

Initial Characterization of PCB, Mercury, and PAH Contamination in the Drainages of Western Alameda County, CA

Produced for the Alameda Countywide Clean Water Program



Andrew J. Gunther, Paul Salop, David Bell¹

Arleen Feng²

Joe Wiegel³

Rebecca Wood⁴

¹ Applied Marine Sciences, 4749 Bennett Dr, Suite L, Livermore, CA 94550

² Alameda Countywide Clean Water Program, 951 Turner Court, Ste 300, Hayward, CA 94544

³ Columbia Analytical Services, 1317 S. 13th, Kelso, WA 98626-2845

⁴ Brooks-Rand, Ltd., 3950 6th Ave, N.W., Seattle, WA 98107

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Executive Summary

A key regional pollution problem driving water quality policy is the accumulation of polychlorinated biphenyls (Σ PCBs, or total PCBs) and mercury in estuarine organisms. The objective of this study was to begin the assessment of watersheds in Alameda County to determine which, if any, might contain major sources of mercury (including methylmercury), Σ PCBs, or polycyclic aromatic hydrocarbons (Σ PAHs). Sediments were collected from twenty-one sites in creeks, concrete-lined flood control channels, and one sedimentation basin in western Alameda County, using methods modeled after the National Ambient Water Quality Assessment of the U.S. Geological Survey and the National Status and Trends Program of the National Oceanographic and Atmospheric Administration. The majority of sites were located at the base of local watersheds, above the region of tidal influence, to be representative of all conditions upstream. Since sediment contamination can be highly variable, the results from the first year of this project should be interpreted cautiously, as several years of sampling will be required to definitively characterize watershed contamination.

In general, the results from the first year of sampling indicate that the watersheds of Alameda County are not alike with respect to contamination by Σ PCBs, Σ PAHs, and mercury. Some watersheds have much higher concentrations than others, which suggests that important sources of these contaminants occur in some watersheds but not in others. The concentration of Σ PCBs in sediments from the Ettie Street Pump Station near the eastern anchorage of the Bay Bridge (3.2 ppm) are among the highest measured in Bay Area watersheds, and indicate there is an important source of PCBs in this watershed. Only two sites sampled in this study, Codornices Creek and the Ettie Street pump station, had mercury concentrations above the Regional Water Quality Control Board's preliminary guideline of 400 ppb, although concentrations of mercury in San Leandro Creek were also relatively high. Methylmercury concentrations were the highest at the sites with very fine grain sediments, which is expected as these sediments provide more anaerobic conditions required by the bacteria that methylate mercury.

A rough calculation of contaminant loads to the Bay from Alameda County watersheds indicates that the high concentrations at the Ettie Street site make this watershed a relatively important source of all contaminants, despite its relatively small size. For example, although Alameda Creek produces a suspended sediment load 500 times the size of Ettie Street, more than 5 times as much Σ PCBs are estimated to be delivered to the Bay by Ettie Street. Codornices Creek stands out as a relatively large source of total mercury.

Contaminant concentrations are clearly higher in watersheds with extensive urban development, which is consistent with the hypothesis that local human activities are responsible for contamination of watersheds. That mercury does not show this trend as strongly as PCBs and PAHs is consistent with the presence of some natural sources of mercury. As stressed above, these interpretations must be considered preliminary because we have only one year of sampling.

It is recommended that the sampling program be repeated for a minimum of two additional years to provide more meaningful characterizations of each watershed as a source of particulate-associated contaminants of concern. In addition, a supplementary investigation should be initiated to determine the source of contamination reaching the Ettie Street Pump station.

Introduction

A key regional pollution problem driving water quality policy is the accumulation of polychlorinated biphenyls (Σ PCBs, or total PCBs) and mercury in estuarine organisms being consumed by humans and other higher trophic order consumers [1]. Contamination has reached concentrations that have triggered health warnings from the State of California, and is also causing violations of California's narrative standard [2] that "controllable water quality factors shall not cause a detrimental increase in the concentration of toxic substances found in bottom sediments or aquatic life." This is despite the implementation of a variety of pollution control measures and best management practices by NPDES permittees, and the cessation of commercial PCB production in 1977 [3]. Although concentrations in bivalves in San Francisco Bay dropped significantly early in the 1980s [4], Σ PCB concentrations in the waters of San Francisco Bay have not declined significantly since the late 1970s [4]. Preliminary modeling suggests this is likely due to both continuing inputs and the large amount of Σ PCBs in the sediments of the estuary equilibrating with the water column [5].

A Total Maximum Daily Load (TMDL) for mercury has been drafted by the San Francisco Bay Regional Water Quality Control Board [6]. A TMDL for Σ PCBs is under development, with a TMDL report expected by June 2002 (Table 1). A key feature of the proposed TMDL implementation plan will be a phased approach, in which pollution control efforts are first focused upon watersheds that contain major sources of contaminants of concern. The focus of the mercury TMDL on the Guadalupe River watershed, which contains the New Almaden mercury mine, is an example of this approach.

WATERBODY	Pollutant(s)	Completion Date on 1998 303(d) List	Current Projected Completion Date		
			TMDL Report	TMDL with Implementation Plan	Basin Plan Amendment
All San Francisco Bay Segments	Mercury	2003	June 2000	June 2001	June 2002
All SF Bay Segments	PCBs	2008	June 2002	June 2003	June 2004
SF Bay Urban Creeks (36)	Diazinon	Listed by USEPA	June 2002	June 2003	June 2004
Guadalupe River Watershed	Mercury	2003	June 2003	June 2004	June 2005

Table 1: Total Maximum Daily Load (TMDL) Implementation Schedule for the San Francisco Bay Regional Water Quality Control Board. Only a small portion of the scheduled TMDL work is presented. The full schedule is available on the RWQCB web site (www.swrcb.ca.gov/rwqcb2/Downloadable_Files/downloadable_files.html).

The objective of this study was to begin the assessment of watersheds in Alameda County to determine which, if any, might contain major sources of mercury (including methylmercury) or Σ PCBs. The study design assumes that if a particular watershed contains a major source of these particulate-associated contaminants of concern, these compounds should be significantly elevated in sediments from these watersheds as compared with sediments collected in San Francisco Bay by the Regional Monitoring Program for Toxic Substances in the San Francisco Estuary (RMP). If sediment deposits at the mouth of a watershed suggest it could contain a major source, then mass loads from that watershed should be estimated and compared to other inputs to the estuary, including those from POTWs, major industrial dischargers, and the Delta. The study includes analysis of sediments for polycyclic aromatic hydrocarbons (PAHs), as these contaminants also exist in the environment predominantly in a particulate-associated form.

This project addresses several important regional goals. The RWQCB will obtain the benefits of geographic prioritization of source reduction efforts, and the survey will address a key recommendation from the Chlorinated Hydrocarbon Work Group of the RMP for identifying local sources of PCBs [5]. The project also fulfills the purposes of the BASMAA Regional Monitoring Strategy, the Alameda Countywide Clean Water Program's Stormwater Management Plan, and the revised goals of the RMP to develop data that support efforts to identify sources of key contaminants and reduce contaminant loading to the estuary.

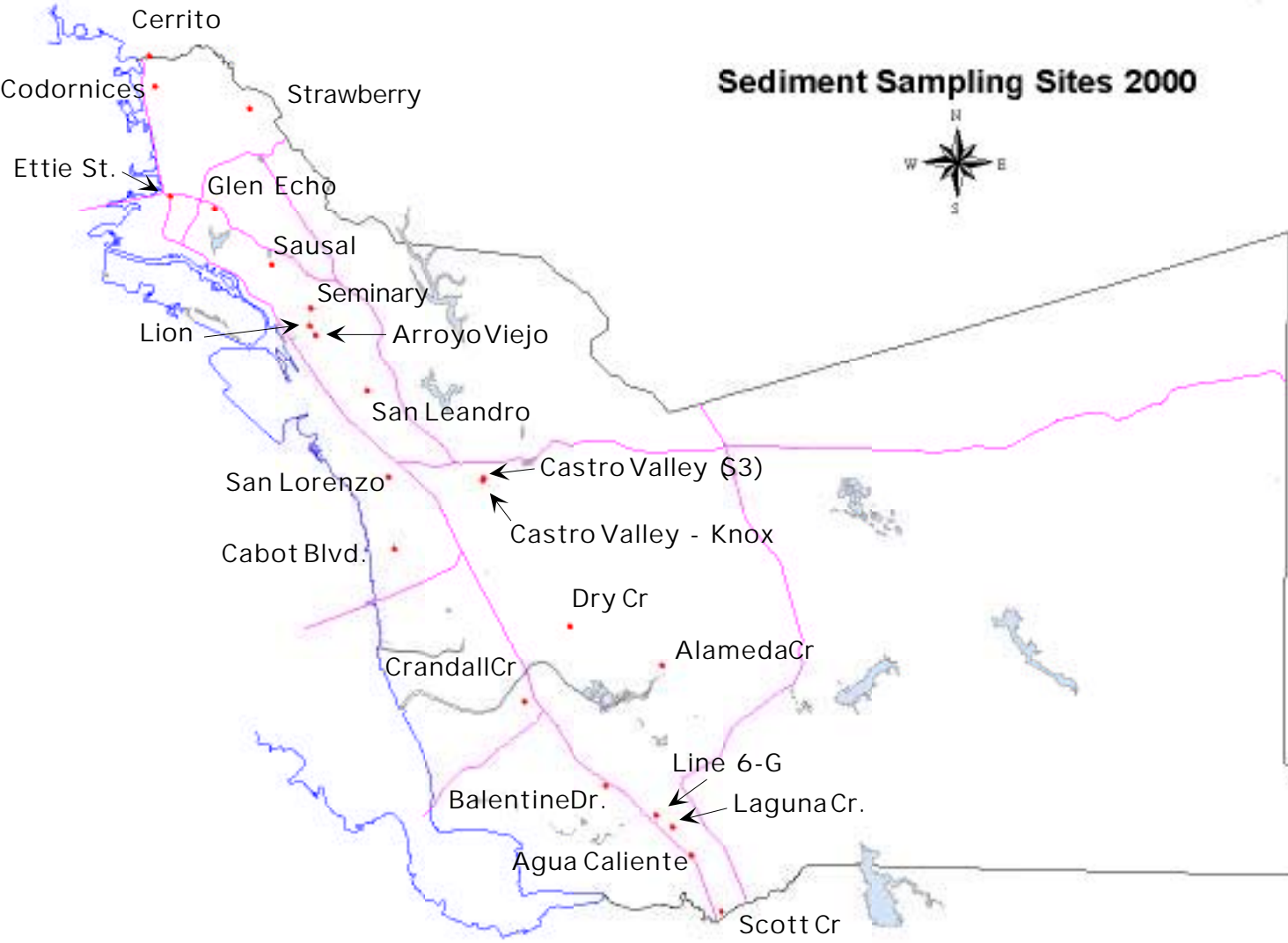
Methods

Sampling Sites. Sediments were collected from twenty-one sites in creeks, concrete-lined flood control channels, and one sedimentation basin in western Alameda County. 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 considered, which limits the number of potential sampling sites, as many of the County creeks and channels are underground. The sampling sites stretch from Cerrito Creek at the northern County boundary to channels in southern Fremont (Fig. 1), and are described in Appendix I.

Sample Collection. Sample collection procedures were modeled to the maximum extent possible after the National Ambient Water Quality Assessment [7], the National Musselwatch Program [8], and the RMP [9]. Prior to sampling, all equipment was fully immersed for three days in a solution of Alconox™ detergent and deionized water. Equipment was then rinsed three times each with deionized water, a 1.0 % solution of hydrochloric acid, petroleum ether, and deionized water again. Between sites in the field, sampling equipment was cleaned with native water and a scrub brush prior to leaving a sampling site. At each subsequent site, the equipment was scrubbed with an Alconox™ solution, rinsed sequentially with native water, reagent-grade dilute hydrochloric acid, reagent-grade methanol, and distilled water.

At most creek and channel sites, Kynar™-coated scoops were used to remove sediments to a depth of 2-3 cm from a minimum of three stations at each site, and these sediments were composited in a Kynar™-coated bucket. Depositional areas within the channels were targeted for sample collection; typical locations included the leading edges of point bars, around emergent vegetation, near the toes of banks in slight bays, beneath undercuts and root wads at banks, and behind large rocks or other obstructions. Samples

Sediment Sampling Sites 2000



were not collected in areas where sediments appeared to be the product of bank sloughing. Great care was taken to make sure that fine material was not lost as sediments were lifted from the streambed by the scoop. If fine material was observed to cloud any overlying water, the sample was discarded.

A stainless steel Ekman-dredge (Wildco, Inc.) was used to collect sediments from the sedimentation basin at the Ettie Street Pump Station, and from the channel of Alameda Creek. After the actuated dredge was removed, the sample was checked for integrity (samples showing evidence of washout or blow-out were discarded), the surface water carefully drained off taking care not to lose fines, and the top 2-3 cm of sediment was placed in the compositing bucket. Composited samples were thoroughly mixed, placed in pre-cleaned containers (16 oz. glass [ICHEM, Inc.] for organic chemistry, 100 ml teflon for mercury), double bagged in Ziploc™ bags and stored on ice in the field. At the conclusion of each sampling day, samples were either stored overnight on dry ice or removed to a freezer (-20°C).

All sampling was completed between September 12 and October 3, 2000, near the end of the several-month dry period that characterizes California's climate during the late spring and summer (One sample from Codornices Creek, collected on July 27, 2000, was also included in the analysis for mercury and PCBs). This timing 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.

Chemical Analysis. 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. PCBs were measured using EPA Method 8082 [10], with dual column confirmation of congener concentrations using RTX-5 and RTX-200 columns. PAHs were measured following EPA Method 8270C [11]. Mercury [12, 13] and monomethylmercury [14] were analyzed by cold vapor atomic fluorescence. TOC was measured using by standard colorimetric methods [15]. Percent fines (<63 μ, or the percentage of material able to pass through a 63 micron filter) were analyzed using the peroxide digestion method of the RMP in order to develop comparable data (Appendix 2). The results for TOC (%) and % Fines (<63μ) are reported only for the fraction of the sample that passed through the 2-mm sieve.

Data Analysis. ΣPCBs 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, 199, 203, 206, 209. Congeners with values below detection limits were assigned a value of zero for purposes of calculating ΣPCBs. Originally, it was intended that PCB congener 201 would be analyzed instead of congener 199. However, not until after analysis was it discovered that Columbia Analytical Laboratories uses an older naming convention (BZ from [16]). By the older naming convention BZ congener 201 is the same as IUPAC congener 199, and so analysis of IUPAC 199 was substituted for IUPAC 201.

ΣPAH was calculated by summing the concentrations of the following compounds: 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, tetrachloro-m-xylene.

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 $<63\mu$.

Relative percent difference of duplicate samples was calculated as:

where X_1 and X_2 are the concentrations of the duplicate samples.

Estimates for particulate-associated contaminant loads were derived by the equation (the assumptions behind the analysis are presented in the Discussion section under *Contaminant Load Estimates*):

$$(\text{TSS Annual Loading}) \times (\text{Analyte Concentration}) = \text{Annual Loading of Analyte}$$

TSS annual loads were obtained by summing dry and wet season TSS loads developed through stormwater measurements in watersheds throughout the County from 1989-1991 [17]. Analyte concentrations were those measured in this study for mercury, monomethylmercury, Σ PCBs, and Σ PAHs. Given the significant variability of stormwater chemistry, and the fact that this study has taken only single samples, the load estimates generated by this method are quite uncertain, and are presented to only two significant figures.

Results

Analytical Results The results of sediment analyses are presented in Table 2. The measurements made at the Ettie Street Pumping Station are the highest from all stations for Σ PCBs, Σ PAHs, and mercury. The measurement for Σ PCBs at Ettie Street (3.2 ppm) is among the highest sediment concentrations of Σ PCBs reported for the San Francisco Bay area, and is two orders of magnitude higher than nearby RMP stations (see below) [Due to the order of magnitude difference between the Σ PCBs measurement for the Ettie Street sample and the other samples, the laboratory was requested to reanalyze the Ettie Street sample for Σ PCBs. Results obtained in the second analysis (3.2 ppm) verified that the initial measurement did not represent an analytical error (such as a poorly-mixed sample)]. Since the concentration of Σ PCBs, mercury, and PAHs are known to co-vary with grain size and total organic carbon, watersheds are compared by presenting the sediment concentrations normalized to grain size and TOC in many of the following figures.

For Σ PCBs, samples taken from Glen Echo Creek (160 ppb averaged from two replicates) are higher than all other sites except Ettie Street. Other sites with concentrations above 50 ppb include Lion and Cerrito Creeks, and the Cabot Blvd flood control channel (Fig. 2). The South County sites at Balentine Dr., Scott Creek, and Crandall Creek have relatively high concentrations of TOC and fine grained sediments, but exhibit relatively low Σ PCBs concentrations. When measurements are normalized to grain size (Fig. 3), samples that stand out as elevated include Ettie Street, Glen Echo, San Leandro, Seminary, and Lion.

Site	Σ PCBs	Σ PAHs	TOC	F ₆₃	Hg	mmHg
Arroyo Viejo	16	400	1.3	9.7	44	1.1
San Lorenzo S.B.	3.00	410	1.6	9.2	130	1.0
Castro Valley S-3	23	3300	1.2	9.7	77	0.13
Line 6-G, Chevron	21	2500	0.00	35	140	0.19
San Leandro Creek	32	520	1.3	5.7	260	1.8
Seminary Creek	32	1000	1.1	6.4	160	1.2
Lion Creek†	65	5800	1.5	12.6	290	0.76
Alameda Creek	1.1	110	0.66	32.1	110	0.12
Laguna Creek	1.8	140	0.54	38	110	0.31
Cabot Blvd	69	7100	1.6	39	110	1.1
Aqua Caliente†	3.0	220	1.1	38	170	1.4
Castro Valley†	7.0	1600	0.60	32	62	0.15
Ettie St. Pump	3300	160000	6.7	36	800	1.7
Cerrito Creek	63	810	1.5	34	340	1.1
Glen Echo†	160	4400	1.4	19	170	1.0
Sausal Creek	33	190	0.5	26	310	0.03
Crandall Creek	4.4	850	2.5	68	120	2.2
Scott Creek	11	510	3.5	83	150	3.9
Strawberry Creek	1.1	41	1.4	16	53	0.32
Dry Creek	0.30	39	0.61	16	35	0.70
Balentine Drive	10	4100	1.4	57	100	2.0
Codornices	19	N/A	0.54	21	490	0.66

Table 2: Sediment Chemistry for Sites Sampled in this Study. All data as ppb (d.w.) except TOC and Fines, which are percent by weight for the fraction passing a #10 sieve. F₆₃ = fines less than 63 μ in diameter, mmHg=monomethylmercury. † indicates an average of the two duplicates is reported.

For mercury (Fig. 4), the Ettie Street and Codornices Creek sites are the only two sites that are above the 400 ppb guideline contained in the RWQCB's draft TMDL (one of the two replicates for Lion Creek was also above this concentration). Other sites with relatively high concentrations of mercury in sediments include Sausal, Lion, and Cerrito Creeks. As was the case for Σ PCBs, the South County sites at Balentine Dr., Scott Creek, and Crandall Creek had low concentrations of mercury despite their fine-grained composition. When the mercury results are normalized to percent fines, several other watersheds (especially San Leandro Creek) also appear to contain elevated concentrations of mercury (Fig. 5).

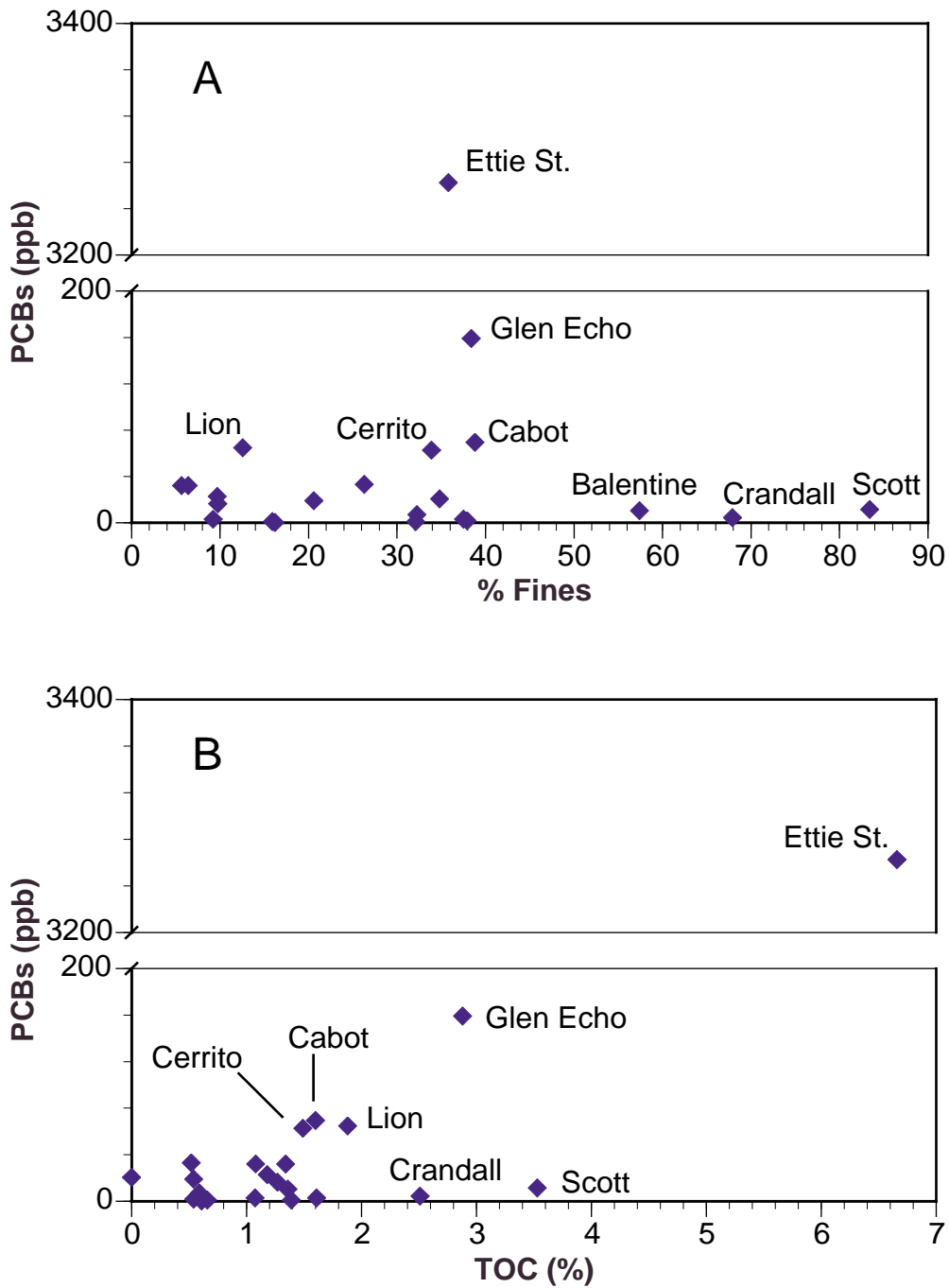


Figure 2: PCBs in Sediments from Summer 2000 Sampling.
(A) PCBs v. % fines (<63μ). (B) PCBs v. Total Organic Carbon.

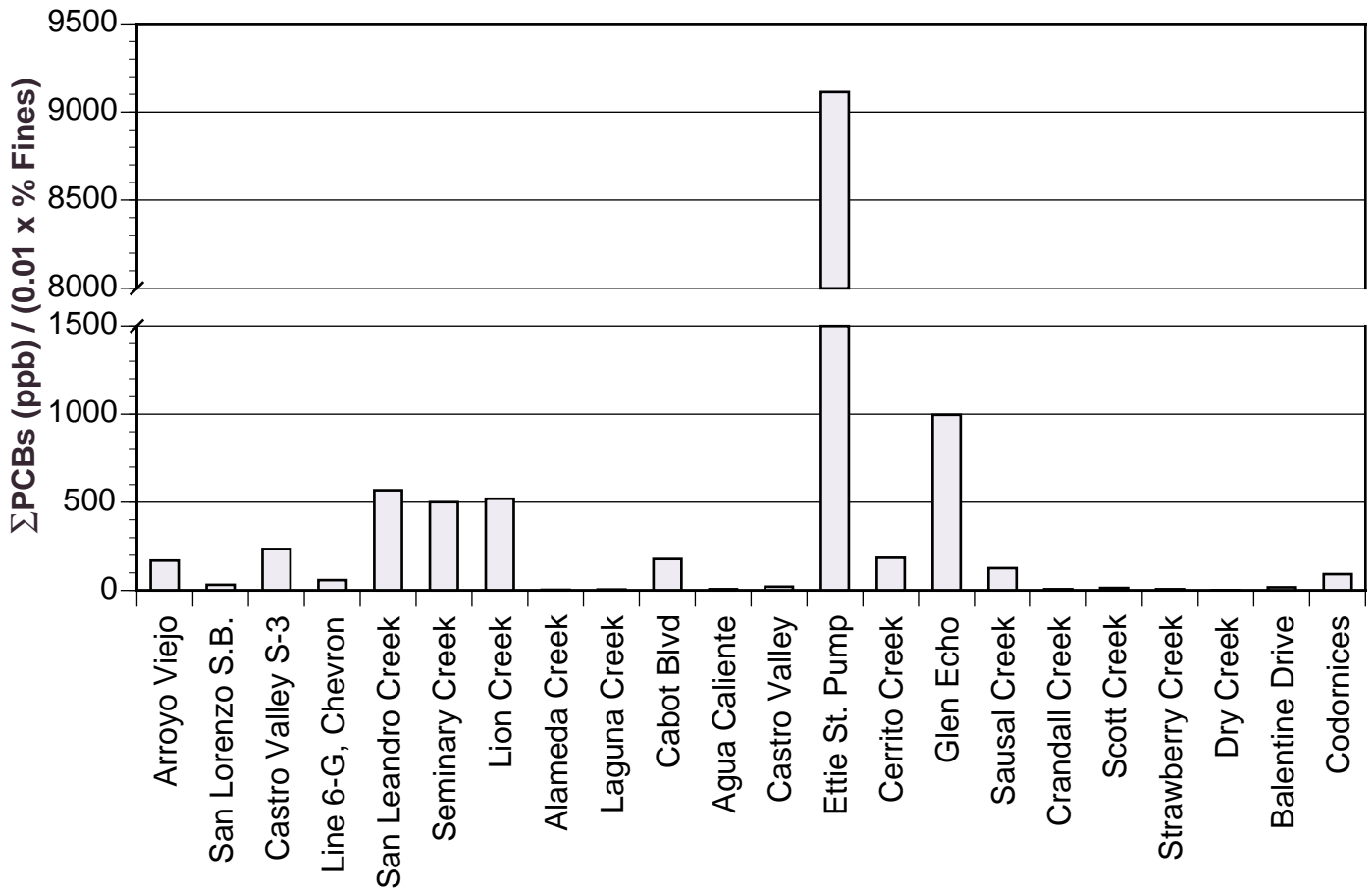


Figure 3: ΣPCBs in Sediments from Summer 2000 Sampling, Normalized to Percent Fines (<0.63μ). Non-normalized data in Table 2.

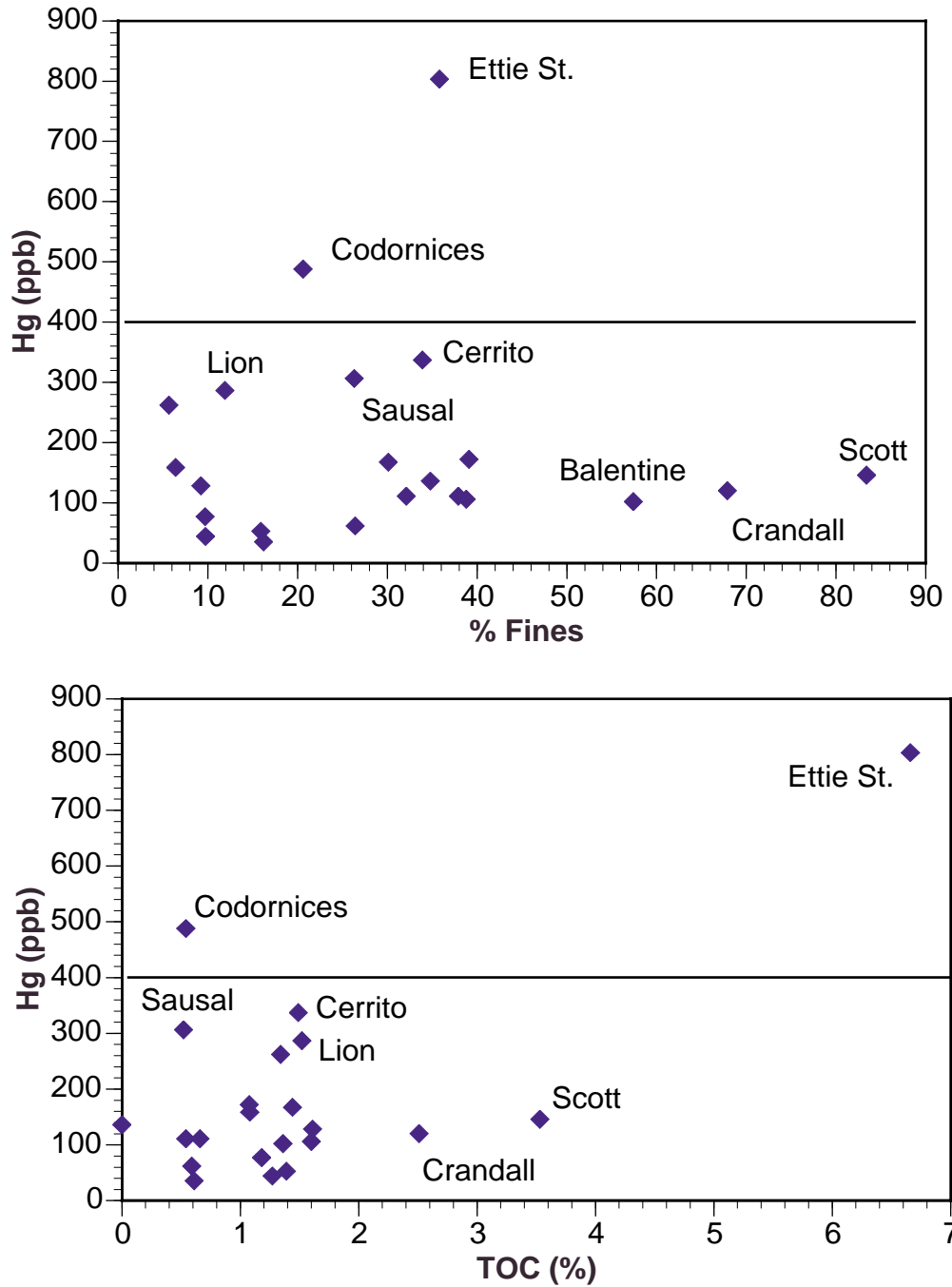


Figure 4: Total Mercury in Sediments from Summer 2000 Sampling. (A) Hg v. % fines (<63μ). (B) Hg v. Total Organic Carbon. Line at 400 ppb is suggested guideline for mercury contamination from Hg TMDL.

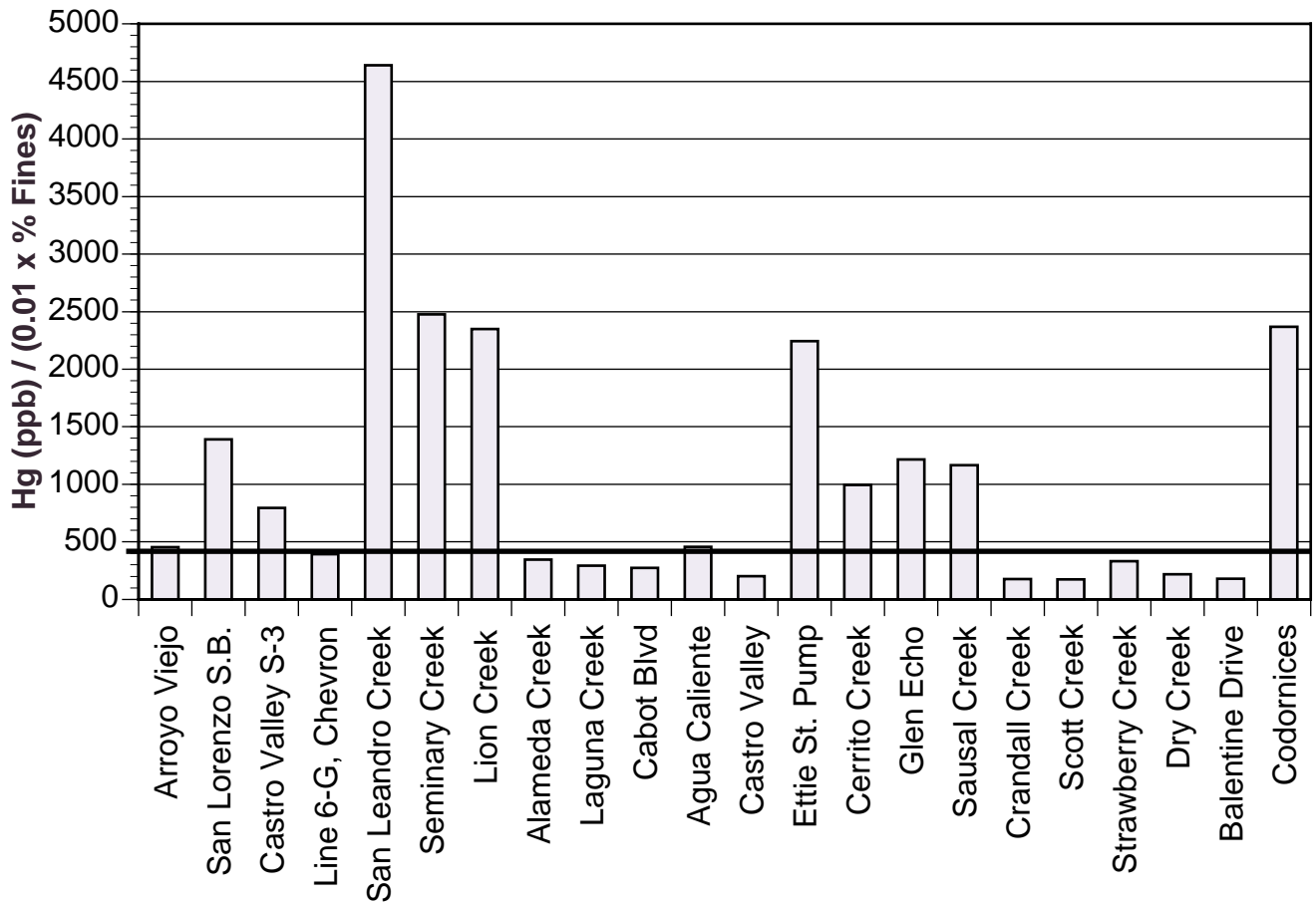


Figure 5: Hg in Sediments from Summer 2000 Sampling, Normalized to Percent Fines (<math><0.63\mu</math>). Non-normalized data in Table 1. Line at 400 ppb is suggested guideline for mercury contamination from Hg TMDL.

Unlike mercury and Σ PCBs, monomethylmercury (mmHg) concentrations in sediments are highest in the South County drainages with very fine grain size, including Crandall and Scott Creeks and the Balentine Dr. site (Fig. 6). As mmHg is produced by the action of anaerobic bacteria, the correlation noted between mmHg and grain size is expected, as fine grained sediments will provide more anaerobic conditions for methylation. Concentrations of mmHg were also relatively high at the San Leandro Creek and Ettie Street sites.

Of the contaminants measured, Σ PAHs was the most variable across watersheds. Ettie Street was again much more contaminated than the other sites, with a concentration about 15 times higher than the next most contaminated site at Cabot Blvd (Fig. 7).

The results of quality control analyses (Appendix 3) were consistent with data quality objectives (Table 3) in all instances with one exception. For one batch of mmHg analyses, matrix spike recovery (156%) was outside the target range (65-135%). This suggests the possibility of a matrix interference in some mmHg samples, but is not significant enough to alter the present interpretation of the data.

Table 4 presents the results of analysis of field duplicate samples. These samples were collected from the same reach of the creek/flood control channel on the same day, but are separate composites. The data indicate that the relative percent difference for duplicates, a measure of precision (sampling and analytical precision combined), is about 50% for Σ PCBs, 40% for mercury, TOC, and grain size, 75% for Σ PAHs and over 80% for mmHg.

Due to the order of magnitude difference between the Σ PCBs value for the Ettie Street sample and the remaining samples, CAS was requested to reanalyze the Ettie Street sample for PCBs. Results obtained in the second analysis were consistent with the original results obtained.

Discussion

Prior to considering the implications of the results reported above, two factors must be kept in mind. First, the results from duplicate samples presented in Table 4 indicate that our ability to replicate samples from the same site is limited to at least $\pm 50\%$, and closer to $\pm 80\%$ for mmHg and Σ PAH. This is not unexpected, as sediments are renowned for their heterogeneity, with significant variations in chemical content possible over small spatial scales. Second, the sample results are for one season only. If sources are intermittent or transitory in a watershed, we will only be able to determine this through a multi-year sampling program. Consequently, characterization of watersheds in the following discussion must be considered preliminary, to be verified and refined with additional sampling in subsequent years.

In general, the results from the first year of sampling indicate that the watersheds of Alameda County are not alike with respect to contamination by Σ PCBs, Σ PAH, and mercury. Some watersheds have much higher concentrations than others, which suggests that important sources of these contaminants occur in some watersheds but not in others. If a large-scale, background source of contamination (such as aerial deposition) were the most important source, contamination would tend to be a function only of grain size or percent fines (Fig 8; line labeled "background"). While certain watersheds fall along a

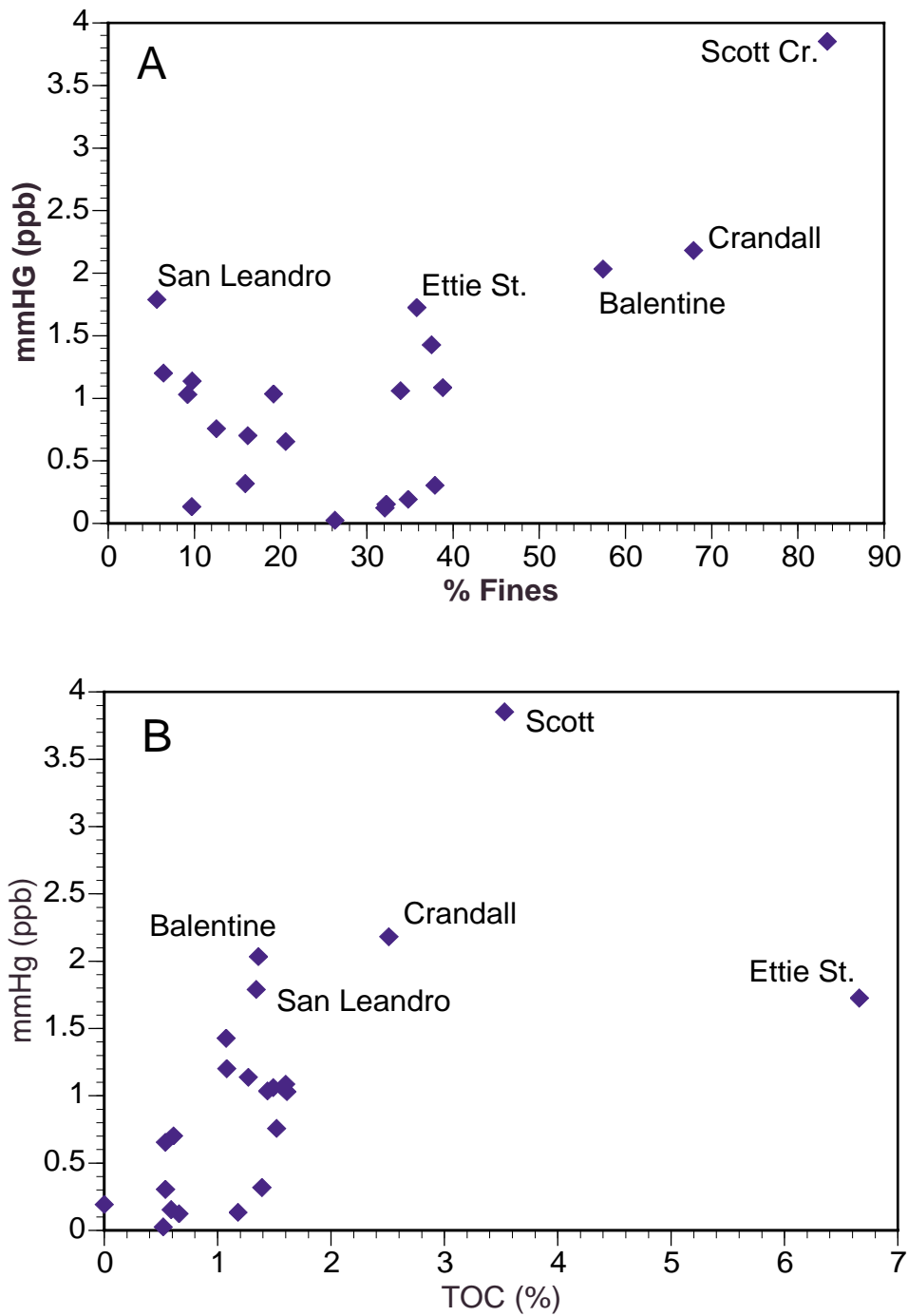


Figure 6: Methylmercury (mmHg) in Sediments from Summer 2000 Sampling. (A) mmHg v. % Fines (<63μ). (B) mmHg v. Total Organic Carbon.

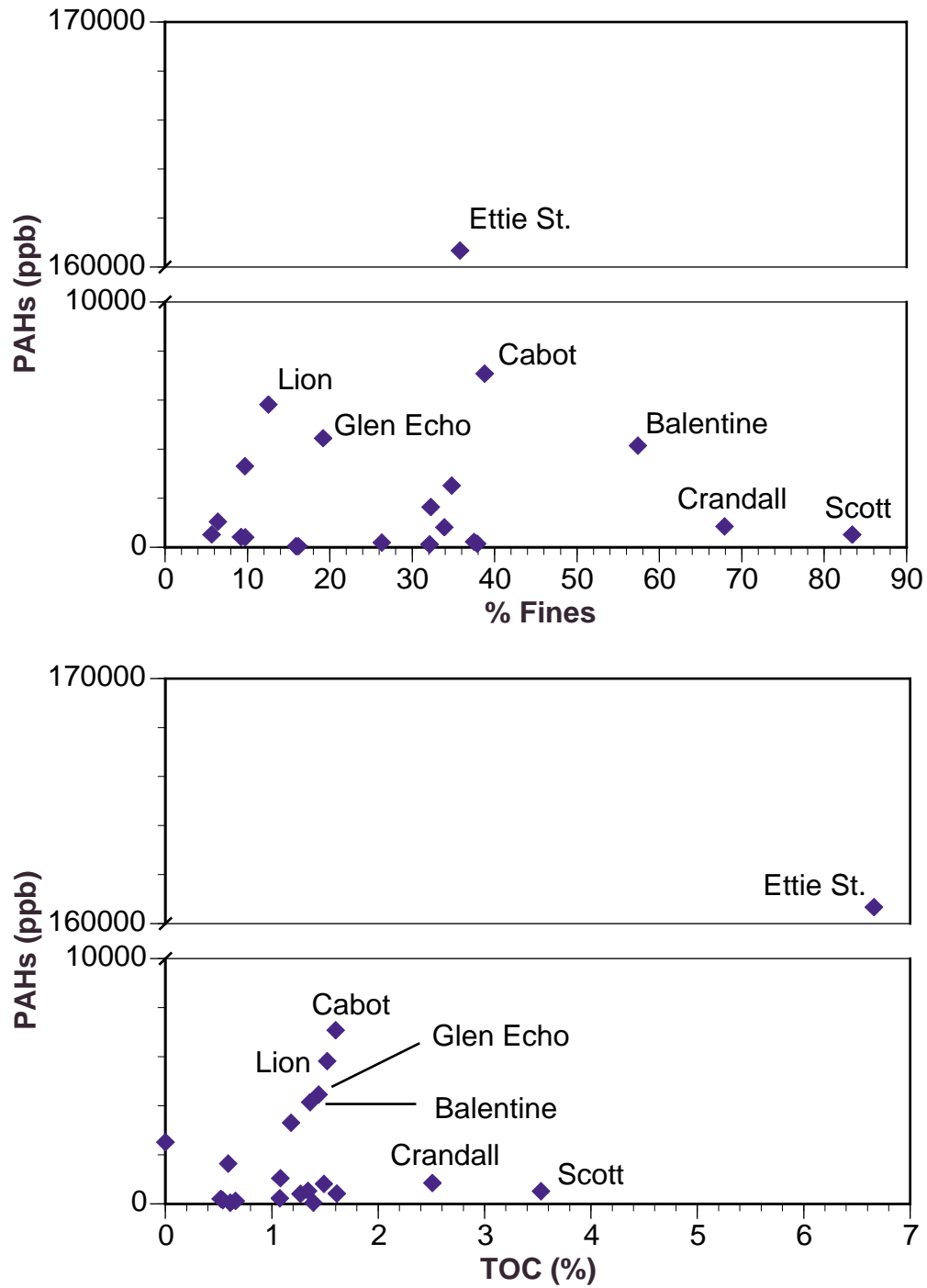


Figure 7: PAHs in Sediments from Summer 2000 Sampling.
(A) PAHs v. % fines (<63μ). (B) PAHs v. Total Organic Carbon.

Analyte	Lab	QC Sample	Minimum Frequency per Batch	Typical Acceptance Limits
PCBs	CAS	Certified SRM†	1	Varies by congener
		Lab Control Sample	1	60 – 140% Recovery
		Matrix Spike	1	30 – 150% Recovery
		Dup. Matrix Spike	1	30 – 150% Recovery
		Method Blank	1	Below MDL††
TOC	CAS	Lab Control Sample	1	85 - 115% Recovery
		Matrix Spike	1	75 – 125% Recovery
		Method Blank	1	Below MDL
PAHs	CAS	Certified SRM	1	Varies by PAH
		Lab Control Sample	1	Varies by PAH within range of 25 – 135% Recovery
		Method Blank	1	Below MDL
mmHg	BRL	Lab Control Sample	2	65 – 135% Recovery
		Matrix Spike	2	65 – 125% Recovery
		Method Blank	2	Below MDL
mmHg	BRL	Lab Control Sample	2	75 - 125% Recovery
		Matrix Spike	2	65 – 135% Recovery
		Method Blank	2	Below MDL

Table 3: Summary of Laboratory Quality Control Performance Measures.
 † = Standard Reference Material; †† = Method Detection Limit

Analyte	Relative Percent Difference
PCBs	56
PAHs	73
TOC	42
% Fines	42
Hg	43
mmHg	88

Table 4: Relative Percent Difference (RPD) of Duplicate Samples. Each duplicate was collected as a separate composite sample from the same sampling site.

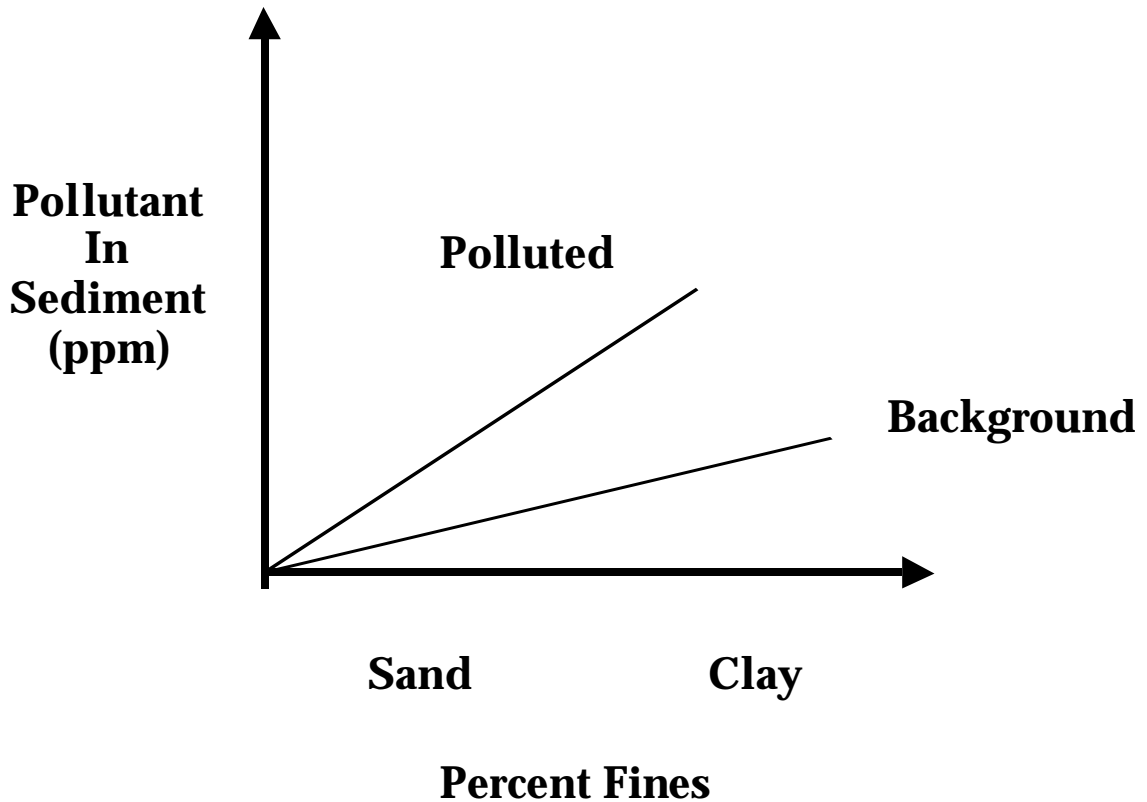


Figure 8: Generalized Diagram of the Linkage Between Total Contaminant Concentration in Sediment and Grain Size. A generalized source of contamination will produce background concentrations, while sediments with additional sources of contamination will appear elevated relative to the background distribution (line labeled polluted). Figure after Abu-Saba (in preparation).

line of “background” contamination, many other watersheds tend to fall along a line characterized by higher concentrations of contaminants (Fig 8, line labeled “polluted”). This structure can be observed in Figures 2 (Σ PCBs), 4 (mercury), and 7 (Σ PAHs), although until additional sampling years can be represented on the graph this analysis must be considered preliminary. The following paragraphs will review each contaminant separately.

Σ PCBs. The concentration of Σ PCBs at the Ettie Street Pump Station are among the highest measured in Bay Area watersheds, although not the highest (Fig. 9). PCBs (measured as Aroclor 1248 rather than as the sum of congeners) have been measured at 42 ppm in sediments from a storm drain collected just north of the Richmond Field Station [18]. Recent sampling by the Santa Clara Valley Urban Runoff Program (using the same analytical methods as this study) measured Σ PCBs in storm drain sediments from an industrial location at a concentration of 26.7 ppm [19].

In December of 1998, the County of Alameda accepted ownership of the Ettie Street Pump Station from the City of Oakland after a \$2.5 million renovation. Preliminary indications from the City of Oakland are that approximately three feet of sediment was removed from the facility at this time and transported to a Level 2 disposal site in Utah (F. Sweiss, City of Oakland, personal communication). When the site was sampled during this project, sediment accumulations were much smaller, on the order of a few inches in each sedimentation basin. It therefore appears reasonable to assume that the sediment sample collected during this study was transported into the pump station from the watershed during the last two years.

The Ettie Street Pump Station drains a region of western Oakland, and pumps this stormwater into a drainage channel that empties into the Emeryville Crescent just north of the East Bay anchorage of the San Francisco-Oakland Bay Bridge. In 1993, a sample taken at station B-9 along the northern shoreline of the Emeryville Crescent generated a measurement of 1660 ppb at 1 ft. depth and 500 ppb at 4 ft. depth, both reported as Arochlor 1254 [20]. The Bay Protection and Toxic Clean-up Program took a single sample from the Emeryville Crescent, which contained 97 ppb Σ PCBs [21], and the sediment studies of the Pilot RMP measured 101 ppb Σ PCBs at this location [22]. Although this is twice the concentration found at the RMP Yerba Buena Island site, it is not as high as many other sites along the Bay margin (e.g., Pt. Potrero, Fig 9).

The closest Regional Monitoring Program station to this discharge site is Yerba Buena Island, which shows higher concentrations of Σ PCBs in sediment than surrounding stations (Fig. 10). There are many potential sources for the regional elevation in Σ PCBs found at Yerba Buena Island, not all of which have been investigated. Preliminary indications are that one such potential source resides within the watershed drained by the Ettie Street Pumping Station.

Mercury. The draft TMDL for mercury submitted by the RWQCB to the USEPA suggests a numeric target for sediment inputs to San Francisco Bay of 400 ppb (dry weight), directed at preventing the continued accumulation of mercury in bottom sediments in the Bay. Watersheds that have sediment concentrations higher than this value are considered likely to be exacerbating the mercury contamination problem in San Francisco Bay, and these regions will be the subject of source investigations and waste discharge requirements if necessary [23].

Only two sites sampled in this study had mercury concentrations above the 400 ppb guideline, Codornices Creek and the Ettie Street pump station. In addition, one of the duplicate samples from Lion Creek was above the guideline (Lion Creek Rep #1 at 430

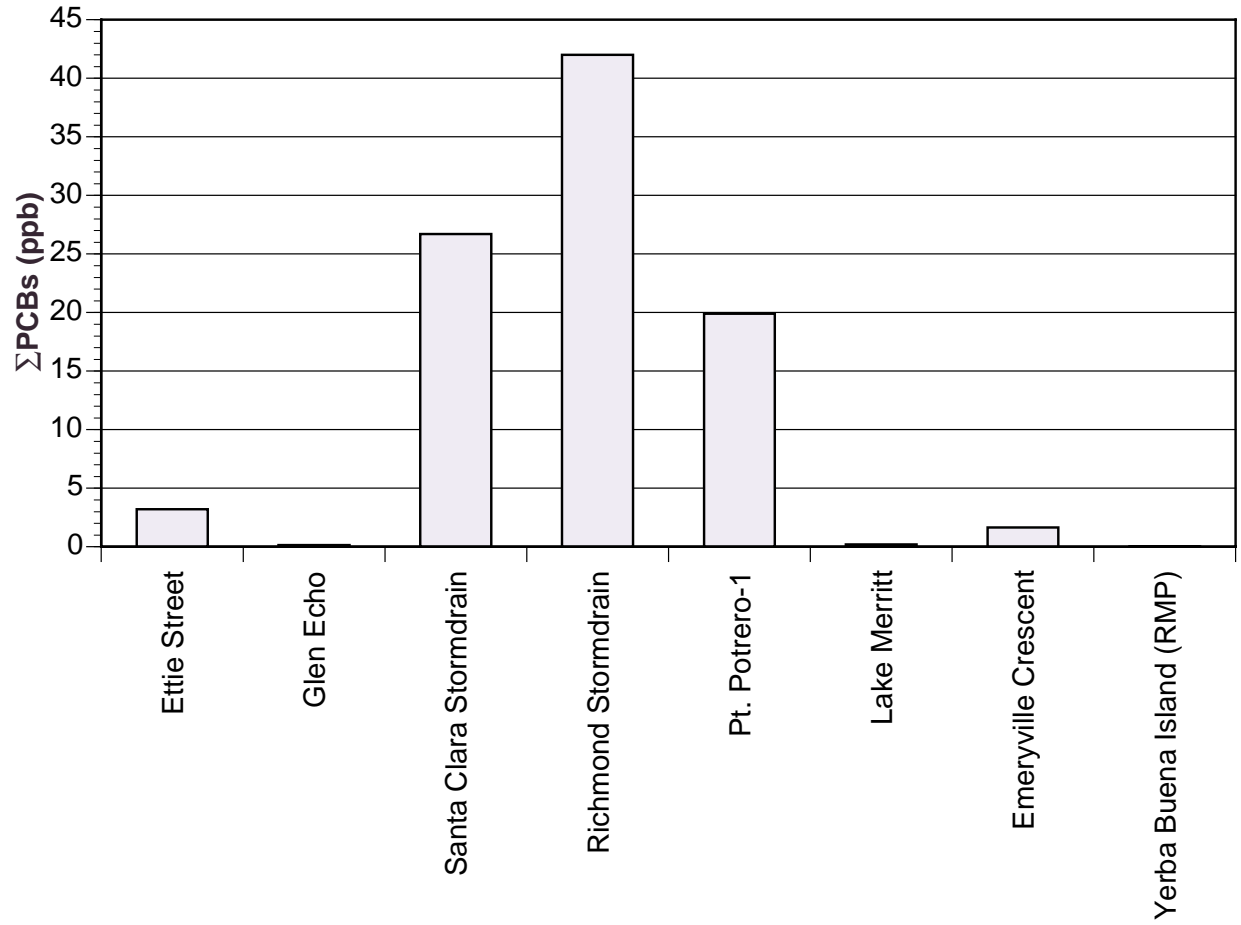


Fig 9: ΣPCBs at Selected Locations in the San Francisco Bay Area. Lake Merritt, Pt. Potrero from Bay Toxic Protection and Clean-up Program (SWRCB, 1998); Santa Clara Stormdrain from Kinnetics Laboratories (in prep); Richmond Stormdrain (as Aroclor 1248) from URS (2000); Emeryville Crescent (as PCB-1254) from Tetra Tech (1993); Yerba Buena Island from Regional Monitoring Program, 1996-1998, (SFEI 1998; 1999; in press)

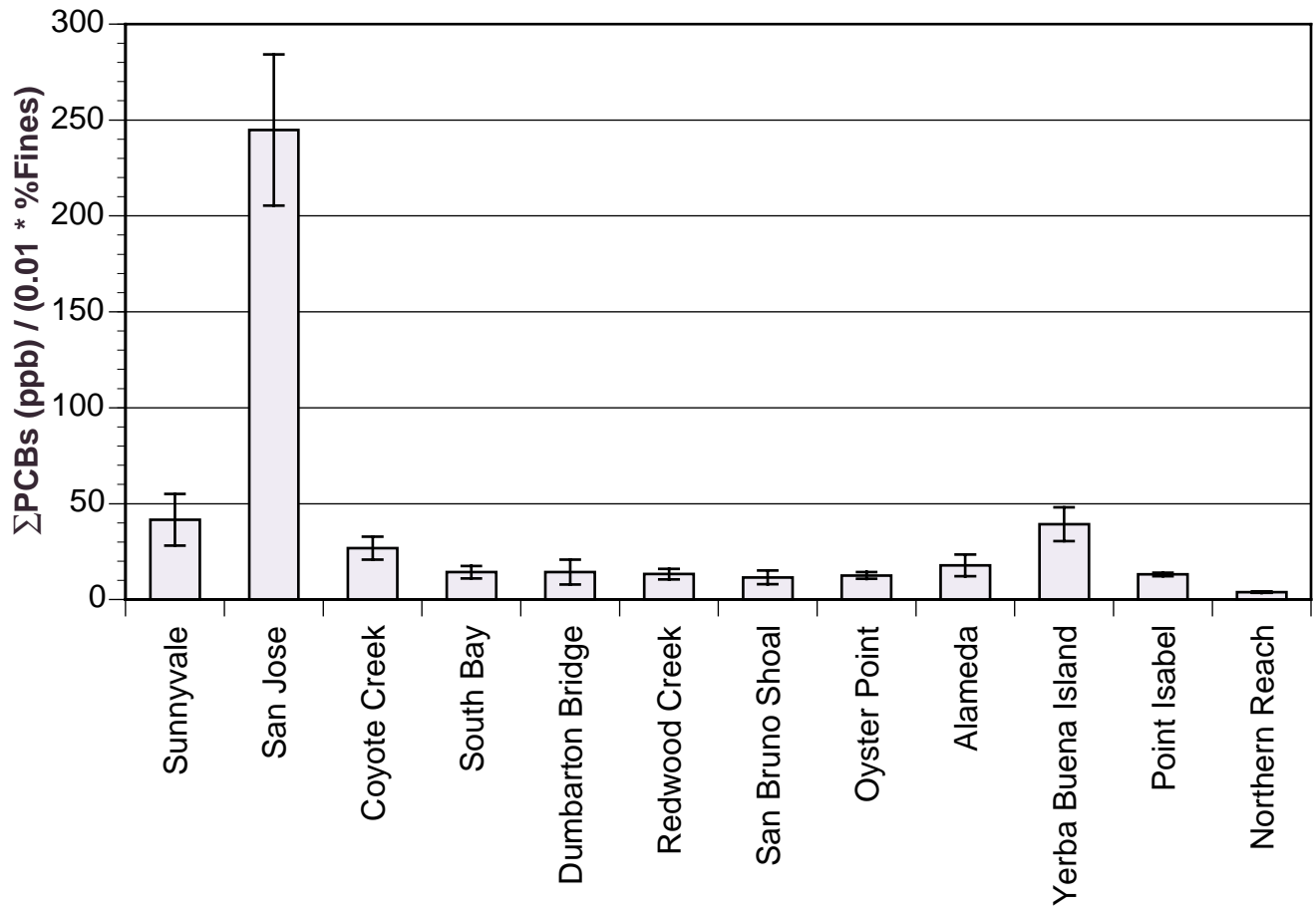


Fig. 10: ΣPCBs in Sediment, Normalized to % Fines. Data are the average for 1996-98 RMP Sediment Sites, from SFEI (1998; 1999; in Press). Error bars are ± 1 standard error of the mean.

ppb). Given the sampling precision noted in Table 4, and the potential for interannual variation, additional samples from these watersheds will be required before a definitive comparison to the draft TMDL guideline can be made. Additional sampling in the Codornices watershed provides a total of 11 samples, with a range of 125-876 ppb and a mean of 375 ppb. By comparison, the highest mercury concentration the recent watershed sampling was 4.26 ppm measured at site SCV012 (West Virginia) in the South Bay [19].

The RWQCB may decide that the 400 ppb guideline should be compared to the concentration of mercury in the fine material only, as a sample below 400 ppb may still increase the average concentration of mercury in the Bay if it has relatively low fine material content. When the mercury results are normalized to percent fines (Fig. 5), several sites are above the guideline. The normalized mercury concentration for San Leandro Creek is almost twice as high as the next highest sample.

Samples with the finest grain sediments exhibited highest mmHg levels. This is an expected result, as fine grain sediments will provide more anaerobic environments for methylating bacteria. It is interesting to note that San Leandro Creek, although not a sample with very fine grained sediments ($F_{63}=5.6\%$), has one of the highest concentrations of mmHg. One possible explanation for this is that anaerobic sediments in Chabot and San Leandro reservoirs are generating mmHg that is then carried downstream.

Σ PAHs. There is not currently a TMDL for Σ PAHs scheduled by the RWQCB, as no finding of impairment due to Σ PAHs has been made pursuant to 305(b) of the Clean Water Act. However, a growing body of research is documenting impacts of PAHs at the parts per billion level, especially the high-molecular-weight PAHs that are strongly particulate-associated and slow to degrade in the environment. These include impacts to reproduction in fish [24, 25], and photo-induced toxicity to zooplankton [26, 27]. Σ PAHs were measured in this study to have available background information for an assessment of the impact of Σ PAHs on beneficial uses in the Estuary. It is likely that the next beneficial use assessment will find impairment in the Bay due to PAHs (T. Mumley, SFBRWQCB, personal communication)

Contaminant Load Estimates. Contaminant loads to San Francisco Bay in stormwaters have been estimated previously by several authors [17, 28-32]. These estimates have mainly focused upon trace elements; there have been relatively few studies to measure concentrations of organic constituents (except for non-specific measures such as oil and grease) in stormwaters locally (see above studies) or nationally [33]. Most of these previous estimates have relied upon the rational or simple method, in which precipitation is combined with land use-specific runoff coefficients to estimate a volume of stormwater to which is applied a volume-weighted or event mean concentration for contaminants of interest.

There is significant variability in contaminant concentrations and runoff coefficients among sites classified as the same land use type [28, 34], however, and runoff coefficients can also vary through a season due to soil moisture changes and the size of storms (e.g., recent measurements in Wildcat Creek). These and other factors make estimating contaminant loads from urban runoff very uncertain, and some have questioned the cost-effectiveness of taking the large number of samples necessary to generate estimates using the rational method.

We can use previously calculated estimates of total suspended solids (TSS) loads to generate rough load estimates for the particulate-associated contaminants we have measured in the present study. In making these calculations, we are making many as-

sumptions, including (1) that the average TSS loads measured by Alameda County during 1989-1991 [18] are representative of present conditions, (2) the sediment samples taken in the present study are satisfactory representations of the TSS in stormwater from the watersheds, (3) that sediments sieved at 2-mm are representative of suspended sediments in stormwater, and (4) that particle movement (e.g., TSS) will account for the majority of contaminant transport. Recent work in the Anacostia River in Washington, D.C., supports this latter contention for mercury and mmHg [35].

The earlier work by Alameda County generated loading estimates for sixteen watersheds, nine of which overlapped with sampling sites chosen for the 2000 watershed sediment sampling program (Strawberry Creek, Ettie Street, Dry Creek, Codornices Creek, San Lorenzo Creek, Castro Valley Creek, Cabot Boulevard, Balentine Drive, and Alameda Creek). The estimated loads for the nine overlapping watersheds are found in Table 5. These estimates should not be considered accurate absolute measures. Instead, they are valuable when compared to estimates generated by other means (for a weight-of-evidence analysis) and for relative comparisons among watersheds.

For example, the estimates indicate that the high concentrations at the Ettie Street site make this watershed a relatively important source of all contaminants, despite its relatively small size. For example, although Alameda Creek produces a TSS load 500 times the size of Ettie Street, more than 5 times as much Σ PCBs are estimated to be delivered to the Bay by Ettie Street. Codornices Creek stands out as a relatively large source of total mercury, which is due to both to a relatively high sediment concentration of mercury (Table 2) and a relatively large TSS load (Table 5).

Site†	Watershed	Area sq km †	Developed Land†† (%)	TSS† (te/yr)	Contaminant Loads (g/yr)			
					Σ PCBs	Total Hg	mmHg	Σ PAH
L1	Strawberry Ck	0.71	0	270	0.3	14	0.09	11
L2	Ettie Street	3.86	100	81	260	65	0.14	13,000
L8	Dry Creek	24.43	2	330	0.1	12	0.23	13
S1	Codornices Ck	0.73	100	1,800	34	870	NA	N/A
S2	San Lorenzo Ck	116.46†††	40	690	2.1	88	0.71	280
S3	Castro Valley Ck	13.20	83	310	7.0	24	0.04	1,000
S4	Cabot Blvd.	4.14	96	440	30	46	0.47	3,100
S6	Balentine Dr.	6.99	91	640	6.7	66	1.3	2,700
S5	Alameda Creek	1,640†††	NA	40,000	44	4,500	5.0	4,600

Table 5: Estimated Annual Average Loads of Particulate Associated Contaminants from Selected Watersheds in Alameda County. Estimated loads rounded to two significant figures; calculations described in text. = from [18]; = from [18, 34]; = includes portions of watershed behind reservoirs; Te = metric ton (1,000 kg).

Relationship of Contaminant Concentrations to Land Use. As indicated above, many previous investigations of contaminant loads in urban stormwater have been designed using the conceptual model that contaminant concentration varies among land uses. Investigators have identified specific land parcels (normally industrial, residential, commercial, and open space), and measured contaminant concentrations from these parcels. The measured concentrations are then applied to all land in that class when modeling contaminant loads. This approach has been criticized because measurements normally indicate a high degree of variation between storms at a given site, and between sites within a single land use class.

Another approach would be to simply differentiate between developed and undeveloped land, as all studies clearly indicate large differences in contaminant concentrations between developed and undeveloped land. Using data on land uses within watersheds in Alameda County from the 1980s [17, 36], it is possible to examine the relationship between contaminant concentrations measured in this study and land uses within the watershed (Fig. 11). While there are significant differences in contaminant concentrations among developed watersheds, we can see clearly for Σ PCBs and Σ PAHs that contaminant concentrations are only elevated in developed watersheds (Appendix 4). This is consistent with the hypothesis that local human activities are responsible for contamination of watersheds. That mercury does not show this trend as strongly (due to the concentration measured at the San Lorenzo site) is consistent with the presence of nonanthropogenic mercury sources. As stressed above, these interpretations must be considered preliminary because we have only one year of sampling.

Strategies and Approaches for Next Phase. In requesting that this work be performed, the RWQCB asked three specific questions [37]:

1. Are PCB/Hg distributed somewhat evenly throughout the landscape resulting in relatively similar PCB/Hg discharges from storm water conveyance systems?
2. Are storm drains or other surface drainage pathways sources of PCBs/Hg in themselves?
3. Are there specific locations within watersheds where prior or current use of PCB/Hg results in land sources contributing to continued PCBs discharge to the Bay via storm water conveyance systems?

From the above discussion, it is clear that the answer to question #1 is no for PCBs and mercury. While all watershed sediments exhibited some presence of these constituents, substantial variation exists between watersheds. Certain watersheds appear to be much more contaminated than others. This variation leads to answering question #3 in the affirmative, as the contamination detected at the base of the watersheds can be reasonably assumed to be derived from prior or current use of the contaminants of concern upstream.

With regards to question #2, the samples collected at Ettie Street, at site SCV001 in the South Bay [19] and near Stege Marsh in Richmond [18] indicate that the storm drain system does contain sediments contaminated with Σ PCBs and mercury; contaminated storm drain sediments have also been detected at local military bases (K. Abu-Saba, SFBRWQCB, personal communication). We do not know, however, if those sediments were recently deposited due to runoff from a contaminated land parcel within the watersheds in question, or if they represent historic deposits that cannot be attributed to a specific location within the watershed (For the Ettie Street site, the sediments do appear

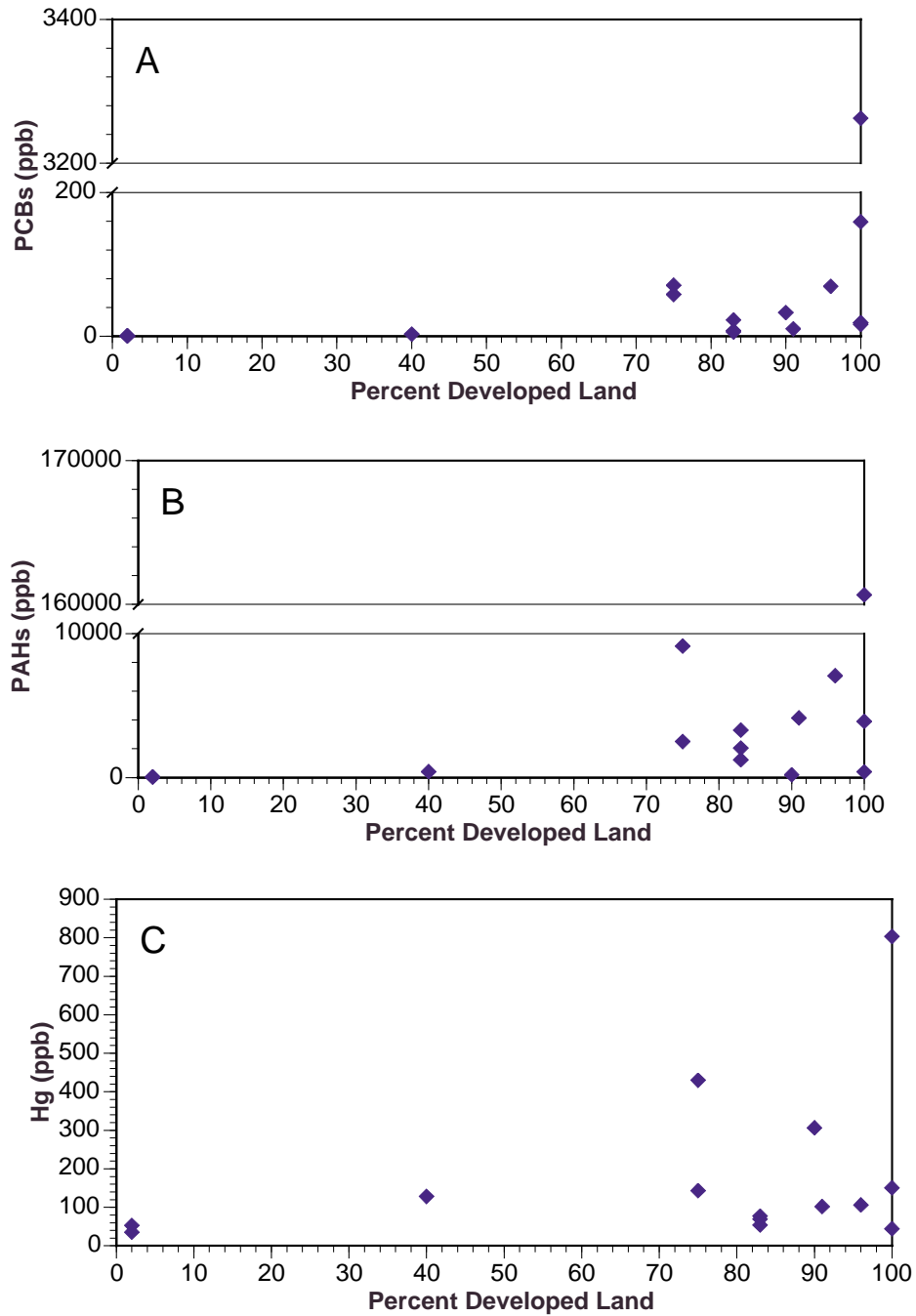


Figure 11: Relationship of Contaminant Concentrations and Percent Developed Land by Watershed. (A) PCBs; (B) PAHs; (C) mercury. Percent developed land (see Table 4) from Woodward-Clyde Consultants (1991) or Scanlin & Feng (1997).

to be recently deposited, which suggests a reservoir of contaminated sediment exists upstream). There is no doubt that these highly contaminated sediment deposits, if transported to the Bay, would exacerbate the PCB and mercury contamination problem.

Follow-up sampling should include the following:

1. Repeat the current sampling for two additional years at sites that appear elevated above background to produce a mean concentration for each watershed with a standard error. The mean concentrations will provide much more meaningful characterizations of each watershed as a source of particulate-associated contaminants of concern. It does not seem necessary to visit all of the sites that exhibited very low concentrations of contaminants, but instead use a few of these sites on a rotating basis to represent regional background. This will free up monitoring resources to characterize more completely the watersheds that appear to contain significant sources of the contaminants of concern.

2. Design a supplementary investigation to determine the source of contamination reaching the Ettie Street Pump station. This investigation could be completed in a two-step process: (1) conduct sediment sampling at sequential points upstream to find contaminated / uncontaminated regions, and (2) use available land use information to identify land parcels in contaminated regions that are potential sources. The storm drain mapping project being conducted by the San Francisco Estuary Institute in conjunction with the City of Oakland and the Oakland Museum could provide valuable guidance for sampling design. If clean-up of contaminated sites occurs in the future, the data from this supplementary investigation will be valuable to determine if clean-up efforts have reduced ambient concentrations. This sampling will require access to confined spaces, and will therefore require adequate equipment and trained personnel to conduct safely.

3. Review the drainage areas of the sedimentation basins in the County. One or more that drain developed regions, and are not upstream of any existing sampling locations, should be considered high priority for sampling in the next round.

4. Review coverage of developed areas sampled in this round of sampling, and identify significant gaps. Data collected to date suggests that even relatively small developed watersheds (i.e., 3.8 sq. km Ettie Street) can contain important sources of particulate-associated contaminants.

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APPENDIX I

This appendix contains a listing of the sampling sites visited as part 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 and best sample sites are located 20-100 m east of the park along the banks of the stream.	37.898	122.304
Codornices Creek	Sampled independently by ACCWP, 6/27/00	37.883	122.3
Strawberry Creek	This is a natural creek that has low to moderate flows and the rocky creek bottom has few areas of fine sediments. Sediments were collected from an area starting where the creek flows into a rectangular underground culvert to approximately 60 meters upstream	37.873	122.241
Ettie Street Pump Station	Loads assessment station; sediment collects in detention basins. Samples collected in three of the basins, near the ladders that extend into the basins. Sampling requires using the Ekman dredge and extra messenger. Sediment is not uniform.	37.665	122.74
Glen Echo Creek	Collected replicate samples. Site 1 from 3038 Richmond, N.E. upstream of bridge crossing stream. Site 2 approximately 100 m upstream of site 1.	37.82	122.259
Sausal Creek	Natural channel with some concrete structures, bottom is broken concrete and small rock. Sediment is scarce but can be found in small pools along the banks of the creek. There is a large pool area (4 feet deep) on the east side of the sample site.	37.791	122.221
Seminary Creek	Natural channel that runs from Elizabeth Street west to the edge of a concrete tunnel. Channel is heavily vegetated and finding adequate sample sites is difficult. An oil sheen was noted on the surface of the water in one of the sampling locations.	37.77	122.195
Lion Creek	Fine sediment in concrete channel, vegetation abundant, no macroalgae under bridge	37.759	122.196
Arroyo Viejo	Sampled under the bridge and eastward in the flood control channel. Dense algal mats at this site.	37.756	122.19
San Leandro Creek	This open-channel creek bed is dry in the summer. Samples were collected from a small pool of water, 50 m in length, located directly underneath the East side for the 14th Street bridge.	37.727	122.157

Site Name	Site Description	Latitude	Longitude
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. Sulfide gas "bubbles" to the surface when lifting sediment from the bottom.	37.682	122.143
Castro Valley Creek	Sampled upstream from the theatre. Sediment deposits can be found on both stream banks up to confluence of Bee & Knox arms of Castro Valley Creek. Creek bed mostly gravel. Natural rockbound channel.	37.68	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 an area approximately 40 meters upstream of the pool.	37.681	122.08
Cabot Blvd	Sampled the channel from the access point to 100 meters downstream. Channel bottom composed of fine, silty sediments although no tidal influence was noted. There is easy access to the site.	37.645	122.138
Dry Creek	Samples were collected from an area 80 meters west of the Mission Blvd. overpass in an area that was undisturbed from construction. There was no water in the creek, so dry sediments were taken from underneath flat rocks.	37.607	122.021
Balentine Drive	Samples were collected from the area starting from the concrete culvert to approximately 50 meters upstream, on the northern side of the channel. Channel bottom composed of fine sediments and mixed cobblestone. Moderate flow in this creek.	37.524	121.997
Crandall Creek	Samples were collected on the east side of the concrete culvert, from an area starting at the culvert to approximately 50 meters upstream. At time of sampling, channel bottom was covered with dense algal mats.	37.567	122.05
Line 6-G	The sample site is an engineered channel with concrete culvert crossing Automall Parkway. Samples were collected from the north and south side of the culvert, by walking through the culvert underneath Automall Parkway.	37.508	121.964
Laguna Creek	Samples were collected from an area starting from the concrete culvert to approximately 50 meters upstream. Channel bottom composed of fine sediments with no sign of tidal influence. Moderate flow runs through the channel.	37.502	121.953

Site Name	Site Description	Latitude	Longitude
Agua Caliente	Samples were collected from an area starting from the concrete culvert to approximately 50 meters 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
Scott Creek	The area adjacent to the FCD gates looked tidally influenced, so samples were collected 80 meters upstream from the gates on the West side of the channel. Channel bottom composed of fine, silty sediments. There was minimal flow noted. Tried using the Ekman	37.46	121.919
Alameda Creek	Samples were collected by Ekman dredge from an area starting from the USGS stream gauge to approximately 50 meters upstream, and 5 meters from the stream banks.	37.587	121.961

APPENDIX 2

Procedure for Analyzing Percent Silt-Clay in Sediments

Based on methods used by San Francisco Bay Regional Monitoring Program (RMP), with modifications by RMP scientists and Regional Board Staff for application in watershed assessment.

Objective

This procedure is intended to yield measurements of percent fines (the silt-clay fraction, <63 μm) in sediments that are comparable to measurements made by the RMP. The method will be used by contractors working on watershed assessment. The RMP has established methods for determination of percent fines in sediment samples. The methods were originally developed by Sharon Hibdon of the University of California, Santa Cruz Department of Environmental Toxicology, under the direction of Dr. A. Russell Flegal, and in collaboration with the United States Geological Survey.

The RMP method quantifies the silt-clay fraction (<63 μm) by traditional wet sieving. It has two improvements over tradition wet-sieving analysis:

- 1) Samples are digested with hydrogen peroxide to remove organic matter; and
- 2) Clays (<4 μm) are characterized by optical methods using a Sedigraph 5100

The method proposed below incorporates the hydrogren peroxide digestion, but not the Sedigraph 5100 analysis.

Reagents

1. 30% Hydrogen peroxide
2. Sodium hexametaphosphate (sodium metaphosphate in Fisher catalogue)
3. MilliQ deionized (DI) water

Equipment

1. Hot plate
2. Analytical balance
3. 1000 TO 15K RMP centrifuge
4. Sonicator
5. Vortex mixer
6. Vacum source, tubing, and aspirator trap

7. Pastuer pipets and bulb
8. 50 mL centrifuge tubes, polypropylene with conical bottom (Fisher Cat. # 14-432-24 or equiv.)
9. 400 mL Brezilus beakers with spout (Fisher Cat. # 02-539-6 or equiv.)
10. 250 mL Griffin beakers (Fisher Cat. # 02-555-25B or equiv.)
11. 40 mL glass vials: 27 mm x 98 mm (standard VOC sample vials; Fisher Cat. # 05-719-129 or equiv.; don't need certified clean bottles; closed or open top)
12. Rubber Spatulas, WILL NEED AT LEAST 5
13. gloves, Nitrile for using with H₂O₂ digestion (poly gloves aren't resistant to burns you get with 30% H₂O₂)
14. small metal spatula

I. Procedure

Removal of organic matter by H₂O₂ digestion

1. Samples have been sieved in the field with a 2-mm mesh sieve and scooped into three 8-oz glass jars. Combine the samples into one container and stir to rehomogenize.
2. Weigh ~50 grams of sample into a labeled 400ml Brezilus beaker (UCSC ONLY USES 8 – 10 GRAMS, EXCEPT FOR SANDY SAMPLES.50 grams may need extra time to digest this much)
3. Add 15-20 ml of 30 % hydrogen peroxide
4. Continue to add 10 ml aliquots of H₂O₂ until the sample is thoroughly digested (disappearance of large brown gas bubbles, evolution of white gas). Must continue stirring during additions of H₂O₂, when heated it digests quicker and needs constant stirring until bubbles stop.
5. Place beaker on hotplate and heat on low (<50°C) for at least four hours, covered with watch glass, STIRRING OCCASIONALLY, KEEPING WATCH GLASS OFF IS OK FOR THE FIRST FEW HOURS.
6. Remove rubber spatula , rinse any residual sediment from spatuala into beaker, and cover with watch glass. Continue on low heat for another hour.
7. Turn off hotplate and let sample stand overnight.

Sample consolidation and removal of salts by successive washes

1. Pour sample into labeled 50 ml centrifuge tube. There will be some (a lot) residual sediment left in the beaker.(Takes at least 2 centrifuge spins)
2. Centrifuge sample at 15000 rpm for 25 - 30 minutes or until the sediment forms a pellet and the solution is crystal clear (Note: Columbia Analytical Services' working definition calls for centrifuging until there is no visible turbidity in the sample (no test for absorbance is performed)).
3. Carefully aspirate overlying water into vacuum flask, leaving a little rinse water solution in tube to prevent losing fine sediment.

4. Transfer residual digested sediment from beaker into centrifuge tube by adding small (5-10 ml) aliquots of DI (MQ) water to beaker, swirling, and pouring into the centrifuge tube. It may be necessary to use a rubber spatula to remove all the sediment from the beaker. Rinse rubber spatula into the centrifuge tube. (this step will be repeated at least 2 times in order to collect entire digestate)
5. Add beaker rinses to centrifuge tube until volume is 40-50 ml.
6. Centrifuge for 20 minutes or until the sediment forms a pellet and the rinse solution is crystal clear.
7. Carefully aspirate water/peroxide into vacuum flask, leaving a little rinse water solution in tube to prevent pulling off the fines.
8. Once all digestate is collected as a pellet in centrifuge tube, add a small amount of MQ water and dislodge/disperse with metal spatula. Bring to approx. 45 ml volume and centrifuge at 15K for 25 minutes. Repeat this step once more. The last wash will require a longer centrifuge time to obtain a clear solution.

Separation of fine and coarse fractions by wet sieving

1. Resuspend the sediment pellet in 0.1% sodium hexametaphosphate using vortex mixer.
2. Sonicate for 30 seconds. Do not allow sample to sit overnight before sieving, or sonication should be repeated.
3. Record the weight of a clean, dry Griffin beaker
4. Just prior to sieving, disperse the sample again by using vortex mixer.
5. Pour the dispersed sediment through a 63 μm sieve into a pre-weighed 250 ml beaker, rinsing it through the screen with DI water
6. Dry the fine fraction in an oven at less than 50°C. Weigh and record as “clay and silt fraction”.
7. Record the weight of a clean, dry 250 ml Griffin Beaker
8. Rinse the remaining sand with deionized water into a pre-weighed 250 ml Griffin beaker.
9. Dry the sand fraction in an oven at less than 50°C. Weigh and record as “sand fraction”.

II. Data Reporting

The original data collected is the mass of the dried “clay and silt fraction” and the mass of the “sand fraction.” The percent fines is calculated as:

$$\left(\text{Mass}_{\text{clay\&silt}} / (\text{Mass}_{\text{sand}} + \text{Mass}_{\text{clay\&silt}}) \right) \times 100$$

APPENDIX 3

Results of Quality Assurance tests performed by analytical laboratories.

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
BRL00-429	LCS	Hg	ppm	Dry	92	90.8	98.7	75 - 125	2	
BRL00-429	LCS	Hg	ppm	Dry	92	96.3	104.7	75 - 125	2	
BRL00-429	MS-3	Hg	ppm	Dry	195	306	156.9	65 - 135	2	Outside control range
BRL00-429	MS-9	Hg	ppm	Dry	182	178	97.8	65 - 135	2	
BRL00-430	LCS	Hg	ppm	Dry	91	95.9	105.4	75 - 125	2	
BRL00-430	LCS	Hg	ppm	Dry	91	97.6	107.3	75 - 125	2	
BRL00-430	MS-12	Hg	ppm	Dry	194	204	105.2	65 - 135	2	
BRL00-430	MS-22	Hg	ppm	Dry	188	216	114.9	65 - 135	2	
BRL00-427	LCS	mmHg	ppm	Dry	5.46	5.05	92.5	65 - 135	2	
BRL00-427	LCS	mmHg	ppm	Dry	5.46	6.76	123.8	65 - 135	2	
BRL00-427	MS-1	mmHg	ppm	Dry	0.876	0.564	64.4	65 - 115	2	Outside control range
BRL00-427	MS-10	mmHg	ppm	Dry	0.734	0.46	62.7	65 - 115	2	Outside control range
BRL00-428	LCS	mmHg	ppm	Dry	5.46	5.8	106.2	75 - 125	2	
BRL00-428	LCS	mmHg	ppm	Dry	5.46	4.91	89.9	75 - 125	2	
BRL00-428	MS-12	mmHg	ppm	Dry	0.9	1.55	172.2	75 - 125	2	Outside control range
BRL00-428	MS-22	mmHg	ppm	Dry	0.93	1.232	132.5	75 - 125	2	Outside control range
BRL00-358	LCS	Hg	ppm	Dry	92	94.3	102.5	75 - 125	2	
BRL00-358	LCS	Hg	ppm	Dry	92	92.3	100.3	75 - 125	2	
BRL00-358	MS-17	Hg	ppm	Wet	120	129	107.5	65 - 135	2	
BRL00-358	MS-20	Hg	ppm	Dry	197	203	103.0	65 - 135	2	

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
BRL00-358	MS-25	Hg	ppm	Wet	176	175	99.4	65 - 135	2	
BRL00-353r2	LCS	mmHg	ppm	Wet	5.46	6.39	117.0	65 - 135	2	
BRL00-353r2	LCS	mmHg	ppm	Wet	5.46	5.92	108.4	65 - 135	2	
BRL00-353r2	MS-1	mmHg	ppm	Wet	2.9	1.95	67.2	65 - 115	2	
BRL00-353r2	MS-3	mmHg	ppm	Wet	2.4	1.59	66.3	65 - 115	2	
K2007140	MS	TOC	%	Dry	4.04	4.06	100.5	75 - 125	1	
K2007140	LCS	TOC	%	Dry	1.16	1.06	91.4	85 - 115	1	
K2007140	LCS	PCBs	ppb	Dry	10	8.3 - 9.8	83 - 98	60 - 140	1	
K2007140	SRM	PCB8	ppb	Dry	22.3	15	NA	10 - 37	1	
K2007140	SRM	PCB18	ppb	Dry	51	32	NA	24 - 80	1	
K2007140	SRM	PCB28	ppb	Dry	80.8	47	NA	39 - 130	1	
K2007140	SRM	PCB44	ppb	Dry	60.2	38	NA	29 - 93	1	
K2007140	SRM	PCB52	ppb	Dry	79.4	44	NA	39 - 120	1	
K2007140	SRM	PCB66	ppb	Dry	71.9	39	NA	34 - 110	1	
K2007140	SRM	PCB87	ppb	Dry	29.9	22	NA	13 - 51	1	
K2007140	SRM	PCB101/90	ppb	Dry	73.4	74	NA	35 - 110	1	
K2007140	SRM	PCB105	ppb	Dry	24.5	27	NA	12 - 38	1	
K2007140	SRM	PCB110	ppb	Dry	62.5	49	NA	29 - 100	1	
K2007140	SRM	PCB118	ppb	Dry	58	34	NA	27 - 93	1	
K2007140	SRM	PCB128	ppb	Dry	8.47	7	NA	4.1 - 13	1	
K2007140	SRM	PCB138/163/164	ppb	Dry	62.1	41	NA	30 - 98	1	
K2007140	SRM	PCB153	ppb	Dry	74	38	NA	36 - 120	1	
K2007140	SRM	PCB156	ppb	Dry	6.52	8.2	NA	2.9 - 11	1	
K2007140	SRM	PCB170	ppb	Dry	22.6	16	NA	11 - 36	1	
K2007140	SRM	PCB180	ppb	Dry	44.3	30	NA	22 - 68	1	
K2007140	SRM	PCB183	ppb	Dry	12.2	9.1	NA	5.8 - 19	1	
K2007140	SRM	PCB187/159	ppb	Dry	25.1	18	NA	12 - 39	1	
K2007140	SRM	PCB195	ppb	Dry	3.75	2.8	NA	1.7 - 6.2	1	
K2007140	SRM	PCB206	ppb	Dry	9.21	6.5	NA	4.4 - 15	1	
K2007140	SRM	PCB209	ppb	Dry	6.81	5.1	NA	3.2 - 11	1	

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
K 2007140	LCS	Naphthalene	ppb	Dry	475	320	67	45 - 135	1	
K 2007140	LCS	2-Methylnaphthalene	ppb	Dry	475	420	88	45 - 135	1	
K 2007140	LCS	1-Methylnaphthalene	ppb	Dry	475	300	63	45 - 135	1	
K 2007140	LCS	2,6-Dimethylnaphthalene	ppb	Dry	475	350	74	45 - 135	1	
K 2007140	LCS	Acenaphthylene	ppb	Dry	475	340	72	45 - 135	1	
K 2007140	LCS	Acenaphthene	ppb	Dry	475	330	69	30 - 116	1	
K 2007140	LCS	2,3,5-Trimethylnaphthalene	ppb	Dry	475	350	74	45 - 135	1	
K 2007140	LCS	Fluorene	ppb	Dry	475	370	78	45 - 135	1	
K 2007140	LCS	Dibenzothiophene	ppb	Dry	475	420	88	45 - 135	1	
K 2007140	LCS	Phenanthrene	ppb	Dry	475	410	86	45 - 135	1	
K 2007140	LCS	Anthracene	ppb	Dry	475	400	84	45 - 135	1	
K 2007140	LCS	1-Methylphenanthrene	ppb	Dry	475	470	99	45 - 135	1	
K 2007140	LCS	Fluoranthene	ppb	Dry	475	470	99	45 - 135	1	
K 2007140	LCS	Pyrene	ppb	Dry	475	560	118	25 - 129	1	
K 2007140	LCS	Benz(a)anthracene	ppb	Dry	475	510	107	45 - 135	1	
K 2007140	LCS	Chrysene	ppb	Dry	475	490	103	45 - 135	1	
K 2007140	LCS	Benzo(b)fluoranthene	ppb	Dry	475	450	95	45 - 135	1	
K 2007140	LCS	Benzo(k)fluoranthene	ppb	Dry	475	450	95	45 - 135	1	
K 2007140	LCS	Benzo(e)pyrene	ppb	Dry	475	430	91	45 - 135	1	
K 2007140	LCS	Benzo(a)pyrene	ppb	Dry	475	400	84	29 - 129	1	
K 2007140	LCS	Indeno(1,2,3-cd)pyrene	ppb	Dry	475	430	91	45 - 135	1	
K 2007140	LCS	Dibenz(a,h)anthracene	ppb	Dry	475	440	93	45 - 135	1	
K 2007140	LCS	Benzo(g,h,i)perylene	ppb	Dry	475	390	82	45 - 135	1	
K 2007140	LCS	Perylene	ppb	Dry	475	400	84	45 - 135	1	
K 2007140	LCS	Biphenyl	ppb	Dry	475	340	72	45 - 135	1	
K 2007140	SRM	Naphthalene	ppb	Dry	1650+/-310	430	NA	670 - 2940	1	Outside control range
K 2007140	SRM	Phenanthrene	ppb	Dry	5270+/-220	3600	NA	2520 - 8240	1	
K 2007140	SRM	Anthracene	ppb	Dry	1770+/-330	750	NA	720 - 3150	1	

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
K2007140	SRM	Fluoranthene	ppb	Dry	8920+/-320	6400	NA	4300 - 13900	1	
K2007140	SRM	Pyrene	ppb	Dry	9700+/-420	7700	NA	4640 - 15200	1	
K2007140	SRM	Benz(a)anthracene	ppb	Dry	4720+/-110	3500	NA	2310 - 7250	1	
K2007140	SRM	Chrysene	ppb	Dry	5900+/-370	4300	NA	2770 - 9410	1	
K2007140	SRM	Benzo(b)fluoranthene	ppb	Dry	3870+/-420	2400	NA	1720 - 6440	1	
K2007140	SRM	Benzo(k)fluoranthene	ppb	Dry	4390+/-640	2600	NA	1880 - 7550	1	
K2007140	SRM	Benzo(a)pyrene	ppb	Dry	4300+/-130	2500	NA	2090 - 6650	1	
K2007140	SRM	Indeno(1,2,3-cd)pyrene	ppb	Dry	2780+/-100	1700	NA	1340 - 4320	1	
K2007140	SRM	Dibenz(a,h)anthracene	ppb	Dry	424+/-69	490	NA	178 - 740	1	
K2007140	SRM	Benzo(g,h,i)perylene	ppb	Dry	2840+/-1500	1500	NA	1370 - 4410	1	
K2007957	MS	TOC	%	Dry	6.88	5.6	81.4	75 - 125	1	
K2007957	LCS	TOC	%	Dry	1.16	1.08	93.1	85 - 115	1	
K2007957	MS	PCBs (35 congeners)	ppb	Dry	10	7.8 - 13	78 - 130	30 - 150	1	
K2007957	Dup. MS	PCBs (35 congeners)	ppb	Dry	10	8.2 - 14	82 - 140	30 - 150	1	
K2007957	LCS	PCBs (35 congeners)	ppb	Dry	10	6.8 - 8.6	68 - 86	60 - 140	1	
K2007957	LCS	PCBs (35 congeners)	ppb	Dry	10	7.5 - 9	75 - 90	60 - 140	1	
K2007957	SRM	PCB8	ppb	Dry	22.3	19.5	NA	10 - 37	1	
K2007957	SRM	PCB18	ppb	Dry	51	41.3	NA	24 - 80	1	
K2007957	SRM	PCB28	ppb	Dry	80.8	59.9	NA	39 - 130	1	
K2007957	SRM	PCB44	ppb	Dry	60.2	47.4	NA	29 - 93	1	
K2007957	SRM	PCB52	ppb	Dry	79.4	57.9	NA	39 - 120	1	
K2007957	SRM	PCB66	ppb	Dry	71.9	50	NA	34 - 110	1	
K2007957	SRM	PCB87	ppb	Dry	29.9	28.4	NA	13 - 51	1	
K2007957	SRM	PCB101/90	ppb	Dry	73.4	73.4	NA	35 - 110	1	
K2007957	SRM	PCB105	ppb	Dry	24.5	32.1	NA	12 - 38	1	
K2007957	SRM	PCB110	ppb	Dry	63.5	79.9	NA	29 - 100	1	
K2007957	SRM	PCB118	ppb	Dry	58	43.1	NA	27 - 93	1	
K2007957	SRM	PCB128	ppb	Dry	8.47	9.1	NA	4.1 - 13	1	
K2007957	SRM	PCB138/163/164	ppb	Dry	62.1	50.8	NA	30 - 98	1	
K2007957	SRM	PCB153	ppb	Dry	74	46.8	NA	36 - 120	1	

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
K2007957	SRM	PCB156	ppb	Dry	6.52	10.5	NA	2.9 - 11	1	
K2007957	SRM	PCB170	ppb	Dry	22.6	16.4	NA	11 - 36	1	
K2007957	SRM	PCB180	ppb	Dry	44.3	32.2	NA	22 - 68	1	
K2007957	SRM	PCB183	ppb	Dry	12.2	10.4	NA	5.8 - 19	1	
K2007957	SRM	PCB187/159	ppb	Dry	25.1	24.5	NA	12 - 39	1	
K2007957	SRM	PCB195	ppb	Dry	3.75	3.54	NA	1.7 - 6.2	1	
K2007957	SRM	PCB206	ppb	Dry	9.21	8.29	NA	4.4 - 15	1	
K2007957	SRM	PCB209	ppb	Dry	6.81	6.26	NA	3.2 - 11	1	
K2007957	SRM	PCB8	ppb	Dry	22.3	17.4	NA	10 - 37	1	
K2007957	SRM	PCB18	ppb	Dry	51	37	NA	24 - 80	1	
K2007957	SRM	PCB28	ppb	Dry	80.8	53.1	NA	39 - 130	1	
K2007957	SRM	PCB44	ppb	Dry	60.2	42.1	NA	29 - 93	1	
K2007957	SRM	PCB52	ppb	Dry	79.4	51	NA	39 - 120	1	
K2007957	SRM	PCB66	ppb	Dry	71.9	44.8	NA	34 - 110	1	
K2007957	SRM	PCB87	ppb	Dry	29.9	25.8	NA	13 - 51	1	
K2007957	SRM	PCB101/90	ppb	Dry	73.4	48.2	NA	35 - 110	1	
K2007957	SRM	PCB105	ppb	Dry	24.5	28.6	NA	12 - 38	1	
K2007957	SRM	PCB110	ppb	Dry	63.5	79.1	NA	29 - 100	1	
K2007957	SRM	PCB118	ppb	Dry	58	36.9	NA	27 - 93	1	
K2007957	SRM	PCB128	ppb	Dry	8.47	8.45	NA	4.1 - 13	1	
K2007957	SRM	PCB138/163/164	ppb	Dry	62.1	45.5	NA	30 - 98	1	
K2007957	SRM	PCB153	ppb	Dry	74	41.6	NA	36 - 120	1	
K2007957	SRM	PCB156	ppb	Dry	6.52	8.96	NA	2.9 - 11	1	
K2007957	SRM	PCB170	ppb	Dry	22.6	14.6	NA	11 - 36	1	
K2007957	SRM	PCB180	ppb	Dry	44.3	28.4	NA	22 - 68	1	
K2007957	SRM	PCB183	ppb	Dry	12.2	9.57	NA	5.8 - 19	1	
K2007957	SRM	PCB187/159	ppb	Dry	25.1	21	NA	12 - 39	1	
K2007957	SRM	PCB195	ppb	Dry	3.75	3.04	NA	1.7 - 6.2	1	
K2007957	SRM	PCB206	ppb	Dry	9.21	6.78	NA	4.4 - 15	1	
K2007957	SRM	PCB209	ppb	Dry	6.81	5.46	NA	3.2 - 11	1	

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
K2007957	LCS	Naphthalene	ppb	Dry	339	210	62	45 - 135	1	
K2007957	LCS	2-Methylnaphthalene	ppb	Dry	339	300	88	45 - 135	1	
K2007957	LCS	1-Methylnaphthalene	ppb	Dry	339	210	62	45 - 135	1	
K2007957	LCS	2,6-Dimethylnaphthalene	ppb	Dry	339	240	71	45 - 135	1	
K2007957	LCS	Acenaphthylene	ppb	Dry	339	220	65	45 - 135	1	
K2007957	LCS	Acenaphthene	ppb	Dry	339	210	62	30 - 116	1	
K2007957	LCS	2,3,5-Trimethylnaphthalene	ppb	Dry	339	210	62	45 - 135	1	
K2007957	LCS	Fluorene	ppb	Dry	339	210	62	45 - 135	1	
K2007957	LCS	Dibenzothiophene	ppb	Dry	339	180	53	45 - 135	1	
K2007957	LCS	Phenanthrene	ppb	Dry	339	250	74	45 - 135	1	
K2007957	LCS	Anthracene	ppb	Dry	339	230	68	45 - 135	1	
K2007957	LCS	1-Methylphenanthrene	ppb	Dry	339	280	83	45 - 135	1	
K2007957	LCS	Fluoranthene	ppb	Dry	339	280	83	45 - 135	1	
K2007957	LCS	Pyrene	ppb	Dry	339	310	91	25 - 129	1	
K2007957	LCS	Benz(a)anthracene	ppb	Dry	339	300	88	45 - 135	1	
K2007957	LCS	Chrysene	ppb	Dry	339	310	91	45 - 135	1	
K2007957	LCS	Benzo(b)fluoranthene	ppb	Dry	339	280	83	45 - 135	1	
K2007957	LCS	Benzo(k)fluoranthene	ppb	Dry	339	290	86	45 - 135	1	
K2007957	LCS	Benzo(e)pyrene	ppb	Dry	339	260	77	45 - 135	1	
K2007957	LCS	Benzo(a)pyrene	ppb	Dry	339	230	68	29 - 129	1	
K2007957	LCS	Indeno(1,2,3-cd)pyrene	ppb	Dry	339	300	88	45 - 135	1	
K2007957	LCS	Dibenz(a,h)anthracene	ppb	Dry	339	330	97	45 - 135	1	
K2007957	LCS	Benzo(g,h,i)perylene	ppb	Dry	339	270	80	45 - 135	1	
K2007957	LCS	Perylene	ppb	Dry	339	230	68	45 - 135	1	
K2007957	LCS	Biphenyl	ppb	Dry	339	230	68	45 - 135	1	
K2007140	SRM	Naphthalene	ppb	Dry	1650+/-310	220	NA	670 - 2940	1	Outside control range
K2007140	SRM	Phenanthrene	ppb	Dry	5270+/-220	3900	NA	2520 - 8240	1	
K2007140	SRM	Anthracene	ppb	Dry	1770+/-330	780	NA	720 - 3150	1	

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
K2007140	SRM	Fluoranthene	ppb	Dry	8920+/-320	6800	NA	4300 - 13900	1	
K2007140	SRM	Pyrene	ppb	Dry	9700+/-420	7600	NA	4640 - 15200	1	
K2007140	SRM	Benz(a)anthracene	ppb	Dry	4720+/-110	3900	NA	2310 - 7250	1	
K2007140	SRM	Chrysene	ppb	Dry	5900+/-370	4800	NA	2770 - 9410	1	
K2007140	SRM	Benzo(b)fluoranthene	ppb	Dry	3870+/-420	2500	NA	1720 - 6440	1	
K2007140	SRM	Benzo(k)fluoranthene	ppb	Dry	4390+/-640	2800	NA	1880 - 7550	1	
K2007140	SRM	Benzo(a)pyrene	ppb	Dry	4300+/-130	2800	NA	2090 - 6650	1	
K2007140	SRM	Indeno(1,2,3-cd)pyrene	ppb	Dry	2780+/-100	2100	NA	1340 - 4320	1	
K2007140	SRM	Dibenz(a,h)anthracene	ppb	Dry	424+/-69	600	NA	178 - 740	1	
K2007140	SRM	Benzo(g,h,i)perylene	ppb	Dry	2840+/-1500	1900	NA	1370 - 4410	1	
K2008435	LCS	PCBs (13 congeners)	ppb	Dry	10	8.1 - 8.8	81 - 88	60 - 140	1	
K2008435	Dup. LCS	PCBs (13 congeners)	ppb	Dry	10	7.0 - 7.8	70 - 78	60 - 140	1	
K2007991	MS	TOC	ppm	Dry	7.74	7.18	92.8	75 - 125	1	
K2007991	LCS	TOC	ppm	Dry	1.16	1.01	87.1	85 - 115	1	
K2007991	MS	PCBs (35 congeners)	ppb	Dry	10	7.8 - 13	78 - 130	30 - 150	1	
K2007991	Dup. MS	PCBs (35 congeners)	ppb	Dry	10	8.2 - 14	82 - 140	30 - 150	1	
K2007991	LCS	PCBs (35 congeners)	ppb	Dry	10	7.5 - 9.0	75 - 90	60 - 140	1	
K2007991	SRM	PCB8	ppb	Dry	22.3	17.4	NA	10 - 37	1	
K2007991	SRM	PCB18	ppb	Dry	51	37	NA	24 - 80	1	
K2007991	SRM	PCB28	ppb	Dry	80.8	53	NA	39 - 130	1	
K2007991	SRM	PCB44	ppb	Dry	60.2	42.1	NA	29 - 93	1	
K2007991	SRM	PCB52	ppb	Dry	79.4	51	NA	39 - 120	1	
K2007991	SRM	PCB66	ppb	Dry	71.9	44.8	NA	34 - 110	1	
K2007991	SRM	PCB87	ppb	Dry	29.9	25.8	NA	13 - 51	1	
K2007991	SRM	PCB101/90	ppb	Dry	73.4	48.3	NA	35 - 110	1	
K2007991	SRM	PCB105	ppb	Dry	24.5	28.6	NA	12 - 38	1	
K2007991	SRM	PCB110	ppb	Dry	63.5	79.1	NA	29 - 100	1	
K2007991	SRM	PCB118	ppb	Dry	58	36.9	NA	27 - 93	1	
K2007991	SRM	PCB128	ppb	Dry	8.47	8.45	NA	4.1 - 13	1	

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
K2007991	SRM	PCB138/163/164	ppb	Dry	62.1	45.5	NA	30 - 98	1	
K2007991	SRM	PCB153	ppb	Dry	74	41.6	NA	36 - 120	1	
K2007991	SRM	PCB156	ppb	Dry	6.52	8.96	NA	2.9 - 11	1	
K2007991	SRM	PCB170	ppb	Dry	22.6	14.6	NA	11 - 36	1	
K2007991	SRM	PCB180	ppb	Dry	44.3	28.4	NA	22 - 68	1	
K2007991	SRM	PCB183	ppb	Dry	12.2	9.57	NA	5.8 - 19	1	
K2007991	SRM	PCB187/159	ppb	Dry	25.1	21	NA	12 - 39	1	
K2007991	SRM	PCB195	ppb	Dry	3.75	3	NA	1.7 - 6.2	1	
K2007991	SRM	PCB206	ppb	Dry	9.2	6.78	NA	4.4 - 15	1	
K2007991	SRM	PCB209	ppb	Dry	6.81	5.46	NA	3.2 - 11	1	
K2007991	LCS	Naphthalene	ppb	Dry	466	310	67	45 - 135	1	
K2007991	LCS	2-Methylnaphthalene	ppb	Dry	466	470	101	45 - 135	1	
K2007991	LCS	1-Methylnaphthalene	ppb	Dry	466	340	73	45 - 135	1	
K2007991	LCS	2,6-Dimethylnaphthalene	ppb	Dry	466	360	77	45 - 135	1	
K2007991	LCS	Acenaphthylene	ppb	Dry	466	330	71	45 - 135	1	
K2007991	LCS	Acenaphthene	ppb	Dry	466	330	71	30 - 116	1	
K2007991	LCS	2,3,5-Trimethylnaphthalene	ppb	Dry	466	320	69	45 - 135	1	
K2007991	LCS	Fluorene	ppb	Dry	466	320	69	45 - 135	1	
K2007991	LCS	Dibenzothiophene	ppb	Dry	466	280	60	45 - 135	1	
K2007991	LCS	Phenanthrene	ppb	Dry	466	380	82	45 - 135	1	
K2007991	LCS	Anthracene	ppb	Dry	466	360	77	45 - 135	1	
K2007991	LCS	1-Methylphenanthrene	ppb	Dry	466	400	86	45 - 135	1	
K2007991	LCS	Fluoranthene	ppb	Dry	466	410	88	45 - 135	1	
K2007991	LCS	Pyrene	ppb	Dry	466	420	90	25 - 129	1	
K2007991	LCS	Benz(a)anthracene	ppb	Dry	466	420	90	45 - 135	1	
K2007991	LCS	Chrysene	ppb	Dry	466	440	94	45 - 135	1	
K2007991	LCS	Benzo(b)fluoranthene	ppb	Dry	466	390	84	45 - 135	1	
K2007991	LCS	Benzo(k)fluoranthene	ppb	Dry	466	400	86	45 - 135	1	
K2007991	LCS	Benzo(e)pyrene	ppb	Dry	466	400	86	45 - 135	1	

Batch	Type	Parameter	Units	Basis	True Value	Result	% Recovery	Acceptance Limits	No. Blanks	Comments
K2007991	LCS	Benzo(a)pyrene	ppb	Dry	466	360	77	29 - 129	1	
K2007991	LCS	Indeno(1,2,3-cd)pyrene	ppb	Dry	466	380	82	45 - 135	1	
K2007991	LCS	Dibenz(a,h)anthracene	ppb	Dry	466	400	86	45 - 135	1	
K2007991	LCS	Benzo(g,h,i)perylene	ppb	Dry	466	410	88	45 - 135	1	
K2007991	LCS	Perylene	ppb	Dry	466	370	79	45 - 135	1	
K2007991	LCS	Biphenyl	ppb	Dry	466	350	75	45 - 135	1	
K2007991	SRM	Naphthalene	ppb	Dry	1650+/-310	220	NA	670 - 2940	1	Outside control range
K2007991	SRM	Phenanthrene	ppb	Dry	5270+/-220	3700	NA	2520 - 8240	1	
K2007991	SRM	Anthracene	ppb	Dry	1770+/-330	670	NA	720 - 3150	1	Outside control range
K2007991	SRM	Fluoranthene	ppb	Dry	8920+/-320	6800	NA	4300 - 13900	1	
K2007991	SRM	Pyrene	ppb	Dry	9700+/-420	6600	NA	4640 - 15200	1	
K2007991	SRM	Benz(a)anthracene	ppb	Dry	4720+/-110	3700	NA	2310 - 7250	1	
K2007991	SRM	Chrysene	ppb	Dry	5900+/-370	4500	NA	2770 - 9410	1	
K2007991	SRM	Benzo(b)fluoranthene	ppb	Dry	3870+/-420	2500	NA	1720 - 6440	1	
K2007991	SRM	Benzo(k)fluoranthene	ppb	Dry	4390+/-640	2600	NA	1880 - 7550	1	
K2007991	SRM	Benzo(a)pyrene	ppb	Dry	4300+/-130	2600	NA	2090 - 6650	1	
K2007991	SRM	Indeno(1,2,3-cd)pyrene	ppb	Dry	2780+/-100	1900	NA	1340 - 4320	1	
K2007991	SRM	Dibenz(a,h)anthracene	ppb	Dry	424+/-69	530	NA	178 - 740	1	
K2007991	SRM	Benzo(g,h,i)perylene	ppb	Dry	2840+/-1500	1700	NA	1370 - 4410	1	

APPENDIX 4

Alameda County watershed and land use information

Site	Site Code	Watershed		Existing Data from "Loads Assessment"	Land Uses in Watershed					Potential Contribution to "Hot Spot"
		Base of WS	Area, sq. mi.		R	C	I	O	Note	
North plain										
Cerrito	CER	X	1.7		+	+				
Codornices	COD	X	0.3	X	75	21	4	17	(1)	
Strawberry (upper watershed)	STR		0.3	X	--	--	--	98	(1) upper	
Line 12-A/Temescal	TEM	X	6.8		90	1	--	9	(2) upper	Emeryville
Ettie St. pump station	ETT		1.5	X	42	20	38	--	(1)	Emeryville
Glen Echo	GLN		2.1		85	15	--	--	(2)	Oak. Harbr
Sausal	SAU	X	4.1		89	1	--	10	(2)	Oak. Harbr
Line 12-I/Seminary	SEM	X			+	+	+			SL Bay
Lion	LIO	X	3.4		60	15	--	25	(2)	SL Bay
73 rd Ave channel/Arroyo Viejo	ARR	X	5.6		+	+	+			SL Bay
Elmhurst channel	ELM	X	3.0	(above base)	90	5	5	--	(2)	SL Bay
San Leandro	SLE	X	~7.5		+	+	+	+		SL Bay
Central plain										
San Lorenzo Creek	SLZ	X	45	X	15	2	1	81	(1)	
					30	9	1	60	(2)	
Castro Valley Creek: S3 Knox branch at Grove Way	CVC		5.1 ~2.0	X	67	13	3	17	(1)	
					49	14	--	37	(3)	
Line 4-A (Cabot Blvd.)	CAB		1.6	X	33	30	33	4	(1)	
Line 5-L/Dry Creek	DRY		9.4	X	2	--	--	98	(1)	
South plain										
Line 5-D (Balentine Dr.)	BAL		2.7	X	60	29	2	9	(1)	
Line 6-K,E/Laguna Creek	LAG	X			+	+	+	+		
Line 6-F/Agua Caliente	AGU	X			+	+	+	+		
Line 6-A/Scott Creek	SCT	X			+	+	+	+		
East County										
Alameda Creek at Niles	ALA	X	633	X	+	+	+	+		

Land Uses in watershed: C- Commercial, R- Residential, I- Industrial, O- Open Space;

- Notes: (1) percentages from Loads Assessment 1991: "Transportation" included with Industrial; "public facilities" included with Commercial
 (2) percentage from LUDA project of USGS based on 1976 Landsat imagery, cited in Sack 1982;
 (3) est from Table 3.2.1 in Scanlin & Feng 1997