32	19	.	16	.	109	.	23	.	.	.	.	.	.	.
A4cz0	.	.	.	57	25	53	135	20	20	23	28	.	.	.	91	.	.	.	.	.	.	.	.	10
A4cz1	150	.	.	680	110	100	1040	74	80	77	62	.	.	.	293	.	.	.	.	.	.	.	.	.
A5g	16	.	.	51	15	37	119	11	13	12	7	.	7	.	50	.	.	6	.	.	.	.	.	.
A6g	.	.	.	70	25	49	144	12	22	16	11	.	.	.	61	.	.	.	.	.	.	.	.	.
A7cz0	15	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A7cz1	17	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A8g	.	.	.	37	12	18	67	.	.	10	.	.	.	.	10	.	.	.	.	.	.	.	.	.
B1cz0	.	.	.	19	14	21	54	.	.	17	.	.	.	.	17	.	12	.	.	.	.	.	.	.
B1cz1	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B2cz0	21	21	.	.	12	.	.	.	.	12	.	.	.	.	.	.	.	.	.
B2cz1	25	25	.	.	13	.	.	.	.	13	.	.	.	.	.	.	.	.	.
B2cz2	96	190	286	.	.	84	.	.	.	.	84	.	.	.	.	.	.	.	.	.
B2cz3	44	59	.	.	93	230	426	.	.	98	57	.	.	.	155	.	.	.	.	.	.	.	.	.
B3cz0	13	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B3cz2	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B4g	10	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B5g	8	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B7g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B8cz0	.	.	.	7	7	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B8cz1	11	.	11	.	.	16	.	.	.	.	16	.	.	.	.	.	.	.	.	.
B8cz3	0	.	.	124	.	.	.	.	124	.	.	.	.	.	.	.	.	.
B9g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C1g	.	.	.	13	11	24	48	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C2g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C3g	.	.	.	9	5	23	37	.	.	8	.	.	.	.	8	.	.	.	.	.	.	.	.	.
C4g	.	.	.	5	.	9	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C5g	.	.	.	19	17	.	36	.	10	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.
C6cz0	.	.	.	19	11	24	54	11	13	14	11	.	.	.	49	.	.	.	.	.	.	.	.	.
C6cz1	.	.	.	210	51	140	401	50	90	48	50	.	.	.	238	.	.	.	.	.	.	.	.	.
C7cz0	19	19	10	.	11	.	.	.	.	21	.	.	.	.	.	.	.	.	.
C8g	.	.	.	20	23	19	62	12	12	.	10	.	.	.	34	.	.	.	.	.	.	.	.	.
C9g	11	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
D1g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
D2g	.	.	.	6	18	24	.	6	.	.	.	.	.	.	6	.	.	.	.	.	.	.	.	.
D3cz0	.	.	.	15	12	21	48	13	17	13	11	.	.	.	54	.	12	.	.	.	.	.	.	.
D3cz1	.	.	.	49	40	.	89	21	41	.	23	.	.	.	85	.	.	.	.	.	.	.	.	.
D3cz2	.	.	.	220	.	.	220	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
D4cz0	.	.	.	17	12	24	53	.	11	10	10	.	.	.	31	.	.	.	.	.	.	.	.	.
D4cz1	.	.	9	23	11	173	216	.	8	.	.	.	.	.	8	.	.	.	.	.	.	.	.	.
D5g	.	14	.	.	24	72	110	.	.	34	7	.	.	.	41	.	.	.	.	.	.	.	12	8
D6cz0	.	.	.	15	20	.	35	17	24	.	12	.	.	.	53	.	.	.	.	.	.	.	.	.
D6cz1	.	.	.	25	10	9	44	10	13	.	6	.	.	.	29	.	.	.	.	.	.	.	.	.
D6cz2	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
D7g	.	.	.	13	13	19	45	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
D8g	.	.	.	10	8	18	36	6	8	7	6	.	.	.	27	.	.	.	.	.	.	.	.	.
E2g	.	.	.	17	16	.	33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E3g	8	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E4cz0	33	33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E6g	12	31	43	.	.	17	.	.	.	.	17	.	18	.	.	.	.	.	.	.
E7cz0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E8g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Appendix Table 6 (Cont'd). Concentrations of Pesticides (µg/Kg) in San Leandro Bay sediment samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. "." = below detection limit

	DDTs							Chlordanes							Cyclopentadienes			HCHs				Other		
	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	Total DDT	alpha-Chlordane	gamma-Chlordane	cis-Nonachlor	trans-Nonachlor	Heptachlor	Heptachlor Epoxide	Oxychlordane	Total Chlordanes	Aldrin	Dieldrin	Endrin	alpha-HCH	beta-HCH	delta-HCH	gamma-HCH	Hexachlorobenzene	Chlorpyrifos
Station Code																								
F1g	.	.	.	14	18	34	66	7	10	12	5	.	.	.	34	.	.	.	.	.	.	.	.	.
F2g	.	.	.	30	15	32	77	16	17	5	14	.	.	.	52	.	.	.	.	.	.	.	.	12
F3g	.	7	.	29	16	48	100	11	13	16	14	.	.	.	54	.	.	.	.	.	.	.	.	7
F4g	.	.	.	8	.	7	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F5g	38	.	.	38	25	.	101	.	.	26	.	.	.	.	26	.	.	.	.	.	.	.	.	.
F6g	.	.	.	22	17	.	39	.	.	.	.	.	.	.	.	.	.	.	17	.	.	.	.	17
F7cz0	.	.	.	18	12	26	56	.	.	11	.	.	.	.	11	.	.	.	.	.	.	.	.	.
F7cz1	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F8cz0	.	.	.	24	13	.	37	.	.	.	12	.	.	.	12	.	.	.	.	.	.	.	.	.
F8cz1	.	.	.	99	.	.	99	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F9g	.	.	.	47	29	.	76	37	20	30	27	.	.	.	114	.	43	.	.	.	.	.	.	.
G1g	.	22	.	36	35	.	93	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G3g	.	.	.	41	35	.	76	.	23	.	.	.	.	.	23	.	.	.	.	.	.	.	.	.
G4g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G5g	22	25	.	89	41	61	238	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G6g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G7g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G8g	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G9g	.	.	.	20	20	.	40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Appendix Table 7. Concentrations of P450 RGS equivalents in San Leandro Bay sediment samples.

All samples were collected between 9/15/98 and 9/18/98. Site codes are coded to aid in identifying the location and type of sample. The first letter indicates the spatial area of San Leandro Bay where the site is located (see Map Figure 1). The lower case letter indicates grab (g) or core (c) samples. For core samples, z0 = surface, z1 = first foot depth, z2, second foot depth, z3 = third foot depth. B(a)Peq = Benzo(a)pyrene equivalents, TEQ = dioxin equivalents (after 6 hours only).

Site code	B(a)Peq	TEQ
	mg/Kg	µg/Kg
A1g	216.9	13.0
A2g	78.9	4.7
A3g	316.1	19.0
A4cz0	304.4	18.3
A4cz1	433.2	26.0
A5g	327.9	19.7
A6g	305.0	18.3
A7cz0	146.4	8.8
A7cz1	88.8	5.3
A8g	169.8	10.2
B1cz0	75.1	4.5
B1cz1	45.0	2.7
B1cz2	15.0	0.9
B2cz0	72.6	4.4
B2cz1	68.9	4.1
B2cz2	317.2	19.0
B2cz3	196.3	11.8
B3cz0	91.1	5.5
B3cz1	13.5	0.8
B3cz2	83.7	5.0
B4g	43.8	2.6
B5g	104.9	6.3
B6g	32.3	1.9
B7g	90.8	5.4
B8cz0	101.4	6.1
B8cz1	113.5	6.8
B8cz2	156.1	9.4
B8cz3	375.0	22.5
B9g	65.6	3.9
C1g	113.2	6.8
C2g	89.0	5.3
C3g	75.2	4.5
C4g	63.7	3.8
C5g	109.6	6.6
C6cz0	132.3	7.9
C6cz1	203.3	12.2
C7cz0	99.6	6.0
C7cz1	18.5	1.1
C7cz2	12.5	0.7
C7cz3	23.1	1.4
C8g	96.8	5.8
C9g	63.6	3.8

Site code	B(a)Peq	TEQ
continued	mg/Kg	µg/Kg
D1g	154.0	9.2
D2g	219.1	13.1
D3cz0	143.0	8.6
D3cz1	137.3	8.2
D3cz2	88.6	5.3
D4cz0	194.0	11.6
D4cz1	98.0	5.9
D5g	94.0	5.6
D6cz0	181.6	10.9
D6cz1	121.2	7.3
D6cz2	313.8	18.8
D7g	79.9	4.8
D8g	132.1	7.9
E1g	39.5	2.4
E2g	150.3	9.0
E3g	107.6	6.5
E4cz0	215.0	12.9
E4cz1	26.4	1.6
E4cz2	13.1	0.8
E5cz0	38.0	2.3
E5cz1	15.6	0.9
E5cz2	8.4	0.5
E6g	106.0	6.4
E7cz0	49.5	3.0
E7cz1	31.9	1.9
E7cz2	7.3	0.4
E8g	97.0	5.8
F1g	411.3	24.7
F2g	405.4	24.3
F3g	299.8	18.2
F4g	153.8	9.2
F5g	223.6	12.7
F6g	410.0	24.6
F7cz0	122.9	7.4
F7cz1	47.9	2.9
F7cz2	9.0	0.5
F8cz0	163.6	9.8
F8cz1	378.0	22.7
F9g	232.2	18.6
G1g	121.2	7.3
G3g	256.1	15.4
G4g	94.6	5.7
G5g	218.6	13.1
G6g	52.0	3.1
G7g	152.0	9.1
G8g	47.0	2.8
G9g	142.0	53.2

Appendix Table 8. Metals Standard Reference Materials (SRMs)*

values in ppm

Analyte	Value	Limits	9809435	9809436	9809437	9809438	9809439
Aluminum	5720	3760-7690	4700	5200	5200	4600	5500
Antimony	26.6	3.49-49.6	20	24	17	33	21
Arsenic	163	102-225	160	160	160	160	160
Cadmium	114	84.9-142	100	99	110	100	98
Chromium	175	121-229	160	160	160	160	150
Copper	91	64.6-117	80	81	84	84	80
Iron	9080	4830-13300	7100	8800	7300	7700	9000
Lead	66	44.7-87.3	60	60	63	62	59
Manganese	261	204-319	220	230	230	230	230
Mercury	1.75	0.951-2.56	1.87	2	1.6	1.7	1.7
Nickel	68.3	38.1-98.6	57	54	61	59	55
Selenium	123	91.4-155	110	110	120	120	120
Silver	57.2	40.8-73.5	49 **	33	50	53	51
Zinc	190	144-236	180	170	180	170	170

* Standard Reference Material (from Environmental Resource Associates. Lot # 239)

** did not meet data quality objectives

Appendix Table 9. Organics Standard Reference Materials (SRMs)

PCB Standard Reference Materials (SRMs)				
	parameter	Percent Recovery	True Value	Acceptance Limits
KWG9803782-6	2,2',4,4',6,6'-Hexabromobiphenyl	62		30-150
KWG9803783-6	2,2',4,4',6,6'-Hexabromobiphenyl	45		30-150
KWG9803819-6	2,2',4,4',6,6'-Hexabromobiphenyl	75		30-150
K981210-SRM1	2,2',4,4',6,6'-Hexabromobiphenyl	62		30-150
K981210-SRM2	2,2',4,4',6,6'-Hexabromobiphenyl	59		30-150

SRMs - Congener Specific PCBs				
		Result (ppb)	True Value	Acceptance Limits
KWG9803819-6	PCB 008	1.3	1.39 ± 0.19	0.6-2.4
KWG9803819-6	PCB 018	3.1 *	1.15 ± 0.16	0.50-2.0
KWG9803819-6	PCB 028_31	4.8	9.8 ± 3.7	3.0-20
KWG9803819-6	PCB 044	4.4	4.8 ± 0.62	2.1-8.1
KWG9803819-6	PCB 049	4.6	9.5 ± 2.1	3.7-17
KWG9803819-6	PCB 052	5.6	6.9 ± 0.56	3.2-11
KWG9803819-6	PCB 066_95	11.6	14.3 ± 2.5	5.9-25
KWG9803819-6	PCB 087	3.0 *	6.7 ± 0.37	3.2-11
KWG9803819-6	PCB 099	5.7	4.17 ± 0.51	1.8-7.0
KWG9803819-6	PCB 101	8.7	11 ± 1.6	4.7-19
KWG9803819-6	PCB 105	3.0	3.65 ± 0.27	1.7-5.9
KWG9803819-6	PCB 110	7.6	9.47 ± 0.85	4.3-16
KWG9803819-6	PCB 118	6.6	10 ± 1.1	4.4-17
KWG9803819-6	PCB 128	1.3	1.87 ± 0.32	0.78-3.3
KWG9803819-6	PCB 138	10.9	13.38 ± 0.97	6.2-22
KWG9803819-6	PCB 149	7.4	9.2 ± 1.1	4.0-16
KWG9803819-6	PCB 151	2.3	2.62 ± 0.22	1.2-4.3
KWG9803819-6	PCB 153	9.7	17.6 ± 1.9	7.8-29
KWG9803819-6	PCB 156	1.6	0.93 ± 0.14	0.40-1.6
KWG9803819-6	PCB 170	3.5	3 ± 0.46	1.3-5.2
KWG9803819-6	PCB 180	7.0	5.83 ± 0.58	2.6-9.6
KWG9803819-6	PCB 183	1.3	1.63 ± 0.15	0.74-2.7
KWG9803819-6	PCB 187	5.1	7.0 ± 2.6	2.2-14
KWG9803819-6	PCB 194	1.8	1.78 ± 0.23	0.78-3.0
KWG9803819-6	PCB 206	3.0	3.67 ± 0.87	1.4-6.8
KWG9803819-6	PCB 209	7.2	8.34 ± 0.49	3.9-13

PAH SRMs				
		Percent Recovery		Acceptance Limits
KWG9803548-4	Fluorene-d10	103		13-142
KWG9803548-4	Fluoranthene-d10	112		13-142
KWG9803548-4	p-Terphenyl-d14	106		15-145
KWG9803552-4	Fluorene-d10	103		13-142
KWG9803552-4	Fluoranthene-d10	105		13-142
KWG9803552-4	p-Terphenyl-d14	107		15-145
KWG9803611-6	Fluorene-d10	90		13-142
KWG9803611-6	Fluoranthene-d10	109		13-142
KWG9803611-6	p-Terphenyl-d14	96		15-145
KWG9803632-5	Fluorene-d10	91		13-142
KWG9803632-5	Fluoranthene-d10	101		13-142
KWG9803632-5	p-Terphenyl-d14	88		15-145
KWG9803645-3	Fluorene-d10	97		13-142
KWG9803645-3	Fluoranthene-d10	116		13-142
KWG9803645-3	p-Terphenyl-d14	87		15-145

* did not meet data quality objectives