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2000-01 Alameda County Watershed Sediment Sampling Program: Two-Year Summary and Analysis



Alameda Countywide Clean Water Program

A Consortium of Local Agencies

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Scope

The Alameda Countywide Clean Water Program conducts Watershed Assessment and Monitoring/Special Studies activities in coordination with the requirements of its NPDES permit for stormwater discharge, as outlined in the Stormwater Quality Management Plan for FY 2002-2008. These program components encompass data collection and analysis tasks ranging from general characterization of water quality and watershed conditions to investigation of Best Management Practices for reducing localized impacts from urban runoff. This report supports ACCWP Task MS-1, Characterization and Tracking of Pollutants of Concern, as part of the effort to address pollutants of concern outlined in the Program's draft NPDES permit.

Executive Summary

Introduction. This study reports on measurements designed to assess sources and loadings of pollutants of concern in Alameda County stormwater conveyances in support of Total Maximum Daily Load (TMDL) development by the Regional Water Quality Control Board. The assessment focuses on pollutants that are predominantly associated with sediments: polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), mercury, and certain pesticides.

The first phase of this project, begun in 2000, identified two conveyances that had sediments with substantially elevated concentrations of PCBs relative to measurements in San Francisco Bay: the Ettie Street Pump Station and Glen Echo Creek. Follow-up studies to locate sources are underway in those two catchments. As part of the 2001 study, sediments were collected from nineteen sites in creeks, flood control channels, and one in-channel stilling basin in western Alameda County. Samples were subsequently analyzed for PCBs, total mercury, PAHs, selected pesticides and grain size.

Results. In 2001, concentrations for total mercury were highest at the San Leandro Creek site (4.29 ppm). Other sites with concentrations above 1 ppm were Decoto – BART (2.70 ppm), Cerrito Creek (1.99 ppm), and one of the two Codornices Creek replicates (1.92 ppm). Concentrations for total PCBs were highest at the Ettie Street Pump Station (763 ppb), San Leandro Creek (472 ppb), and Cerrito Creek (299 ppb). Raw concentrations for total PAHs were highest at the two Balentine Drive replicates (13,681 and 13,443 ppb), Ettie Street (13,380 ppb), Glen Echo Creek (11,751 ppb), and San Leandro Creek (10,383 ppb). Sampling for organochlorine pesticides was initiated in 2001. A number of the pesticides analyzed were not detected in any of the samples (aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, endosulfan I, endosulfan II, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, and mirex), though this is likely due in part to elevated method detection limits.

Analysis. To identify watersheds that may contain controllable sources causing an increase in the pollutant concentration of Bay sediments, pollutant concentrations in watershed sediments are compared to ambient concentrations of Bay sediments. Watershed sediments that have significantly higher pollutant concentrations than Bay sediments can be expected to increase in the pollutant concentrations of Bay sediments if the watershed sediment load is sufficiently high.

Results of analyses for each analyte were compared, where possible, with existing ambient sediment concentrations as one method of gauging sediment quality. Of the twenty-four sites sampled as part of the 2002 program, sixteen sites exceeded ambient concentrations for total PCBs, eleven exceeded screening values for mercury, and nineteen exceeded screening values for total PAHs. There is no

screening value for total organochlorine pesticides, though a comparison for total DDTs showed that at least twenty of the twenty-four sites exceeded the ambient concentrations.

It should be noted that for each of these comparisons, ambient values were calculated based on historic Bay sampling data. As this data is generated from “spine of the estuary” sites and are generally heavily-weighted toward sites somewhat removed from the Bay margins, they may underestimate ambient concentrations were shallower sites more represented within the dataset used to calculate the ambient concentrations. The Clean Estuary Partnership has proposed a study for 2002-2003 to calculate nearshore sediment ambient concentrations that may result in better screening values for the purposes of these types of comparisons.

Findings & Recommendations *Finding 1: Pollutant concentrations in bedded sediment are useful for detecting order-of-magnitude differences between watersheds.* Based on the spatial and temporal variability inherent to the methods, tenfold or greater differences between watersheds are statistically significant, but twofold to threefold differences are not. This order-of magnitude approach is useful for identifying high priority areas, and for verifying assumptions about the difference between urbanized and open space watersheds. Using this approach, eight watersheds in Alameda County stand out as appropriate areas for further investigation. These sites are the Ettie Street Pumping Station (PCBs), Glen Echo Creek (PCBs), San Leandro Creek (mercury, PCBs, DDT), Cerrito Creek (mercury and PCBs), Codornices Creek (mercury), Castro Valley Creek (DDTs), Seminary Creek (DDTs), and Alameda Creek (large watershed)

Recommendation 1: Follow-up actions initiated by this study should be based on statistically significant differences. Previously recommended actions, such as eliminating certain open space sites and conducting more intensive source investigations on certain urban catchments, are based on tenfold or greater observed differences. Future management decisions should continue to refer to the limits of the resolving power of watershed assessment data. If decisions need to be made based on more subtle differences between watersheds, then a more sensitive sampling and assessment approach will have to be developed.

Finding 2: The analytical methods used for measuring concentrations of pesticides in sediment did not allow for comparisons of the data with concentrations in Bay sediments. In many cases, the MDLs associated with specific pesticide analytes were above the concentrations expected for Bay sediments. For these pesticides, a “no detect” result could be produced from a sample with concentrations that exceeded sediment screening values.

Recommendation 2: An attempt should be made to identify an alternative methodology for gathering and interpreting pesticide data. These efforts may be complicated somewhat in the uncertainties surrounding degradation rates and residence times of pesticides in the sediment. They may also be affected by the tendency of PCBs to interfere with analysis of certain pesticides, resulting in higher than expected MDLs and method reporting limits (MRLs). Analyses of pesticides should be excluded from future sampling programs until an acceptable methodology for analysis of pesticides can be developed.

Introduction

This study assesses sources and loadings of pollutants of concern in Alameda County stormwater conveyances. The assessment focuses on pollutants that are predominantly associated with sediments: polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), mercury, and organochlorine, or chlorinated (OC) pesticides. These pollutants primarily affect the beneficial uses of fishing, wildlife habitat, and preservation of rare and endangered species.

The underlying assumption of the study design is that bedded sediments with substantially higher pollutant concentrations compared to Bay sediments may indicate upstream pollutant sources. If sediments at the base of a watershed are consistently found to have significantly higher pollutant concentrations, after considering textural variations and background concentrations in non-urbanized watersheds, then follow-up source investigations can be conducted further upstream to ascertain whether there are current, controllable sources discharging pollutants into stormwater conveyances. The first phase of this project, which began in 2000, identified two conveyances that had sediments with elevated concentrations of PCBs: the Ettie Street pumping station and Glen Echo Creek. Follow-up source identifications are underway in those two catchments (Salop *et al.*, 2002).

This project was initiated by the ACCWP based upon discussions with staff of the San Francisco Bay Regional Water Quality Control Board (SFRWQCB) and the monitoring committee of the Bay Area Stormwater Management Agencies Association (BASMAA). The project addresses several ACCWP objectives:

- 1) The study will compile baseline data on pollutants of concern in bedded sediments from major watersheds in Alameda County, incorporating both spatial and temporal variation in the study design.
- 2) The results will be used to identify watersheds in need of follow-on study based on the results of the study.
- 3) The data will be analyzed in conjunction with other relevant data to assess to what extent it can be used to estimate sources and loadings from County watersheds.

Methods

Sampling Program Design and Sample Collection

Sampling Sites

Sediments were collected from nineteen sites in creeks, concrete-lined flood control channels, and one sedimentation basin in western Alameda County (Table 1). The majority of sites were located at the base of local watersheds, above the region of tidal influence, thus integrating a large variety of upstream land uses, channel types, and drainage basin sizes. Open-air locations were targeted, which limits the number of potential sampling sites, as many of the County creeks and channels are culverted for much of their length. The sampling sites stretch from Cerrito Creek at the northern County boundary to channels in southern Fremont (Figure 1), encompass the vast majority of Alameda County land (Figure 2) and are described in Appendix A.

Site	Sampled in 2001	Sampled in 2000	Comments
Cerrito Creek	x	x	
Codornices Creek	x	x	Site investigation for Hg only, 2000
Ettie Street	x	x	Site investigation, 2001
Glen Echo Creek	x	x	Site investigation, 2001
Sausal Creek	x	x	
Arroyo Viejo	x	x	
Lion Creek	x	x	
Seminary Creek	x	x	
San Leandro Creek	x	x	
Seminary Creek	x	x	
Castro Valley, Knox	x	x	
Castro Valley, S3	x	x	
San Lorenzo Creek	x	x	
Cabot Blvd.	x	x	
Line 6-G	x	x	
Balentine Drive	x	x	
Agua Caliente	x	x	
Alameda Creek	x	x	
Decoto – BART	x		Site Investigation, 2001
Decoto – Zwissig	x		Site Investigation, 2001
Strawberry Creek		x	
Scott Creek		x	
Dry Creek		x	
Crandall Creek		x	
Laguna Creek	x	x	2001 data available through City of Fremont

Table 1. ACCWP Sediment Sampling Program Site List, 2000-01.

A total of twenty-three sites were sampled in 2000. Partially due to the significant increase in analytical costs per site resulting from the addition of pesticides to the analytical list, the number of sites sampled was reduced to keep overall project costs in-line with those of 2000. This action is not expected to interfere with achieving the project's objectives because in several watersheds, contaminant concentrations were relatively low, suggesting that these watersheds are not contributing significant amounts of particulate-associated contaminants to the Bay. Only such low-concentration sites were eliminated from 2001 sampling.

Based on initial analytical results for PCBs, PAHs, and mercury concentrations obtained in 2000, Scott Creek, Strawberry Creek, Laguna Creek, Crandall Creek, Alameda Creek, and Dry Creek were identified as potential sites for elimination from the 2001 ACCWP sampling program. The Laguna Creek sampling site was subsequently restored to the sampling program as part of a monitoring program being implemented for the City of Fremont for which information was made available to the ACCWP. Alameda Creek was left as part of the sampling program due to the relatively large size of the watershed and therefore its contribution of a significant portion of flow to the Bay from Alameda County watersheds.

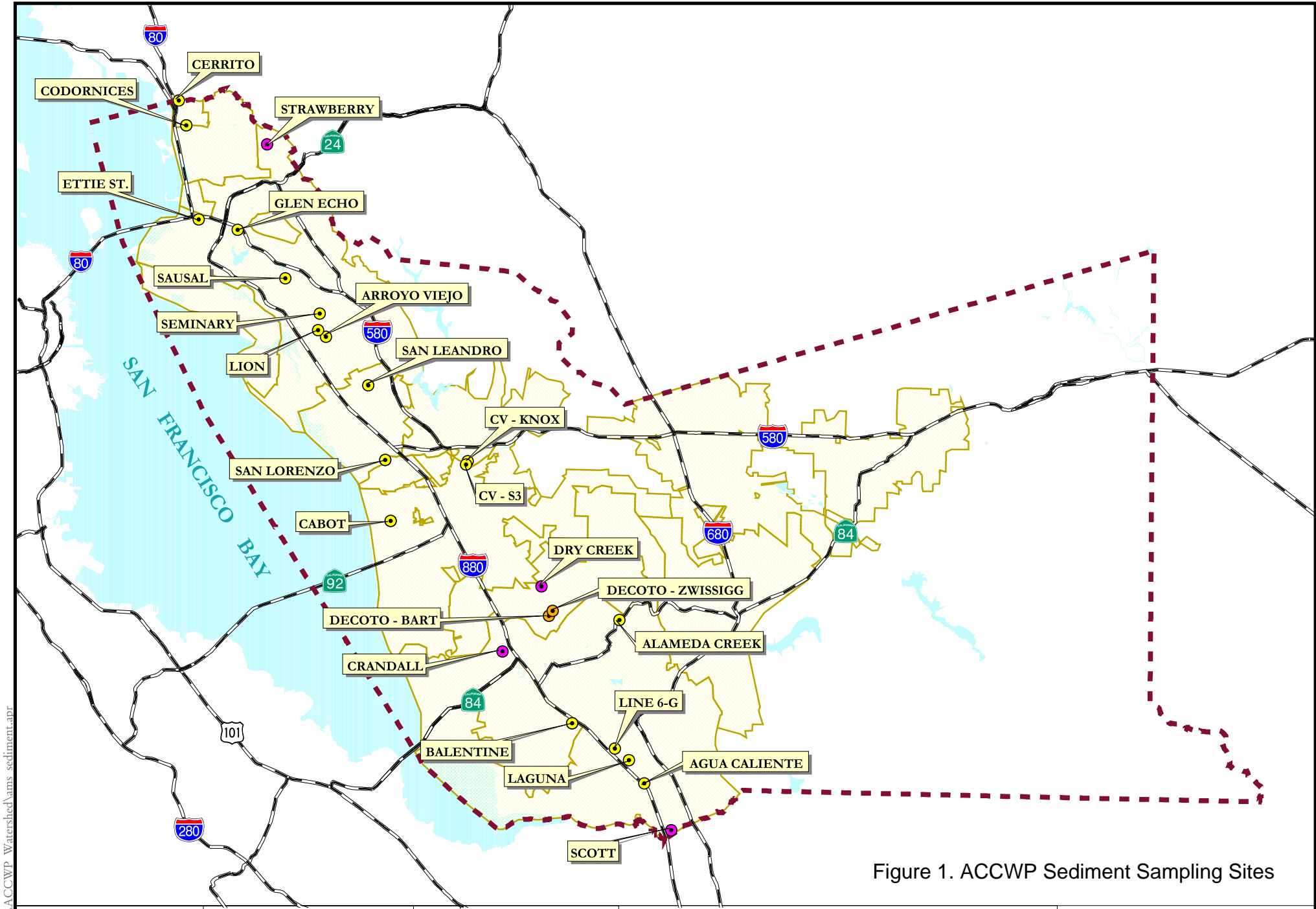
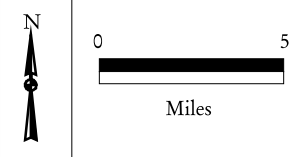


Figure 1. ACCWP Sediment Sampling Sites

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Source: Census Bureau, City and County Boundaries, 2000; ESRI, Major Highways, June 19, 1999; ACCWP and AMS, Sample Locations, April 12, 2002; and EIP Associates, GIS Program, April 19, 2002.



County Boundary	Major Highway
City Boundary	Water
Sample Year	2000 2000 and 2001 2001

Alameda County, CA



Figure 2. Alameda County drainages represented within ACCWP Sediment Sampling Program. 2001 source identification projects (Ettie Street and Glen Echo Creek watersheds in Oakland) highlighted.

Two new sampling sites were added to the 2001 sampling program to gather data on a section of the flood control channel draining an industrial catchment in Union City. This location was added with the goal of sampling near an industrial area with a history of contamination by PCBs, mercury, and potentially other pollutants of concern. Two sites were sampled, one just above the spill area (identified as Decoto-Zwissig) and one just below (identified as Decoto-BART).

Sample Collection

Procedures for the watershed sediment sampling follow those used for the 2000 sampling program, which were based upon those in use by the Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP) and the USGS National Water Quality Assessment Program (NAWQA).

Mobilization and Laboratory Cleaning

Sediment sampling equipment was prepared in the laboratory a minimum of four days prior to sampling. Cleaning methods followed protocols adapted from the NOAA National Status and Trends Program for use by the Regional Monitoring Program (Bell et al., 1999):

- Ekman dredge, 6" x 6" x 6" (3,540 ml capacity)
- Kynar-coated sample scoops
- Kynar-coated compositing bucket
- Wash bottles for deionized water, hydrochloric acid, and methanol

Prior to sampling, all equipment was cleaned. Equipment was soaked (fully immersed) for three days in a solution of Alconox™ detergent and deionized water. Equipment was then rinsed three times with deionized water. Equipment was next rinsed with 1.0 % solution of hydrochloric acid, followed by a rinse with petroleum ether, followed by another set of three rinses with deionized water. All equipment was then allowed to dry in a clean place.

The cleaned dredge and compositing bucket were then wrapped in aluminum foil until used in the field. All other equipment was stored in clean Ziploc™ bags until used in the field.

Sampling Procedures

Directions, photographs, and GPS coordinates recorded as part of the 2000 sampling program were used to locate approximate sampling sites, though depositional areas may have shifted between years. Coordinates for 2001 sediment sampling sites were determined in the field and one GPS position was taken for each site sampled (where GPS signals were received). To reduce variability within any sampling site, a minimum of three stations (distinct depositional areas within a stream reach with sufficient sediments to allow sample collection) was sampled and mixed to produce a single site composite; the stations were selected to ensure that sediments originated from the same source (*i.e.*, no tributaries or outfalls located between stations). Unless otherwise indicated, all stations were located within a 100m radius of the site coordinates. Field data sheets were compiled for each site, and include at a minimum: date, names of crew members, narrative description of the sampling site (general location), whether sediment was submerged or exposed, and method used to collect sediment.

Similar to procedures established for NAWQA (Shelton and Capel, 1994), one of two sets of sampling equipment was used to collect sediments, depending upon the site-specific conditions:

- Stainless Steel Ekman Dredge – The Ekman Dredge can be used for collection in shallow and deeper channel segments characterized by fine sediments. For its use, the Ekman is lowered into the sediment approximately 5 cm then triggered either by hand or with a messenger. After the actuated dredge is removed, the surface water is allowed to drain off, and the top 2-3 cm of sediments are removed with cleaned Kynar-coated scoops to the compositing bucket, or if appropriate, the entire grab is dumped into the bucket.
- Kynar-coated scoops – The scoops can be used to collect sediments from areas adjacent to obstructions and other areas for which other sampling gear is inappropriate. The scoops will remove sediments to a depth of 2-3 cm to be placed directly into the compositing bucket.

The typical locations for collection of sediment using scoops includes the leading edges of point bars, around emergent vegetation, near the toe of bank in slight bays, beneath undercuts and root wads at bank (also where scoured below old channel structures), and behind large rocks or other obstructions. Field personnel should take care to sample only sediments deposited by stream processes, not sediments deposited by other processes such as local landslides and bank sloughing.

The quality of samples collected with the dredge or cores was ensured by requiring each sample to satisfy a set of criteria concerning the disturbance of the sediment within the grab. In this way, each sample will normally contain the surficial sediments. Samples were rejected for the following conditions:

- The Ekman dredge did not close fully allowing sample to wash out.
- Removal of overlying water resulted in significant wash out of sediment fines.

At the conclusion of sample collection at the final station within a site, all collected sediment was mixed in the compositing bucket, and transferred into pre-cleaned containers provided by CAS. The compositing bucket was covered with aluminum foil when not in use.

All sampling equipment was rinsed with native water between uses at different stations within a site (*i.e.*, for replicates). All sampling equipment used at a particular sampling site was field-cleaned prior to use at a different sampling site. The field-cleaning protocol calls for 1) removal of sediments using native water and a scrub brush; 2) scrubbing of the sampling gear and compositing equipment with an Alconox™ solution; 3) rinse with dilute HCl; 4) rinse with methanol; and 5) rinse with deionized water. All wash water and chemicals were collected in the field for proper disposal.

At the conclusion of sample processing at each sampling location, all samples were wrapped in protective material and stored on blue ice in the field. At the conclusion of sampling days, all samples were refrigerated overnight. At appropriate intervals at the conclusion of sampling days, samples were distributed via overnight delivery, with itemized chain-of-custody forms.

All sampling was completed between September 11th and 19th, 2001, near the end of the several-month dry period that characterizes California's climate during the late spring and summer. This timing followed the schedule used in 2000 and was expected to maximize retention of fine sediments in the channels, which would otherwise be scoured with the first storm events of the winter season.

Laboratory and Analytical Procedures

Chemical Analysis

Analysis for monomethyl mercury performed in 2000 was dropped from the analytical program, while analysis for selected organochlorine (OC) pesticides was added at the request of Regional Board staff. Prior to analysis, each laboratory passed the sample material through a 2-mm sieve (#10), with all subsequent analysis performed on the fraction that passed through the screen. Standard methods for each analyses are as follows:

- PCBs were measured using EPA Method 8082 (USEPA, 1996a) with dual column confirmation of congener concentrations using RTX-5 and RTX-200 columns.
- PAHs were measured following EPA Method 8270C (USEPA, 1996b).
- Mercury was analyzed by cold vapor atomic fluorescence (Liang and Bloom, 1993) (Bloom and Fitzgerald, 1988).
- Pesticides were measured using EPA Method 8081.
- Percent fines (<62.5 μm , or the percentage of material able to pass through a 63 micron filter) were analyzed using ASTM D422M/PSEP with oxidation. The results for percent fines (<62.5 μm) are reported only for the fraction of the sample that passed through the 2-mm sieve.

Reported Results

PCBs was calculated by summing the concentrations of the following IUPAC congeners: 8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66, 70, 74, 77, 81, 87, 90, 95, 97, 99, 101, 105, 110, 114, 118, 123, 126, 128, 132, 138, 141, 149, 151, 153, 156, 157, 158, 166, 167, 169, 170, 174, 177, 180, 183, 184, 187, 189, 194, 195, 201, 203, 206, 209. Congeners with values below detection limits were assigned a value of zero for purposes of calculating PCBs.

PAHs was calculated by summing the concentrations of the following compounds: 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, biphenyl, chrysene, dibenz(a,h)anthracene, dibenzothiophene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, perylene, phenanthrene, pyrene, 2,6-dimethylnaphthalene, 2,3,5-trimethylnaphthalene, and 1-methylphenanthrene. Individual PAHs with values below detection limits were assigned a value of zero for purposes of calculating PAHs.

Pesticides analyzed were alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, heptachlor, aldrin, heptachlor epoxide, gamma-chlordane, endosulfan I, alpha-chlordane, dieldrin, 4,4'-DDE, endrin, endosulfan II, 4,4'-DDD, endosulfan sulfate, 4'4''-DDT, chlorpyrifos, oxychlordane, 2,4'-DDJE, trans-nonachlor, 2,4'-DDD, cis-nonachlor, 2,4'-DDT, and mirex.

Samples were normalized to grain size by dividing the measured concentration by the product (0.01 * F_{63}), where F_{63} is the percent fine material <62.5 μm .

Results

At the conclusion of the 2001 sampling effort, the ACCWP has generated two years of data for analysis of total mercury, total PCBs, and total PAHs, and one year of data for analysis of

pesticides. Analytical results for all analyses with the exception of OC pesticides are shown in Appendix B. Analytical results for OC pesticides are shown in Appendix C.

PCBs

In 2001, raw concentrations for PCBs were highest at the Ettie Street Pump Station (763 ppb), San Leandro Creek (472 ppb), and Cerrito Creek (299 ppb). Other sites with concentrations above 50 ppb include, in decreasing order, Glen Echo Creek, Decoto – BART, Arroyo Viejo, Lion Creek, Castro Valley – Knox, Seminary Creek, and one of the two Codornices replicates (Figure 1). The rankings for normalized concentrations of PCBs were similar to those for raw concentrations, with the Castro Valley - S3 site (5% fines) replacing the Arroyo Viejo site (80% fines) in ranking due to its much smaller grain size.

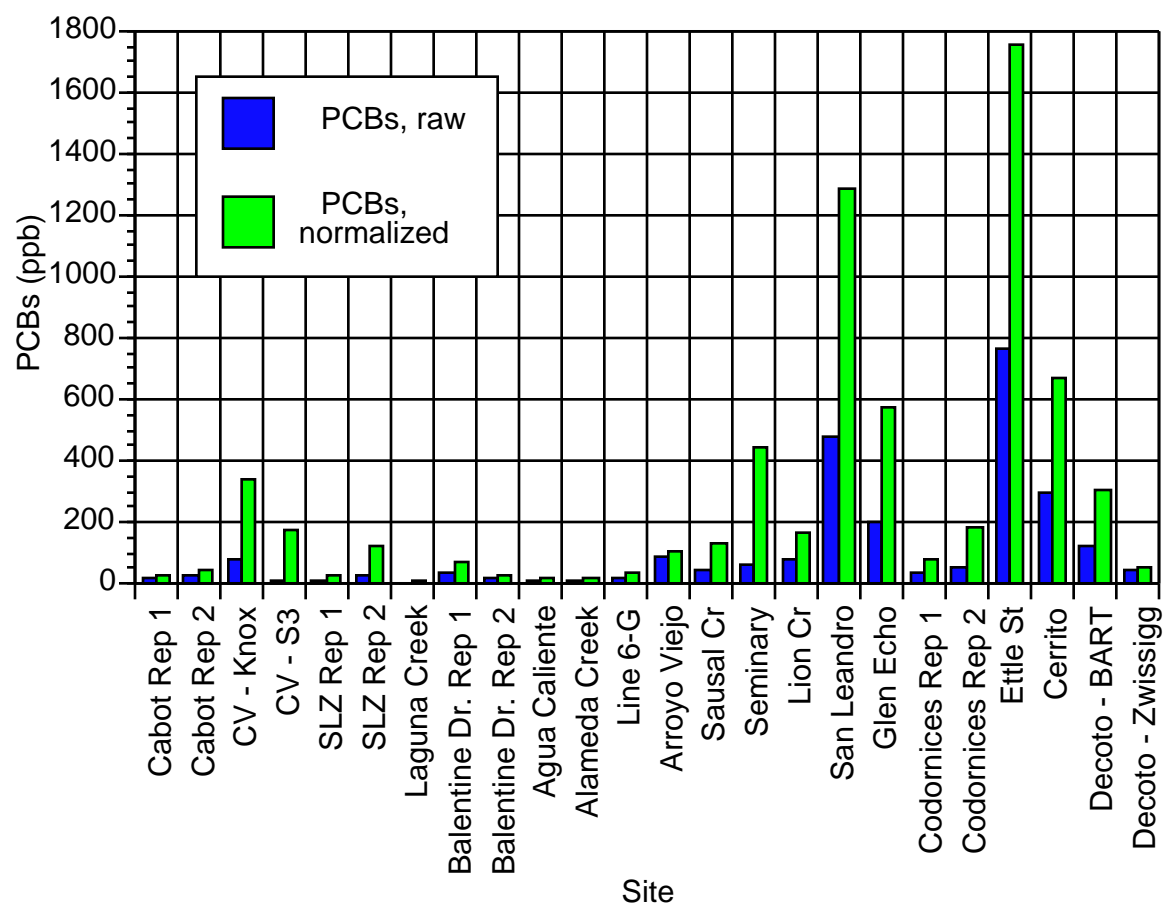


Figure 3. Total PCBs from 2001 ACCWP Sediment Sampling. Both raw values and values normalized to percent fines (<62.5 μm) are shown. All concentrations in $\mu\text{g}/\text{kg}$ (ppb).

In general, for sites sampled in both 2000 and 2001, concentrations of PCBs in 2001 were greater than those found in 2000. The most obvious example of this increase was observed at San Leandro Creek, where raw concentrations increased from 32 ppb in 2000 to 472 ppb in 2001, and normalized concentrations increased from 567 ppb to 1281 ppb. Another noticeable increase was found at Cerrito Creek where raw concentrations increased from 63 ppb in 2000 to 299 ppb in 2001, and normalized concentrations rose from 185 ppb to 659 ppb. One obvious exception to this pattern was at the Ettie Street Pump Station where raw concentrations dropped from 3263 ppb in 2000 to 763 ppb in 2001, and normalized concentrations dropped from 9113 ppb to 1753 ppb. A scatter plot of all 2000 and 2001 data is shown in Figure 4. A geographical distribution of the two years of data is shown in Figure 5.

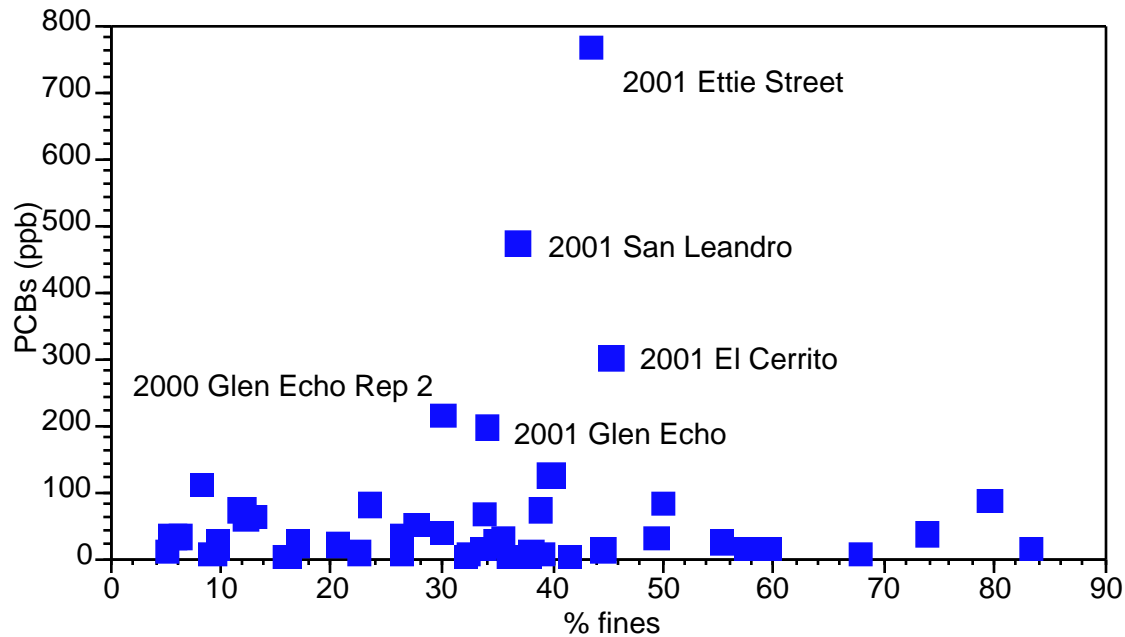
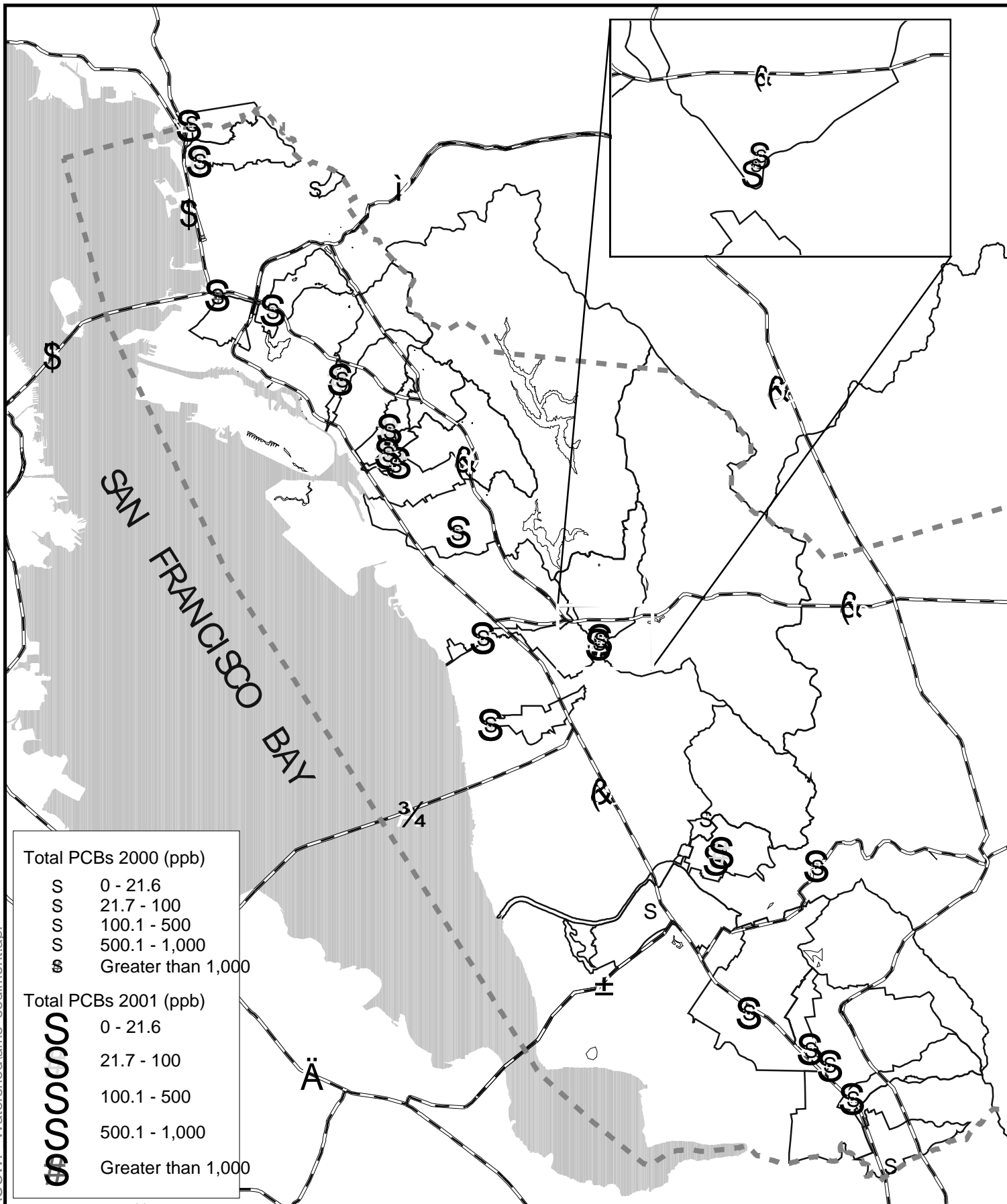
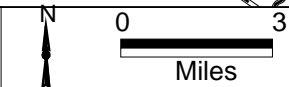


Figure 4. Total PCBs vs. Percent Fines from 2000 and 2001 ACCWP Sediment Sampling. 2000 Ettie Street value (3262 $\mu\text{g/g}$) off the scale of the chart and not represented. All concentrations in $\mu\text{g/kg}$ (ppb).



Total PCBs 2000 (ppb)	
S	0 - 21.6
S	21.7 - 100
S	100.1 - 500
S	500.1 - 1,000
S	Greater than 1,000
Total PCBs 2001 (ppb)	
S	0 - 21.6
S	21.7 - 100
S	100.1 - 500
S	500.1 - 1,000
S	Greater than 1,000



Source: Census Bureau, County Boundary, 2000; ESRI, Major Highways, 1999; ACCWP, Sample Locations and PCB Results, 2000 and 2001; and EIP Associates, Subwatersheds and GIS Program, April 19, 2002.

- Watershed Boundary
- County Boundary
- Major Highway
- Water
- Mixed Urban
- Predominantly Open

Figure 5

Mercury

In 2001, raw concentrations for Hg were highest at the San Leandro Creek site (4.29 ppm). Other sites with concentrations above 1 ppm were Decoto – BART (2.70 ppm), Cerrito Creek (1.99 ppm), and one of the two Codornices Creek replicates (1.92 ppm). Although it had a relatively low raw concentration of Hg, the Castro Valley – S3 site had the second highest normalized concentration (7.9 ppm), trailing only the San Leandro site (11.6 ppm). 2001 mercury data is shown in Figure 6.

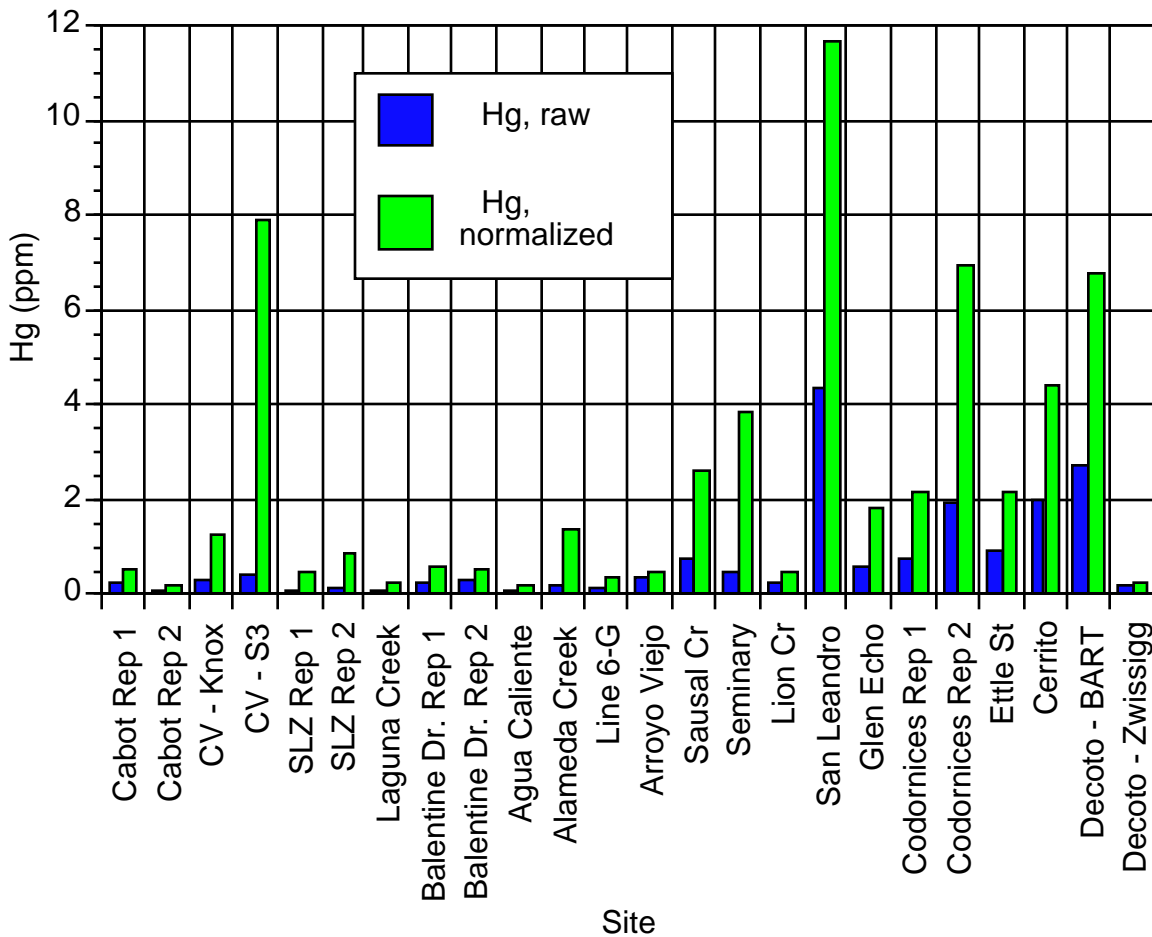


Figure 6. Total Mercury from 2001 ACCWP Sediment Sampling. Both raw values and values normalized to percent fines (<62.5 μm) are shown. All concentrations in mg/kg (ppm).

In general, for sites sampled in both 2000 and 2001, concentrations of Hg in 2001 were much greater than those found in 2000. The five highest concentrations of Hg were all found in 2001 (Figure 6). The most obvious example of this increase was found at San Leandro Creek, where raw concentrations increased from 0.3 ppm in 2000 to 4.29 ppm in 2001, and normalized concentrations increased from 4.6 ppm to 11.6 ppm. Another observable increase was found at Cerrito Creek where raw concentrations increased from 0.3 ppm in 2000 to 1.99 ppm in 2001, and

normalized concentrations rose from 1.0 ppm to 4.4 ppm. A scatter plot of all 2000 and 2001 data is shown in Figure 7. A geographical distribution of the two years of data is shown in Figure 8.

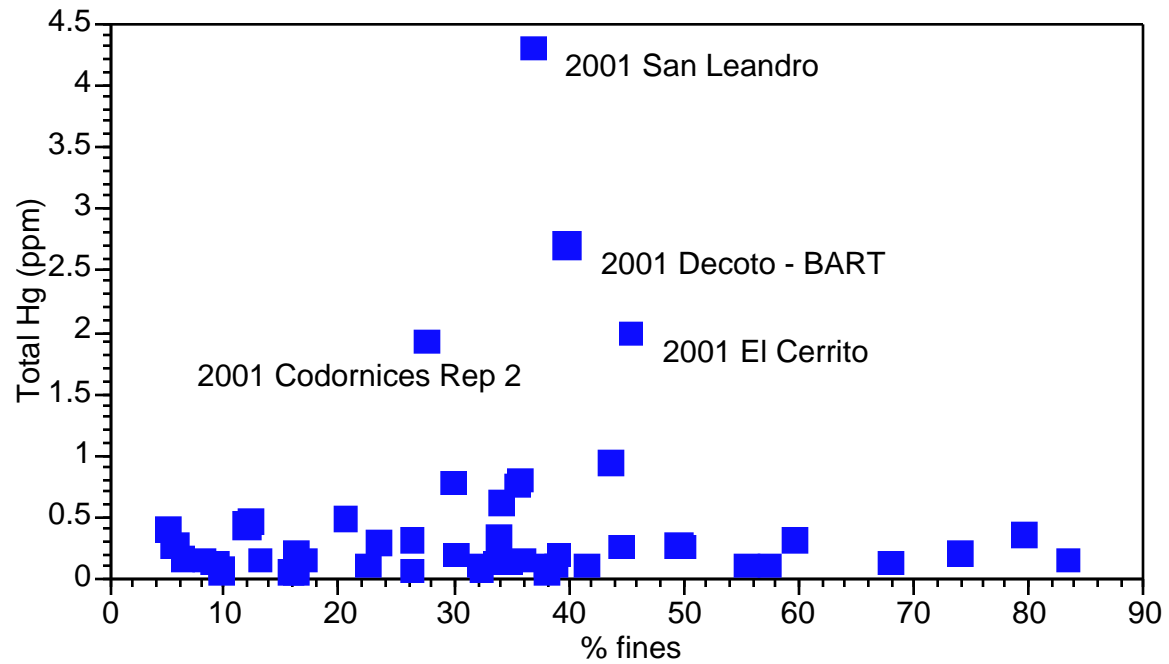


Figure 7. Total Mercury vs. Percent Fines from 2000 and 2001 ACCWP Sediment Sampling. All concentrations in mg/kg (ppm).

PAHs

In 2001, raw concentrations for PAHs were highest at the two Balentine Drive replicates (13,681 and 13,443 ppb), Ettie Street (13,380 ppb), Glen Echo Creek (11,751 ppb), and San Leandro Creek (10,383 ppb). When the PAH data is normalized, one of the two San Lorenzo Creek replicates (55,556 ppb) exceeds all other sites. Other sites with relatively high concentrations of PAHs normalized to percent fines include (in decreasing order) Glen Echo Creek (34,421 ppb), Ettie Street (30,752 ppb), Castro Valley – Knox (29,275 ppb), and San Leandro Creek (28,176 ppb), followed by the two Balentine Drive sites (27,634 and 22,535 ppb respectively). All 2001 PAH data is represented in Figure 9.

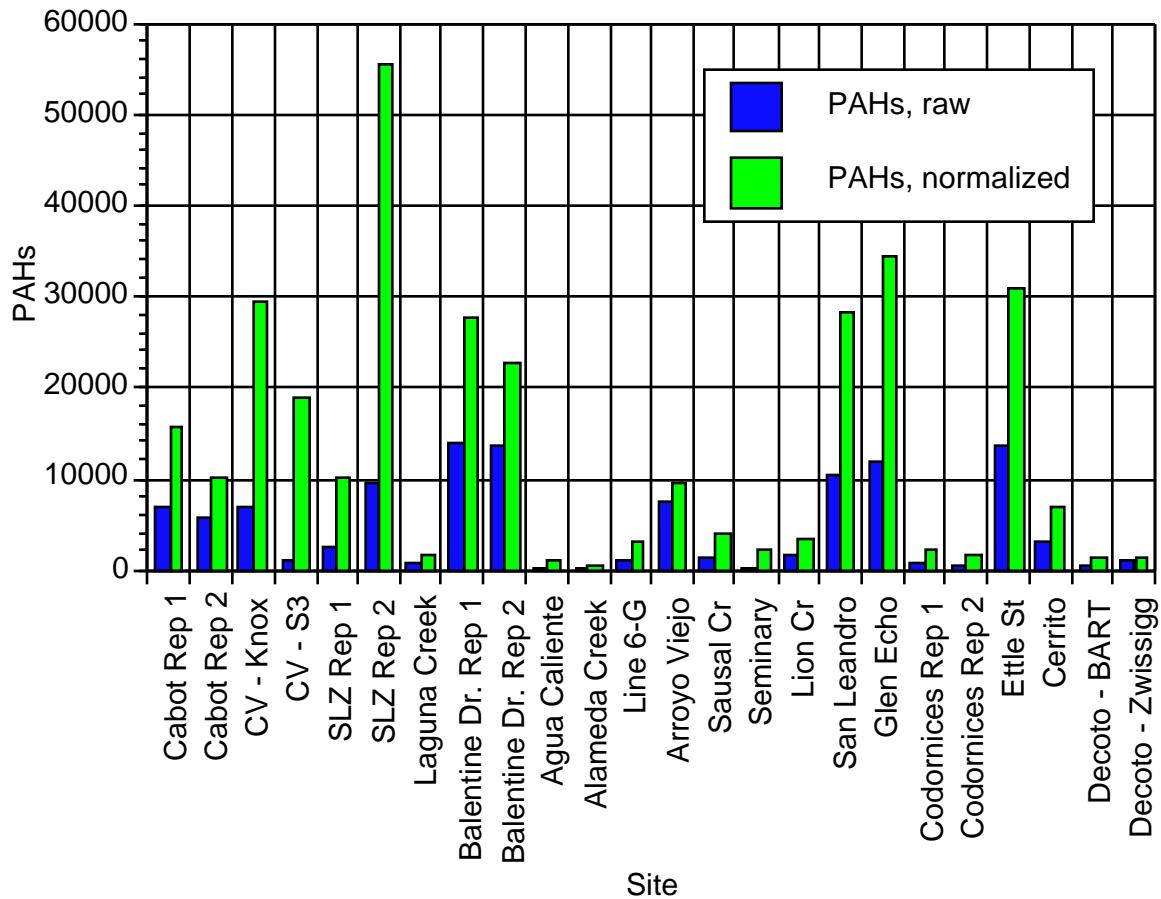


Figure 9. Total PAHs from 2001 ACCWP Sediment Sampling. Both raw values and values normalized to percent fines (<62.5 µm) are shown. All concentrations in µg/kg (ppb).

The raw concentration of PAHs in the 2000 Ettie Street sample (160,670 ppb) is more than an order of magnitude greater than any other site sampled in the two years of the sampling program. With the exception of this one site, PAH concentrations are comparable between 2000 and 2001 with raw concentrations generally higher in the 2001 samples and normalized concentrations generally higher in the 2000 samples. A scatter plot of all data from the first two years of the sampling program is shown in Figure 10. A geographical distribution of the two years of data is shown in Figure 11.

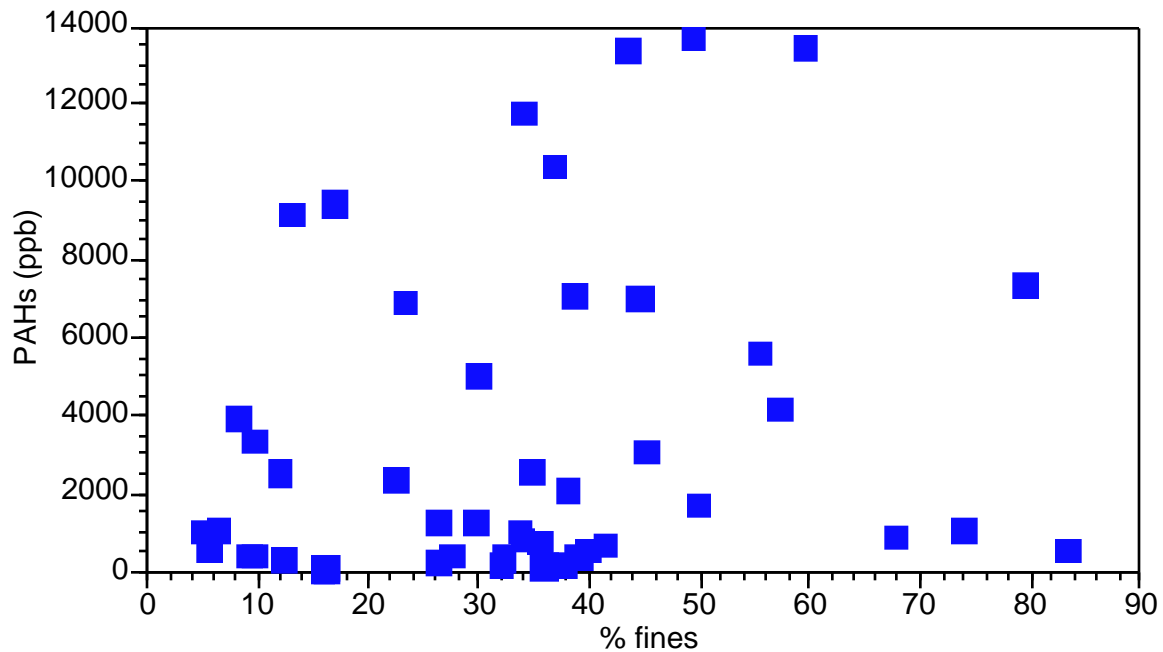


Figure 10. Total PAHs vs. Percent Fines from 2000 and 2001 ACCWP Sediment Sampling. 2000 Ettie Street value (160,670 $\mu\text{g/g}$) off the scale of the chart and not represented. All concentrations in $\mu\text{g/kg}$ (ppb).

Chlorinated Pesticides

Sampling for chlorinated pesticides was added to the analyte list in 2001. A number of the pesticides analyzed were not detected in any of the samples (aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, endosulfan I, endosulfan II, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, and mirex).¹

In general, DDTs were found in detectable amounts. A scatter plot of the total DDT data is represented in Figure 12. A geographical distribution of 2001 DDT data is shown in Figure 13.

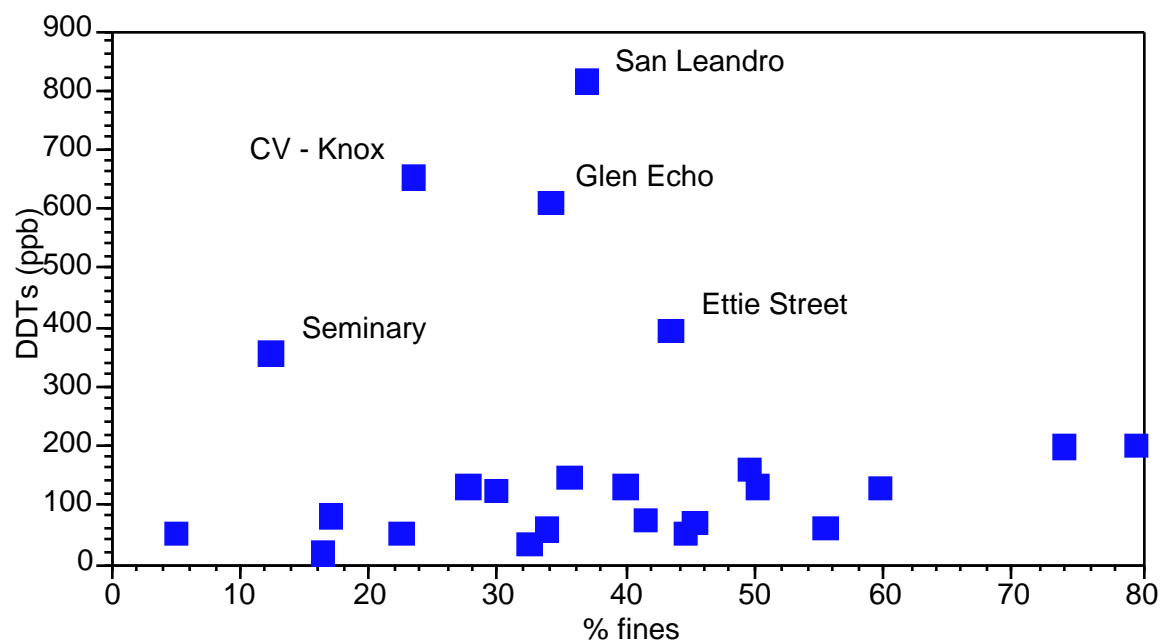


Figure 12. Total DDTs vs. Percent Fines from 2001 ACCWP Sediment Sampling. Only one year of sampling data available. Total DDTs are calculated as the sum of six isomers: 2,4'-DDD; 2,4'-DDE; 2,4'-DDT; 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT. All concentrations in $\mu\text{g}/\text{kg}$ (ppb).

¹ MDLs for chlorinated pesticides for this study were in general elevated by an order of magnitude over quoted CAS MDLs for these analytes (Columbia Analytical Services, 2002).

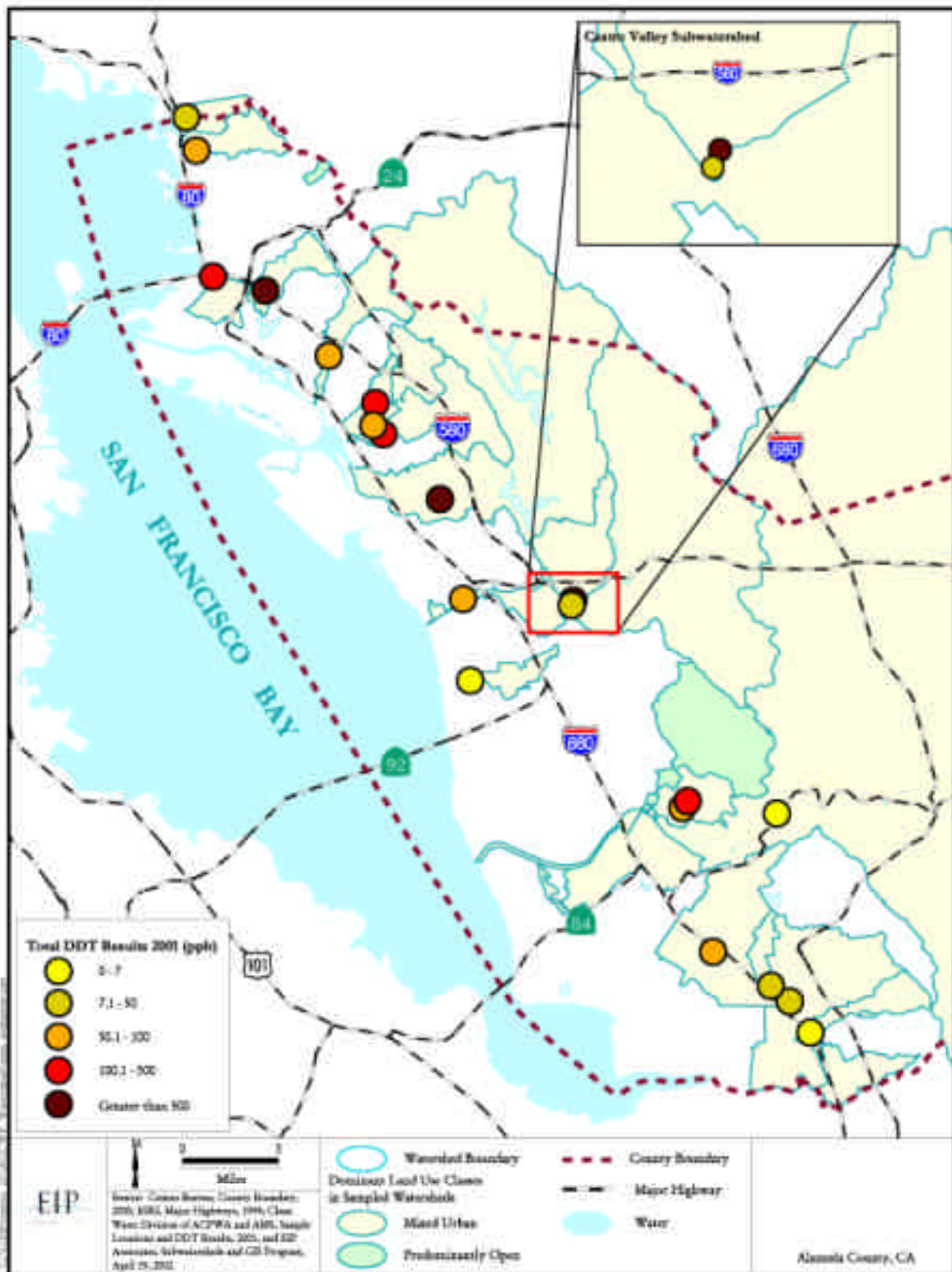


Figure 13. Concentrations of Σ DDTs in Sediment from ACCWP Sampling, 2001.

Discussion

Analysis of Data Quality

AMS collected all samples during two two-day sampling efforts, September 11-12 and September 18-19. All samples were held on blue ice from time of sampling and shipped to CAS in two batches to allow processing within relevant holding times. CAS performed all laboratory analyses in accordance with their quality assurance program (Columbia Analytical Services, 2001). In order to quantify data quality, the quality assurance program included use of method blanks, laboratory replicates (DUP, TRIP), matrix spikes (MS), duplicate matrix spikes (DMS), laboratory control samples (LCS), surrogate spikes, and standard reference materials (SRM). All analyses were performed by batch, with the total number of field samples not to exceed twenty samples per batch. Typical data quality objectives are shown in Table 2.

In general, results for all analytes fell within primary acceptance criteria for data validation. In a few cases, however, specific PCB congeners are known to co-elute and therefore cause a matrix interference with OC pesticides (and vice versa). Analysis of a subset of PCB congeners and pesticides therefore required alternative evaluation criteria to verify data quality.

For a small percentage of analytical results, reported concentrations fell outside of acceptance limits. This situation occurred in laboratory analysis of PCBs 77, 81, 126, and 169, in which analysis failed to detect presence of these congeners in laboratory control samples associated with all samples with the exception of the Balentine Drive Replicate 2. This can indicate a low bias in calculation of total PCBs. However, this is not thought to have a major impact on analyses performed as part of this report as the four congeners mentioned are all in relatively low abundances in standard Aroclor mixtures, typically at trace amounts only (Frame, *et al.*, 1996). Also, none of the four were included as part of the RMP list, and therefore have no impact on determinations of exceedances of screening criteria.

QA Sample	Min. Freq.	Measure	Criterion	Function
Method Blank	One per batch		<MDL	Determination of laboratory contamination
Lab Replicates Hg	One per batch	RPD	RPD < 30%	Assessment of method performance
Matrix Spike PCBs Pesticides Hg PAHs	One per batch	% Recovery	70-130% Varies by analyte 60-130% Varies by analyte	Assessment of matrix problems
Duplicate Matrix Spike PCBs Pesticides PAHs	One per batch	RPD	RPD < 40% RPD < 30% RPD < 40%	Assessment of batch precision
Laboratory Control Sample PCBs Pesticides Hg PAHs	One per batch	% Recovery	70-130% Varies by analyte 57-143% Varies by analyte	Assessment of method performance
Surrogate Spike Tetrachloro-m-xylene 2,2',4,4',5,5'-Hexabromobiphenyl Tetrachloro-m-xylene 2,2',4,4',5,5'-Hexabromobiphenyl Fluorene-d10 Fluoranthene-d10 p-Terphenyl-d14	One per sample	% Recovery	30-150% (PCB) 29-141% (PCB) 48-119% (Pest) 48-136% (Pest) 42-130% (PAH) 55-130% (PAH) 60-119% (PAH)	Assessment of method performance
Standard Reference Material Organic analytes	One per batch	% Recovery	50-150%	Assessment of method performance

Table 2. Summary of data quality objectives for trace metals and trace organics samples from 2001 ACCWP Sediment Sampling Program.

Comparisons with Existing Sediment Quality Criteria

One method for gauging sediment quality of watershed sediments is by comparing the results from the ACCWP sampling program with existing screening values for sediment quality. The Regional Board has previously calculated screening values based on ambient concentrations of various pollutants in Estuary sediments using data generated by the RMP and the Bay Protection and Toxic

Cleanup Program (BPTCP), the forerunner to the RMP. As the goal of the original study was to calculate ambient concentrations, datapoints suspected of being near source sites and marsh stations were removed from the dataset (Gandesbery and Hetzel, 1998). As this data was generally heavily-weighted toward sites somewhat removed from the Bay margins, they may underestimate ambient concentrations were shallow water sites better represented within the dataset. The Clean Estuary Partnership has proposed a study for 2002-2003 to calculate nearshore sediment ambient concentrations that may result in better screening values for the purposes of these types of comparisons.

PCBs

There are no existing numeric objectives for PCBs in sediment in the San Francisco Bay Basin Water Quality Control Plan (Basin Plan). For relatively coarse sediments (less than 40% fines), a PCB screening value of 8.6 ppb was calculated; for relatively fine sediments (40 to 100% fines), a screening value of 21.6 ppb was calculated. Results from the ACCWP sampling can be compared to these screening values to gauge whether inputs to the Estuary fall below ambient levels or are potentially contributing to increased levels of PCBs or mercury in the Bay.

In the case of PCBs, the screening value was calculated for a sum of 40 PCB congeners on the SFEI RMP list. These 40 congeners are a subset of the 54 measured by CAS for the ACCWP. A comparison of total PCBs for the list of 40 and list of 54 congeners showed that the contribution to the calculation of total PCBs of the 14 “additional” congeners was relatively minor, and did not affect the determination of exceedances at any of the sampling sites.

Total PCBs exceeded screening values in sixteen of the twenty-four samples analyzed (including analyses of four field replicates). Table 3 shows the comparisons with PCB screening values for all samples taken in 2001.

Site	PCBs (SFEI 40) (ppb)	% fines	Screening Value (ppb)	Exceedance
Cabot Rep 1	9.7	44.6	21.6	NO
Cabot Rep 2	18.5	55.34	21.6	NO
CV – Knox	78.2	23.4	8.6	YES
CV – S3	8.6	5.1	8.6	NO
SLZ Rep 1	5.8	22.6	8.6	NO
SLZ Rep 2	20.7	17.0	8.6	YES
Laguna Creek	0.48	41.5	21.6	NO
Balentine Dr Rep 1	29	49.5	21.6	YES
Balentine Dr Rep 2	11.8	59.6	21.6	NO
Agua Caliente	3.3	32.4	8.6	NO
Alameda Creek	1.8	16.3	8.6	NO
Line 6-G	10.3	33.8	8.6	YES
Arroyo Viejo	82.8	79.5	21.6	YES
Sausal Creek	38.2	29.8	8.6	YES
Seminary Creek	53.2	12.4	8.6	YES
Lion Creek	78.0	50.1	21.6	YES
San Leandro	444.5	36.8	8.6	YES
Glen Echo	187.2	34.1	8.6	YES
Codornices Rep 1	28.5	35.5	8.6	YES
Codornices Rep 2	47.6	27.6	8.6	YES
Ettie St	725.3	43.5	21.6	YES
Cerrito	284.8	45.3	21.6	YES
Decoto - BART	120.7	39.9	8.6	YES
Decoto - Zwissig	35.2	74.1	21.6	YES

Table 3. Determination of Exceedances of Total PCB Screening Values for 2001 ACCWP Site Investigation Samples. Screening values calculated by Regional Board for Bay sediments.

Mercury

There are no existing numeric objectives for mercury in sediment in the Basin Plan. The Regional Board has calculated screening values of 0.25 ppm for relatively coarse sediments (less than 40% fines) and 0.43 ppm for relatively fine sediments (40 to 100% fines) (Gandesbery *et al.*, 1999). Using these criteria in combination with the 2001 results resulted in exceedances of the screening values in eleven of twenty-four samples (Table 4).

Site	Hg (ppm)	% fines	Screening Value (ppm)	Exceedance
Cabot Rep 1	0.25	44.6	0.43	NO
Cabot Rep 2	0.10	55.34	0.43	NO
CV – Knox	0.30	23.4	0.25	YES
CV – S3	0.40	5.1	0.25	YES
SLZ Rep 1	0.11	22.6	0.25	NO
SLZ Rep 2	0.15	17.0	0.25	NO
Laguna Creek	0.10	41.5	0.43	NO
Balentine Dr Rep 1	0.28	49.5	0.43	NO
Balentine Dr Rep 2	0.32	59.6	0.43	NO
Agua Caliente	0.07	32.4	0.25	NO
Alameda Creek	0.22	16.3	0.25	NO
Line 6-G	0.12	33.8	0.25	NO
Arroyo Viejo	0.36	79.5	0.43	NO
Sausal Creek	0.78	29.8	0.25	YES
Seminary Creek	0.47	12.4	0.25	YES
Lion Creek	0.25	50.1	0.43	NO
San Leandro	4.29	36.8	0.25	YES
Glen Echo	0.61	34.1	0.25	YES
Codornices Rep 1	0.76	35.5	0.25	YES
Codornices Rep 2	1.92	27.6	0.25	YES
Ettie St	0.94	43.5	0.43	YES
Cerrito	1.99	45.3	0.43	YES
Decoto - BART	2.70	39.9	0.25	YES
Decoto - Zwissig	0.20	74.1	0.43	NO

Table 4. Determination of Exceedances of Total Hg Screening Values for 2001 ACCWP Site Investigation Samples. Screening values calculated by Regional Board for Bay sediments.

PAHs

The ACCWP has recently overseen an in-depth analysis of sources and impacts of PAHs, the history of Bay area studies of PAHs, and their comparability to the ACCWP dataset (Salop *et al.*, 2001). In general, the widely varying use of specific PAH analytes, study matrices, and laboratory analytical techniques makes comparisons with other regional studies difficult to interpret.

There are no existing numeric objectives for PAHs in sediment in the Basin Plan. The Regional Board has calculated screening values of 211 ppb for relatively coarse sediments (less than 40% fines) and 3390 ppb for relatively fine sediments (40 to 100% fines) (Gandesbery *et al.*, 1999). Nineteen of the twenty-four samples taken in 2001 exceeded these screening values (Table 5).

Site	PAHs (ppb)	% fines	Screening Value (ppb)	Exceedance
Cabot Rep 1	6974	44.6	3390	YES
Cabot Rep 2	5595	55.34	3390	YES
CV – Knox	6862	23.4	211	YES
CV – S3	959	5.1	211	YES
SLZ Rep 1	2318	22.6	211	YES
SLZ Rep 2	9439	17.0	211	YES
Laguna Creek	648	41.5	3390	NO
Balentine Dr Rep 1	13681	49.5	3390	YES
Balentine Dr Rep 2	13443	59.6	3390	YES
Agua Caliente	296	32.4	211	YES
Alameda Creek	66	16.3	211	NO
Line 6-G	983	33.8	211	YES
Arroyo Viejo	7341	79.5	3390	YES
Sausal Creek	1223	29.8	211	YES
Seminary Creek	263	12.4	211	YES
Lion Creek	1682	50.1	3390	NO
San Leandro	10383	36.8	211	YES
Glen Echo	11751	34.1	211	YES
Codornices Rep 1	716	35.5	211	YES
Codornices Rep 2	415	27.6	211	YES
Ettie St	13380	43.5	3390	YES
Cerrito	3050	45.3	3390	NO
Decoto - BART	550	39.9	211	YES
Decoto - Zwissig	1053	74.1	3390	NO

Table 5. Determination of Exceedances of Total PAH Screening Values for 2001 ACCWP Site Investigation Samples. Screening values calculated by Regional Board for Bay sediments.

Chlorinated Pesticides

There are no existing numeric objectives for OC pesticide concentrations in sediment in the Basin Plan. There are, however, screening values calculated for individual pesticides and groups of pesticides. For example, the Regional Board has calculated screening values for total DDTs as a summation of the individual concentrations of six isomers: 2,4'-DDD; 2,4'-DDE; 2,4'-DDT; 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT. These screening values are 2.8 ppb for relatively coarse sediments (less than 40% fines) and 7 ppb for relatively fine sediments (40 to 100% fines) (Gandesbery *et al.*, 1999). Using these criteria in combination with the raw 2001 analytical data resulted in exceedances of the screening values in twenty of twenty-four samples (Table 6). In addition, the four samples for which exceedances were not indicated by this analysis (Alameda Creek, Agua Caliente, and the two Cabot Blvd. replicates) do not provide appropriate comparisons against screening values. For each of these samples, method detection limits (MDLs) for some of the individual analytes that make up the total DDTs exceed screening values themselves or sum to exceed the values. Assigning a “zero” value to all “no detects” may therefore artificially bias the comparisons.

Site	DDTs (ppb)	% fines	Screening Value (ppb)	Exceedance
Cabot Rep 1	5.5	44.6	7	NO
Cabot Rep 2	5.0	55.34	7	NO
CV – Knox	627.5	23.4	2.8	YES
CV – S3	46.4	5.1	2.8	YES
SLZ Rep 1	27	22.6	2.8	YES
SLZ Rep 2	60.9	17.0	2.8	YES
Laguna Creek	29.4	41.5	7	YES
Balentine Dr Rep 1	108	49.5	7	YES
Balentine Dr Rep 2	67.3	59.6	7	YES
Agua Caliente	0	32.4	2.8	NO
Alameda Creek	0	16.3	2.8	NO
Line 6-G	22.9	33.8	2.8	YES
Arroyo Viejo	120	79.5	7	YES
Sausal Creek	92	29.8	2.8	YES
Seminary Creek	342	12.4	2.8	YES
Lion Creek	77.8	50.1	7	YES
San Leandro	775	36.8	2.8	YES
Glen Echo	576	34.1	2.8	YES
Codornices Rep 1	111.5	35.5	2.8	YES
Codornices Rep 2	100	27.6	2.8	YES
Ettie St	348	43.5	7	YES
Cerrito	21	45.3	7	YES
Decoto - BART	90	39.9	2.8	YES
Decoto - Zwissig	121.4	74.1	7	YES

Table 6. Determination of Exceedances of Total DDTs Screening Values for 2001 ACCWP Sediment Sampling Program. Total DDTs are calculated as the sum of six isomers: 2,4'-DDD; 2,4'-DDE; 2,4'-DDT; 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT. Screening values calculated by Regional Board for Bay sediments.

The Regional Board has also calculated screening values for dieldrin, total chlordanes (alpha-chlordane, gamma-chlordane, oxychlordanes, heptachlor, heptachlor epoxide, cis-nonachlor, and trans-nonachlor), and total HCH (alpha-BHC, beta-BHC, delta-BHC, and gamma-BHC). However, valid comparisons with screening values designated for these pesticides or groups of pesticides are unable to be made due to associated MDLs that are in all cases above calculated screening values. As discussed previously, matrix interferences caused by presence of co-eluting PCB congeners were proposed by CAS as the likely cause of these elevated MDLs that were, in general, an order of magnitude or greater than those quoted in the CAS qualifications for these analyses (Columbia Analytical Services, 2002).

Watershed Characterization

In addition to the work performed on behalf of the ACCWP, AMS used the County data in conjunction with data gathered through the efforts of the remaining Bay Area Clean Water Agencies (BACWA) member agencies (Kinnetics Laboratory Inc. [2001], Kinnetics Laboratories

Inc.[2002]) to assist with interpretation of the raw data on a regional context (Abu-Saba et al. 2002). This effort was performed on behalf of the Clean Estuary Partnership (CEP), a collaborative effort of BACWA and Bay Area Stormwater Manager Agencies Association (BASMAA) member agencies to assist with development of Total Maximum Daily Loads (TMDLs) in the Bay area, and was supported through their funding. This related study discusses among other items:

- 1) Spatial and temporal variability inherent in the ACCWP data.
- 2) A recommended three-tiered classification system for comparing pollutant concentrations in watershed sediment data with those of ambient Bay sediments.
- 3) Estimated loadings from sampled watersheds.

Conclusions and Recommendations

Based on a review of the first two years of sediment data developed by the Program, we have developed the following findings and recommendations:

Finding 1: Pollutant concentrations in bedded sediment are useful for detecting order-of-magnitude differences between watersheds. It is important to understand the limits of this study's approach for resolving differences between watersheds. Based on the spatial and temporal variability inherent in the methods, tenfold or greater differences between watersheds are statistically significant, but twofold to threefold differences are not. This order-of magnitude approach is useful for identifying high priority areas, such as Ettie Street, Glen Echo Creek, and San Leandro Creek, and for verifying assumptions about the difference between urbanized and open space watersheds. Using this approach, eight watersheds in Alameda County stand out as appropriate areas for further investigation. These sites, along with associated contaminants, are (see Abu-Saba et al., 2002 for full discussion of the supporting information for these conclusions):

- 1) Ettie Street Pumping Station (PCBs)
- 2) Glen Echo Creek (PCBs)
- 3) San Leandro Creek (mercury, PCBs, DDT)
- 4) Cerrito Creek (mercury and PCBs)
- 5) Codornices Creek (mercury)
- 6) Castro Valley Creek (DDTs)
- 7) Seminary Creek (DDTs)
- 8) Alameda Creek (large watershed)

Recommendation 1: Follow-up actions initiated by this study should be based on statistically significant differences. Previously recommended actions, such as eliminating certain open space sites and conducting more intensive source investigations on certain urban catchments, are based on tenfold or greater observed differences. Future management decisions should continue to refer to the limits of the resolving power of watershed assessment data. If decisions need to be made based on more subtle differences between watersheds, then a more sensitive sampling and assessment approach will have to be developed.

Finding 2: The analytical methods used for measuring concentrations of chlorinated pesticides in sediment did not allow for comparisons of the data with concentrations in Bay sediments. In many cases, the MDLs associated with specific pesticide analytes were above the concentrations expected

for Bay sediments. For these pesticides, a “no detect” result could be produced from a sample with concentrations that exceeded sediment screening values.

Recommendation 2: Before including analysis of chlorinated pesticides in future sampling efforts, an attempt should be made to identify an alternative methodology for gathering and interpreting pesticide data. These efforts may be complicated somewhat in the uncertainties surrounding degradation rates and residence times of pesticides in the sediment. They may also be affected by the tendency of PCBs to interfere with analysis of certain pesticides, resulting in higher than expected MDLs and method reporting limits (MRLs). Analyses of pesticides should be excluded from future sampling programs until an acceptable methodology for analysis of pesticides can be developed.

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Jay Davis and Jon Leatherbarrow of the San Francisco Estuary Institute assisted with quality assurance review of the trace organics data. Nils Johnson of EIP Associates developed all maps within the report. ACFCWCD Personnel from the Ettie Street Pump Station assisted with sampling the pump station during both years of the program.

References

- Bell, D., Gold, J., Salop, P. and Applied Marine Sciences, I., 1999. Field Operations Manual for the Regional Monitoring Program for Trace Substances in the San Francisco Estuary., San Francisco Estuary Institute.
- Bloom, N.S. and Fitzgerald, W.F., 1988. Determination of Volatile Mercury Species at the Picogram Level by Low-temperature Gas Chromatography with Cold-vapour Atomic Fluorescence Detection. *Anal. Chim. Acta.*, 208: 51-161.
- Columbia Analytical Services, Inc., 2002. Statement of Qualifications for the Analysis of Marine and Freshwater Samples. Kelso, WA.
- Columbia Analytical Services, Inc., 2001. Quality Assurance Manual for Columbia Analytical Services, Kelso, WA.
- Gandesbery, Tom, and Hetzel, Fred, 1998. Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments. Regional Water Quality Control Board, San Francisco Bay Region. Oakland, California.
- Gunther, A.J. et al., 2001. Initial Characterization of PCB, Mercury and PAH Contamination in the Drainages of Western Alameda County, CA, Alameda Countywide Clean Water Program, Hayward, CA.
- Kinnetic Laboratories Inc., 2001. Joint Stormwater Agencies Project to Study Urban Sources of Mercury and PCBs, EOA, Oakland California.
- Kinnetic Laboratories Inc., 2002. Joint Stormwater Agencies Project to Study Urban Sources of Mercury, PCBs, and Organochlorine Pesticides, EOA, Oakland, CA.
- Liang, L. and Bloom, N.S., 1993. Determination of Total Hg by Single-stage Gold Amalgamation with Cold Vapor Atomic Spectrometric Detection. *Journal of Analytical Atomic Spectrometry*, 8: 591-594.
- Salop, P., Hardin, D., Abu-Saba, K. and Gunther, A.J., 2002. Analysis of 2001 Source Investigations in Ettie Street Pump Station and Glen Echo Creek Watersheds, Oakland, California, Prepared for the Alameda Countywide Clean Water Program. Livermore, California.
- Salop, P., Spies, R., Hardin, D., and Gunther, A., 2002. Review of Existing PAH Data Relevant to Proposed ACCWP Sediment Sampling Program. Prepared for the Alameda Countywide Clean Water Program. Livermore, California.
- San Francisco Bay Regional Water Quality Control Board, 1995. San Francisco Bay Basin Water Quality Control Plan, Oakland, CA.
- Shelton, L.R. and Capel, P.D., 1994. Guidelines for Collecting and Processing Samples of Stream Bed Sediment for Analysis of Trace Elements and Organic Contaminants for the National Water-Quality Assessment Program, U.S. Geological Survey, Sacramento, CA.
- Smith, R.W. and Riege, L., 1999. San Francisco Bay Sediment Criteria Project: Ambient Analysis Report, EcoAnalysis, Inc., Ojai, California.

USEPA, 1996a. Polychlorinated Biphenyls (PCBs) by Gas Chromatography, Method 8082, EPA Test Methods for Evaluation of Solid Waste, SW-846, Final Update III., United States Environmental Protection Agency, Washington, D.C.

USEPA, 1996b. Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry, Method 8270C, EPA Test Methods for Evaluation of Solid Waste, SW-846, Final Update III., United States Environmental Protection Agency., Washington, D.C.

Appendix A

This appendix contains a list of the sampling sites visited Year 2 of this study. For each site, the name, description, and geographic coordinates (in decimal form) are given. A map showing the sites is found in the body of the report as Figure 1.

Site Name	Site Description	Latitude	Longitude
Cerrito Creek	Creek is heavily vegetated, sampled at south end of the park above and below the stone wall.	37.898	122.306
Codornices Creek	Natural channel segment. Took two replicates – first from pool just upstream of 8 th Street culvert and from depositional area approximately 10 m upstream, and second from lateral pool beginning approximately 30 m upstream and cobbled area upstream.	37.883	122.300
Ettie Street Pump Station	Samples collected in two of the sedimentation basins that were not cleaned out in 2001, bays 3 and 4. Sampling requires use of Ekman dredge.	37.826	122.289
Glen Echo Creek	Natural channel segment. Collected samples just upstream of where footpath meets the creek and approximately 20 m downstream.	37.82	122.259
Sausal Creek	Natural channel with some concrete structures, bottom is broken concrete and small rock. Sediment was found behind rocks near the upstream dam. There is a large pool area (4 feet deep) on the east side of the sample site.	37.791	122.222
Seminary Creek	Natural channel that runs from Elizabeth Street west to the edge of a concrete culvert. Channel is heavily vegetated. Most sediment found at edge of culvert. Sediment appeared mostly anoxic, with an oily appearance and smell.	37.77	122.195
Lion Creek	Fine sediment in concrete channel, vegetation abundant. Sampled at east end of culvert and approximately 15 m upstream.	37.760	122.196
Arroyo Viejo	Sampled channel sediments under the Hamilton Street bridge and 10-40 m westward. Dense algal mats at this site.	37.756	122.190
San Leandro Creek	This open-channel creek bed is dry in the summer. Small trickle to pond originates from storm drain on the south bank. Samples were collected from a small pool of water, 30-40 m in length, located directly underneath and upstream of the 14th Street bridge.	37.727	122.157
San Lorenzo Creek	Sampled point where rectangular channel changes into trapezoidal channel. Muddy bottom with lots of vegetation and decomposed vegetation mixed into the sediment. Took two replicates – first at deposits at lower end of trapezoidal channel, and second from midchannel vegetated areas approximately 30 m downstream.	37.682	122.143

Castro Valley S3	Natural rockbound channel. Sediment deposits scarce. Sampled upstream and downstream of USGS gauging station behind rocks and other flow obstructions. Creek bed mostly gravel.	37.680	122.081
Castro Valley Knox/Grove	There is an earthen pool directly below the parking lot that forms the confluence of the Chabot and Knox branches of Castro Valley Creek. Samples were collected from the Knox branch in three pools upstream of the confluence.	37.682	122.080
Cabot Blvd	Took two replicates – first approximately 50 m downstream of culvert, and second from culvert apron and pool immediately downstream. The sediments from the first replicate were well-mixed with no noticeable anoxic layer, while sediments from the second replicate had a very clear anoxic layer.	37.645	122.138
Balentine Drive	Took two replicates – first from culvert apron and upstream pool, and second from depositional areas approximately 30 m upstream. Channel bottom composed mostly of fine sediments.	37.524	121.997
Line 6-G	Sampled at upstream end of culvert apron below Automall Parkway, and at pool just above. Channel bottom composed mostly of fine sediments, with some <i>Corbicula fluminea</i> present.	37.509	121.964
Laguna Creek	Samples were collected from the eastern end of the culvert below Grimmer Blvd. and pool just upstream. Channel bottom composed of fine sediments with no sign of tidal influence. Moderate flow runs through the channel.	37.502	121.953
Agua Caliente	Samples were collected from an area starting from approximately 20 m east of Kato Rd. culvert and approximately 10 m upstream, on the south side of the channel. Channel bottom composed of fine, silty sediments with no sign of tidal influence.	37.488	121.941
Alameda Creek	Samples were collected by Ekman dredge from an area starting from the USGS stream gauge and approximately 30 m upstream.	37.587	121.962
Decoto-BART	Fine sediments, with several crawfish noted in channel. Sampled from a pool just downstream of the culvert below the BART line, and from depositional areas in the channel approximately 50 m downstream.	37.589	122.016
Decoto-Zwissig	Sampled concrete channel adjacent to abandoned Pacific Steel yard. Very fine sediments present. Sampled from concrete apron just above enclosed culvert and from within channel just upstream of apron.	37.592	122.013

Appendix B

Results of 2001 ACCWP Sediment Sampling Program,
Total PCBs, Total Mercury, Total PAHs, Percent Fines

Sample	PCBs (µg/kg)	Hg (µg/g)	PAHs (µg/kg)	% fines
Cabot Rep 1	9.7	0.25	6974.0	44.59
Cabot Rep 2	21.2	0.10	5594.9	55.39
CV - Knox	80.0	0.30	6862.0	23.44
CV - S3	8.7	0.40	959.0	5.14
SLZ Rep 1	5.8	0.11	2318.0	22.57
SLZ Rep 2	20.7	0.15	9439.0	16.99
Laguna Creek	0.5	0.10	647.8	41.46
Balentine Dr. Rep 1	31.1	0.28	13680.8	49.51
Balentine Dr. Rep 2	11.8	0.32	13442.9	59.65
Agua Caliente	3.3	0.07	296.0	32.40
Alameda Creek	1.8	0.22	65.7	16.34
Line 6-G	10.3	0.12	983.0	33.78
Arroyo Viejo	85.3	0.36	7341.0	79.53
Sausal Cr	38.2	0.78	1222.9	29.84
Seminary	54.6	0.47	263.3	12.37
Lion Cr	81.4	0.25	1681.9	50.06
San Leandro	472.0	4.29	10383.0	36.85
Glen Echo	194.9	0.61	11751.4	34.14
Codornices Rep 1	29.6	0.76	716.2	35.54
Codornices Rep 2	49.7	1.92	415.3	27.65
Ettle St	762.6	0.94	13380.0	43.51
Cerrito	298.6	1.99	3049.5	45.28
Decoto - BART	121.7	2.70	550.4	39.88
Decoto - Zwissig	35.7	0.20	1053.0	74.09

Notes:

- 1) Total PCBs calculated as the sum of 54 congeners reported by CAS
- 2) For all calculations, No Detects (NDs) assigned a value of zero

Appendix C

Appendix C

Results of 2001 ACCWP Sediment Sampling Program, OC Pesticides

Site	% fines	2,4-DDE		2,4-DDD		2,4-DDT		4,4-DDE		4,4-DDD		4,4-DDT		Aldrin		alpha-BHC		alpha-Chlordane	
		MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.
Cabot Rep. 1	44.59	1.7	ND	2.5	ND	7.5	ND	7.7	5.5	13	ND	8.6	ND	12	ND	5.2	ND	5.5	ND
Cabot Rep. 2	55.39	0.72	2.1	1.1	ND	3.3	ND	3.4	2.85	5.5	ND	3.8	ND	5.3	ND	2.3	ND	2.4	1.8
CV - Knox	23.44	2.2	69.5	3.3	ND	9.8	14.5	11	79.5	17	75	12	389	16	ND	6.9	ND	7.2	28.5
CV - S3	5.14	0.44	6.9	0.66	ND	2	3	2.1	15	3.4	7	2.3	14.5	3.2	ND	1.4	ND	1.5	11.3
SLZ Rep. 1	22.57	2.5	ND	3.8	1.25	12	ND	12	6.75	19	9.5	14	9.5	19	ND	8	ND	8.3	3.5
SLZ Rep. 2	16.99	3.5	9.4	5.3	ND	16		17	13.5	27	19	19	19	26	ND	12	ND	12	7
Laguna Creek	41.46	1.6	6.9	2.4	ND	7.2	ND	7.4	14	12	8.5	8.3	ND	12	ND	5	ND	5.3	ND
Balentine Dr. Rep 1	49.51	2	16	3	10.5	8.9	ND	9.2	25	15	47	61	9.5	15	ND	6.2	ND	6.5	20.5
Balentine Dr. Rep 2	59.65	1.2	13	27	ND	5.1	6.3	5.2	14	8.5	34	35	ND	8.1	ND	3.6	ND	3.7	16
Agua Caliente	32.40	0.62	ND	0.93	ND	2.8	ND	2.9	ND	4.7	ND	3.3	ND	4.5	ND	2	ND	2.1	ND
Alameda Creek	16.34	0.58	ND	0.87	ND	2.6	ND	2.7	ND	4.4	ND	3.1	ND	4.2	ND	1.9	ND	2	ND
Line 6-G	33.78	0.85	4.9	1.3	ND	3.9	ND	4	7.5	6.5	10.45	4.5	ND	6.1	ND	2.7	ND	2.9	7.95
Arroyo Viejo	79.53	3	ND	4.5	ND	14	ND	19	ND	23	38	16	82	22	ND	9.3	ND	9.8	24
Sausal Cr	29.84	1.5	ND	2.2	ND	6.5	ND	6.8	21	11	24	7.6	47	12	ND	4.6	ND	4.8	10
Seminary	12.37	0.46	41	15	ND	2.1	15	2.2	160	3.5	40	2.4	86	3.3	ND	1.5	ND	1.6	33
Lion Cr	50.06	1.8	ND	0.85	ND	2.6	5.8	2.7	13	4.3	17	3	42	4.5	ND	1.8	ND	1.9	8.6
San Lea0ro	36.85	58	ND	3.5	ND	11	85	11	220	18	200	12	270	17	ND	7.3	ND	7.6	38
Glen Echo	34.14	1.2	50	37	ND	5.3	26	5.5	160	8.9	120	6.2	220	8.5	ND	3.7	ND	3.9	78
Codornices Rep. 1	35.54	1.3	12	2	ND	5.9	ND	6.1	38	9.9	19	6.8	42.5	9.4	ND	4.1	ND	4.3	16.5
Codornices Rep. 2	27.65	0.97	11	1.5	ND	4.5	ND	4.6	35	7.5	18	5.2	36	7.1	ND	3.1	ND	3.3	19
Ettle St	43.51	63	ND	36	ND	5.2	28	5.3	200	8.6	120	99	ND	8.2	ND	3.6	ND	3.8	25
Cerrito	45.28	31	ND	55	ND	8	21	22	ND	14	ND	25	ND	13	ND	5.6	ND	5.9	63
Decoto - BART	39.88	0.72	5.5	1.1	ND	3.3	4.5	3.4	11	5.5	42	3.8	27	5.2	ND	2.3	ND	2.4	ND
Decoto - Zwissigg	74.09	0.69	16.5	1.1	ND	3.2	2.35	3.3	14	5.3	65	3.7	23.5	5	ND	2.2	ND	2.3	ND

All concentrations in µg/kg (ppb).

Appendix C

Results of 2001 ACCWP Sediment Sampling Program, OC Pesticides

Site	% fines	beta-BHC		Chlorpyrifos		cis-Nonachlor		delta-BHC		Dieldrin		Endosulfan I		Endosulfan II		Endosulfan Sulfate		Endrin	
		MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.
Cabot Rep. 1	44.59	7.5	ND	2.9	25	2	ND	19	ND	16	ND	6.3	ND	12	ND	8.2	ND	6.8	ND
Cabot Rep. 2	55.39	3.3	ND	1.3	ND	0.84	ND	8.3	ND	6.9	ND	4.6	ND	4.9	ND	3.6	ND	3	ND
CV - Knox	23.44	9.9	ND	3.8	28	2.6	18.5	25	ND	21	11	31	ND	15	ND	45	ND	8.9	ND
CV - S3	5.14	2	ND	0.77	8.15	0.51	3.55	5	ND	4.2	7.3	8.7	ND	3	ND	2.2	ND	1.8	ND
SLZ Rep. 1	22.57	12	ND	4.4	ND	3	3.7	29	ND	24	ND	9.6	ND	17	ND	13	ND	11	ND
SLZ Rep. 2	16.99	16	ND	6.1	ND	4.1	7.4	41	ND	34	ND	14	ND	24	ND	18	ND	15	ND
Laguna Creek	41.46	7.2	ND	2.8	ND	1.9	ND	18	ND	15	ND	6	ND	11	ND	7.9	ND	6.5	ND
Balentine Dr. Rep 1	49.51	9	ND	3.4	ND	2.3	12.05	23	ND	19	ND	24	ND	14	ND	9.7	ND	8	ND
Balentine Dr. Rep 2	59.65	5.1	ND	2	ND	1.3	7	13	ND	11	ND	4.3	ND	7.5	ND	35	ND	4.6	ND
Agua Caliente	32.40	2.8	ND	1.1	ND	0.72	ND	7.1	ND	5.9	ND	2.4	ND	4.2	ND	3.1	ND	2.6	ND
Alameda Creek	16.34	2.7	ND	1	ND	0.67	ND	6.6	ND	5.5	ND	2.2	ND	3.9	ND	2.9	ND	2.4	ND
Line 6-G	33.78	3.9	ND	1.5	ND	0.99	5.4	9.7	ND	8.1	ND	6.2	ND	5.8	ND	4.2	ND	3.5	ND
Arroyo Viejo	79.53	18	ND	34	ND	11	ND	34	ND	28	ND	20	ND	20	ND	16	ND	12	ND
Sausal Cr	29.84	6.6	ND	19	ND	1.7	ND	38	ND	14	ND	5.5	ND	9.7	ND	7.2	ND	5.9	ND
Seminary	12.37	2.1	ND	3.6	ND	15	ND	5.3	ND	8.2	ND	22	ND	4	ND	8.1	ND	1.9	ND
Lion Cr	50.06	2.6	ND	0.97	5.6	4.6	ND	6.4	ND	5.3	ND	5.2	ND	3.8	ND	2.8	ND	3.5	ND
San Lea0ro	36.85	11	ND	200	ND	68	ND	27	ND	98	ND	16	ND	16	ND	12	ND	74	ND
Glen Echo	34.14	5.4	ND	19	ND	37	ND	14	ND	19	ND	56	ND	7.9	ND	37	ND	4.8	ND
Codornices Rep. 1	35.54	6	ND	4.2	ND	5.1	ND	15	ND	18	ND	12	ND	8.8	ND	6.5	ND	5.4	ND
Codornices Rep. 2	27.65	4.5	ND	1.7	ND	5.2	ND	12	ND	11	ND	14	ND	6.6	ND	4.9	ND	4	ND
Ettle St	43.51	5.2	ND	2	29	36	ND	16	ND	11	ND	36	ND	36	ND	36	ND	20	ND
Cerrito	45.28	8	ND	3.1	ND	22	ND	21	ND	17	ND	52	ND	12	ND	8.7	ND	7.2	ND
Decoto - BART	39.88	3.3	ND	1.3	5.5	0.84	2.3	8.3	ND	6.9	ND	2.8	ND	4.9	ND	3.6	ND	3	ND
Decoto - Zwiissigg	74.09	3.2	ND	1.2	ND	0.81	5.25	7.9	ND	6.6	ND	2.7	ND	4.7	ND	3.5	ND	2.9	ND

All concentrations in µg/kg (ppb).

Appendix C

Results of 2001 ACCWP Sediment Sampling Program, OC Pesticides

Site	Ch fines	gamma-BHC (Lindane)		gamma-Chlorocyclohexane		Heptachlor		Heptachlor Epoxide		Mirex	Oxydemeton		trans-Nonachlor		
		MDL	Conc.	MDL	Conc.	MDL	Conc.	MDL	Conc.		MDL	Conc.	MDL	Conc.	
Cabot Rep. 1	44.59	13	ND	7.5	ND	6.9	ND	7	ND	3	ND	4.8	ND	3.2	3.85
Cabot Rep. 2	55.39	5.5	ND	3.3	2.7	3.1	ND	3.1	ND	1.3	ND	2.1	ND	0.73	3.3
CV - Knox	23.44	24	ND	9.9	35.5	9.1	ND	9.2	ND	3.9	ND	6.3	ND	2.2	39
CV - S3	5.14	3.3	ND	2	17.5	1.9	ND	1.9	ND	0.79	ND	1.3	ND	0.45	8.95
SLZ Rep. 1	22.57	59	ND	12	4.25	11	ND	11	ND	4.5	ND	7.3	ND	2.6	9.9
SLZ Rep. 2	16.99	38	ND	16	8.5	15	ND	15	ND	6.3	ND	11	ND	3.6	13.5
Laguna Creek	41.46	12	ND	7.2	ND	6.6	ND	6.7	ND	2.9	ND	4.6	ND	1.6	1.5
Balentine Dr. Rep 1	49.51	15	ND	9	18.5	8.2	ND	8.3	ND	3.6	ND	5.7	ND	2	29
Balentine Dr. Rep 2	59.65	8.4	ND	5.1	30	4.7	ND	4.7	ND	2	ND	3.2	5.3	1.2	17
Agua Caliente	32.40	6.4	ND	2.8	ND	2.6	ND	2.6	ND	1.2	ND	1.8	ND	0.63	ND
Alameda Creek	16.34	4.4	ND	2.7	ND	2.4	ND	2.5	ND	1.1	ND	1.7	ND	0.58	ND
Line 6-G	33.78	6.4	ND	3.9	13	3.6	ND	3.6	ND	1.6	ND	2.5	ND	0.86	9.25
Arroyo Viejo	79.53	23	ND	14	19	13	ND	13	ND	5.3	ND	8.5	ND	91	ND
Sausal Cr	29.84	11	ND	6.6	10	31	ND	6.1	ND	2.6	ND	4.2	ND	6	ND
Seminary	12.37	3.5	ND	2.1	36	2	ND	2	ND	0.82	ND	1.4	ND	20	ND
Lion Cr	50.06	4.2	ND	2.6	12	3.3	ND	2.4	ND	1	ND	1.7	ND	8.2	ND
San Lea0ro	36.85	18	ND	11	100	56	ND	9.7	ND	4.2	ND	6.7	ND	71	ND
Glen Echo	34.14	8.9	ND	5.4	140	4.9	ND	12	ND	2.1	ND	3.4	ND	1.2	64
Codornices Rep. 1	35.54	9.8	ND	6	20.5	5.5	ND	5.5	ND	2.4	ND	3.8	ND	13	ND
Codornices Rep. 2	27.65	7.4	ND	4.5	22	4.1	ND	4.2	ND	1.8	ND	2.9	ND	12	ND
Ettle St	43.51	33	ND	25	ND	4.8	ND	5.3	ND	2.1	ND	3.3	ND	36	ND
Cerrito	45.28	14	ND	8	88	7.4	ND	7.4	ND	3.2	ND	5.1	ND	47	ND
Decoto - BART	39.88	5.5	ND	3.3	4.95	3.1	ND	3.1	ND	1.3	ND	2.1	ND	0.73	0.65
Decoto - Zwissigg	74.09	5.2	ND	3.2	ND	2.9	ND	3	ND	1.3	ND	2	ND	0.7	0.75

All concentrations in µg/kg (ppb).