RMP
REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

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Priority Margin Unit Stormwater Monitoring to Support Load Estimates of PCBs into San Leandro Bay and the Emeryville Crescent

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Introduction

The Priority Margin Unit Studies

The 2014 update of the RMP PCB Strategy called for a multi-year effort to implement the recommendations of the PCB Synthesis Report (Davis et al., 2014) including:

1. identifying margin units that are high priorities for management and monitoring,
2. developing conceptual models and mass budgets for margin units downstream of watersheds where management actions will occur, and
3. monitoring in these units as a performance measure.

The goal of the effort was to inform the review and possible revision of the PCB TMDL and the reissuance of the Municipal Regional Permit for Stormwater (MRP).

Three priority margin units (PMUs) of interest were identified based on observations of high concentrations of PCBs in water, sediment, and biota and the potential for actions to reduce loads in the adjoining watersheds. The three PMUs were Emeryville Crescent, San Leandro Bay, and Steinberger Slough/Redwood Creek. Syntheses of information (conceptual model reports) were performed (Davis et al., 2017; Yee et al., 2019, 2021) to answer three questions related to PCB management and monitoring.

1. Can we expect a decline in any compartment of the PMU in response to projected load reductions in the PMU watershed?
2. How should tributary loads be managed to maximize PMU recovery?
3. How should the PMUs be monitored to detect the expected reduction?

A technical foundation was developed for answering these questions to the extent possible with existing information, and additional information was identified that was most urgently needed to provide answers sufficient to support decision-making.

A conceptual model for each PMU was developed that included four major elements:

Element 1: PCB loading from each of the PMU watersheds;

Element 2: initial PCB deposition and retention within each PMU;

Element 3: processes determining the long-term fate of PCBs in sediment and water in each PMU; and

Element 4: PCB bioaccumulation in the food web of each PMU.

This conceptual model provided a basis for answering the three management questions listed above.

Project Goals

Estimates of PCB loading from the watersheds (Element 1) into the PMUs in the conceptual model reports were based on simple spreadsheet modeling supplemented by limited stormwater monitoring data. The reports concluded that additional data were needed to reduce the uncertainty around the loading estimates. The first task of this Supplemental Environmental Project was to sample the three major subwatersheds draining into the Emeryville Crescent PMU in order to improve estimates of PCB loads.

A second task focused on a specific set of watersheds discharging into the San Leandro Bay PMU. The former General Electric (GE) property was located within one of the subwatersheds of this PMU watershed and known to be highly contaminated with PCBs. Remediation management efforts have been done on this property, but stormwater sampling by the RMP in 2017 indicated that the watersheds draining the GE property still had high concentrations. Further remediation efforts are expected on the GE property in the near future. Therefore, a second goal of this Supplemental Environmental Project was to develop a baseline of stormwater runoff concentration data below the GE site for comparison in the future after additional management actions.

To support both of these efforts, this SEP was funded to monitor stormwater runoff and measure concentrations of PCBs and SSC such that each watershed (three draining to the Emeryville Crescent and two draining to San Leandro Bay) has data for three to four storms upon which to base improved loadings estimates. This report provides the background on the initial concentration and load estimates from the conceptual model reports and details the sampling completed to date.

The Emeryville Crescent

Background

The watershed draining to Emeryville Crescent ("the Crescent"; Figure 1) covers an area of 18.9 km² of mixed land use (Figure 2). Although a portion of the watershed consists of open space in the form of urban parks and some upland areas, the most predominant land use is a mix of mostly medium to high density residential, commercial, and transportation. Although historically the area close to the Bay margin was more predominantly industrial, today, with the onset of redevelopment in the last several decades, the area associated with older industrial land uses is small and redevelopment is continuing. Drainage into the Crescent is dominated by urban runoff entering at two locations (Figure 2).

The southern pour point drains a total area of 8.3 km^2 and comprises two subwatersheds – Ettie Street Pump Station (ESPS) Watershed (WS) and Emeryville Crescent North WS – which come together approximately 0.6 km upstream from the Bay shoreline. ESPS WS (4.6 km^2) is situated between major Oakland highways (580, 880, and 980), and drains the majority of the neighborhood called West Oakland. Located in close proximity to the Port of Oakland and numerous rail lines and spurs, the ESPS WS is a highly impervious (76%), old urban landscape with a relatively high percentage of older industrial area (10%). West Oakland embodies a rich cultural history, and although industrial activity has been in slow decline for approximately 80 years, revitalization of the neighborhood has begun in the form of new affordable housing, transit-oriented housing and businesses, and other forms of redevelopment which are likely to continue.

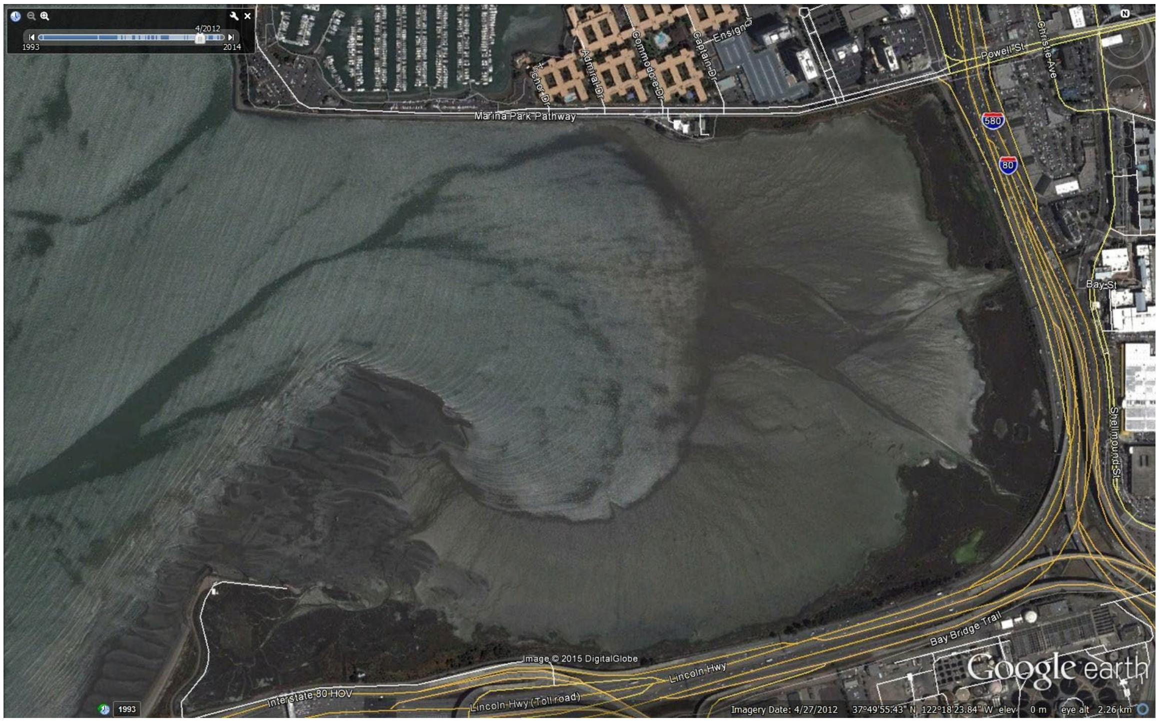

Figure 1. The Emeryville Crescent at low tide. Marsh, intertidal mudflat, and subtidal areas are visible.

The Emeryville Crescent North WS (3.7 km^2) is situated between the ESPS and Temescal Creek watersheds and comprises the southern portions of Emeryville, North Oakland, and Rockridge neighborhoods. The land use profile of Emeryville Crescent North WS is very similar to that of ESPS WS, but includes only about half the amount of industrial area and less commercial area in exchange for more residential. The Emeryville portion of the watershed, once a more industrial area, is now dominated by commercial big box stores (note: some of this redevelopment occurred after 2002—the year represented by the land use spatial data layer (ABAG, 2005) used in the modeling analysis described later—and therefore the percentage of industrial area is over-represented while commercial area is under-represented). North Oakland is predominantly residential but includes the major BART connector station (MacArthur BART) and Highway 24, and is currently experiencing revitalization and gentrification. The Rockridge neighborhood is predominantly residential with some commercial areas mainly along College Avenue.

Temescal Creek WS drains 10.6 km^2 below Lake Temescal and enters the Crescent from the northern drainage point. The upper watershed of Temescal Creek consists of the Claremont Hills, and then runs through Claremont, South Berkeley, North Oakland, and a large portion of Emeryville. Claremont, South Berkeley, North Oakland, and the eastern portions of Emeryville are predominantly residential areas with some commercial, while the west Emeryville area includes the large commercial center of Bay Street, as well as a large proportion of commercial-industrial buildings including Pixar (note: similar to areas in Emeryville Crescent North WS, some of this redevelopment occurred after 2002 and therefore the percentage of industrial area is over-represented in the land use layer while commercial area is under-represented). A short section of the 80/580 freeway, along with a 4 km stretch of Highway 24 and 2 km stretch of Highway 13, all pass through Temescal Creek WS below Lake Temescal.

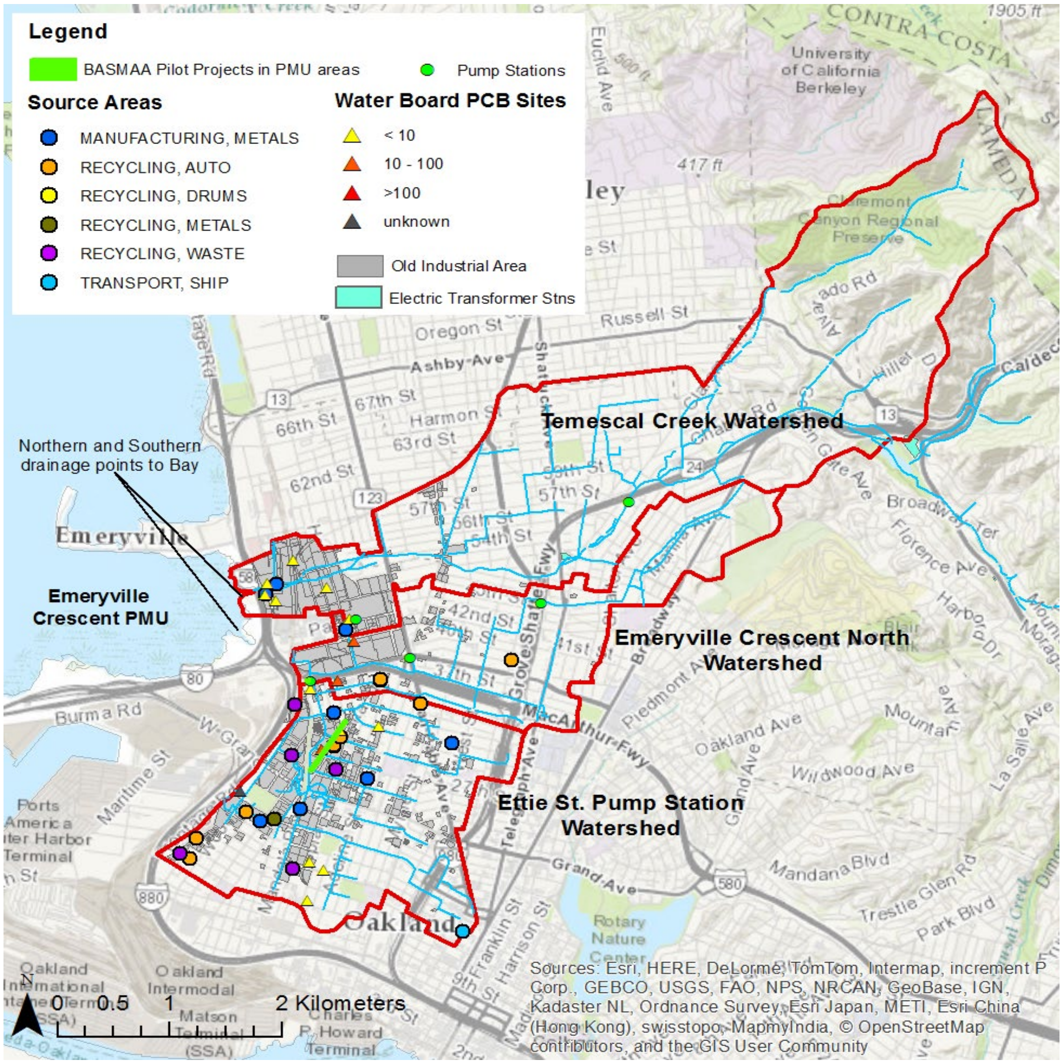

Figure 2. Main tributary subwatersheds of the Emeryville Crescent PMU and discharge points to the Bay. Water Board PCB sites soil concentration data in mg/kg.

Prior Estimates of PCB Export to the Emeryville Crescent PMU

Prior to the PMU studies, PCB loads from ESPS WS had been previously estimated in two efforts, including 1) an EBMUD Environmental Enhancement Project and Supplemental Environmental Project (EBMUD, 2010) and 2) the RMP WY 2011 watershed reconnaissance study (McKee et al., 2012). The EBMUD effort yielded an average annual PCB load of 171 g, while the RMP WY 2011 reconnaissance effort yielded an average annual PCB load for ESPS WS of 343 g. SFEI subsequently re-evaluated the empirical flow data at ESPS and concluded that the previous loading estimates made by EBMUD (2010) and McKee et al. (2012) were likely in error and biased high by a factor of 2-4-fold due to estimates of flow through ESPS WS being biased high. In a later effort, the GreenPlan-IT LID planning tool box was used to estimate baseline loads as a basis for recommending optimal placement of LID to reduce loads. An uncalibrated SWMM model was used to estimate annual average flows as the basis for calibrating a PCB model. They estimated an annual average load of 98.4 g (Wu et al., 2018) 2-4-fold lower than the earlier estimates.

For the PMU study, ESPS WS loads were estimated using the Regional Watershed Spreadsheet Model (RWSM; Wu et al., 2017). The RWSM applies regionally calibrated coefficients for runoff based on a combination of land use, slope, and soil type. Average annual flow volumes of 1.5 Mm^3 were estimated using the RWSM, equivalent to a runoff coefficient of about 0.6 (or 60% of mean annual rainfall). No flow data exist for either the Emeryville Crescent North or Temescal Creek watersheds, and therefore flows were estimated for these watersheds also using the RWSM.

To estimate average annual PCB loads for ESPS WS, flows generated from the RWSM were applied to the SSC-weighted mean concentration of the EBMUD wet weather influent samples and the RMP WY 2011 stormwater grab samples. These concentrations were nearly identical and together averaged 59 ng/L. For Emeryville Crescent North and Temescal Creek watersheds, where no empirical PCB concentrations had been measured, loads were estimated using RWSM-estimated flows and the latest version of the RWSM PCB calibration coefficients (Wu et al., 2017). The resulting revised load estimates (Table 1) included a much smaller mass for the ESPS WS (87 g/yr); given the estimate uncertainty (61-113 g), this was functionally the same as the Wu et al., 2018 estimate. The estimated range for the entire PMU watershed was 141–369 g/year, with a best estimate of 214 g/year (which as mentioned, given land use conversions may be biased high).

Table 1. Average annual load estimates developed in 2017 for the Emeryville Crescent Margin Unit watersheds using the RWSM.

Watershed	Total Area (km^2)	Total Runoff Volume (Mm^3)	PCBs Load - Low Estimate (g)	PCBs Load - High Estimate (g)	PCBs Load - Best Estimate (g)	PCBs Yield - Best Estimate ($\mu g/m^2$)	Method
Emeryville Crescent North WS	3.7	1.2	24	81	39	10.5	RWSM flows and RWSM estimated PCB concentrations

Ettie St Pump Station (ESPS WS)	4.6	1.5	61	113	87	18.9	RWSM flows and empirical PCB concentrations
Temescal Creek WS	10.6	3.3	56	175	88	8.3	RWSM flows and RWSM estimated PCB concentrations
Total for Margin Unit	18.9	6.0	141	369	214	11.3	

Although for planning purposes these loads were conceptually reasonable, there were several data gaps identified.

1. Empirical flow data were lacking for all of these watersheds.
2. Concentration data of any kind were lacking for Emeryville Crescent North and Temescal Creek watersheds.
3. Concentration data collected in the manner that allows for either calibration of the model or empirical-based loads computations were lacking.
4. The underlying land use data did not accurately account for areas redeveloped since 2002. A large percentage of area categorized as old industrial has been redeveloped, particularly in the lower portion of Temescal Creek WS. Consequently, we acknowledge the current load estimate for Temescal Creek WS is likely biased high, perhaps by approximately 30-40%. An updated land use dataset would be of great value for regional modeling purposes and is currently in development through a collaboration between AGAB/MTC and the RMP.

Due to the data gaps described above, in this project we aimed to collect stormwater samples within each of the watersheds in 3-4 storm events, such that we could then apply that empirical data to estimate loads. Funding for this effort was provided from this SEP and supplemented with additional funding from the RMP.

San Leandro Bay

Background

The watershed draining to San Leandro Bay (Figure 3) covers an area of 83.4 km² of mixed land use and drains areas of the southern parts of Oakland and northern parts of San Leandro (Figure 4). Drainage into San Leandro Bay occurs from 15 identified subwatersheds, but the subwatersheds of six of the larger, named creeks dominate, comprising 92% of the area. The nine smaller, unnamed subwatersheds (each referred to as "AC_unk[number identifier]" are each 2 km^2 or smaller and located immediately adjacent to the Bay. For the purposes of this analysis, the 15 drainages were grouped together into five main drainage areas (Figure 4).

- Drainage Area 1 (drains to Drainage Point 1 on the map) includes drainage from Sausal Creek and two much smaller unnamed catchments designated as AC_unk14 and AC_unk15.
- Drainage Area 2 (drains to Drainage Point 2 on the map) includes drainage from Peralta, Courtland, and Seminary Creeks and the unnamed catchment designated as AC_unk16.
- Drainage Area 3 (drains to Drainage Point 3 on the map) includes drainage from Arroyo Viejo Creek, Lion Creek, and three unnamed catchments designated as AC_unk17, AC_unk19 and AC_unk20.
- Drainage Area 4 (drains to Drainage Point 4 on the map) includes drainage from San Leandro Creek and Elmhurst Creek.
- Three additional small catchments drain through several dispersed outfalls into the San Leandro Bay, including the unnamed catchments AC_unk 18, AC_unk21 and AC_unk22.

Although a portion of the San Leandro Bay watershed consists of open space in the form of urban parks and some upland areas, the most dominant land use for the watershed as a whole is a mix of medium to high residential and commercial properties, and transportation. Overall, the imperviousness of the whole San Leandro Bay watershed is 45%. Approximately 10% of the area is industrial (ABAG, 2005), and 85% of that area is either older industrial or source areas that are conceptually associated with higher concentrations of PCBs.

Prior Estimates of PCB Export to the San Leandro Bay PMU

In the absence of multi-year datasets for runoff and PCB concentrations from the SLB PMU subwatersheds, PCB loading to the Bay was estimated using the RWSM (Wu et al., 2017). The RWSM estimates average annual flow volumes of 26.6 Mm^3 (Table 2), equivalent to a runoff coefficient of about 0.52 (or 52% of mean annual rainfall). This value is conceptually reasonable given an impervious cover of 45%. The estimated range of PCB export to the SLB PMU is 462 – 1,747 g/yr, with a best estimate of 986 g/yr. Although for planning purposes these loads are conceptually reasonable, the main data weaknesses are the lack of empirical flow and concentration data for all but San Leandro Creek where a monitoring station was maintained for three water years (2012-2014) to measure both of these parameters. Additionally, two known prominent source locations exist in the San Leandro Bay watershed: the former General Electric (GE) property and a former Union Pacific Railroad (UPRR) site. While the RWSM is nicely calibrated for regional average loads, as is the case for most models, it is not well structured to model loads from high leverage, or "hotspot" areas. Therefore, it is possible that the RWSM-modeled loads may be biased low.

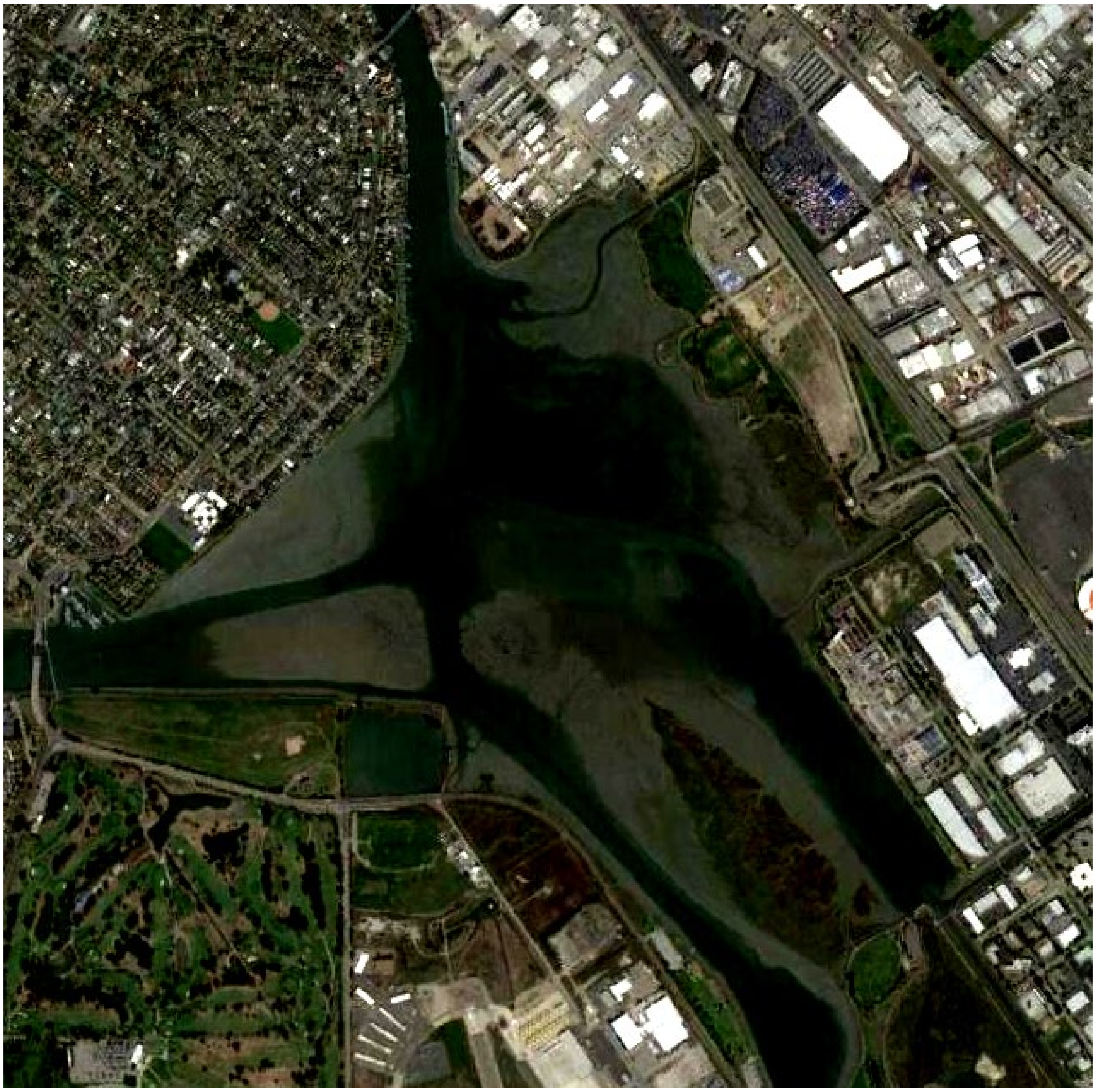

Figure 3. San Leandro Bay at low tide, March 2014. Marsh, intertidal mudflat, and subtidal areas are visible.

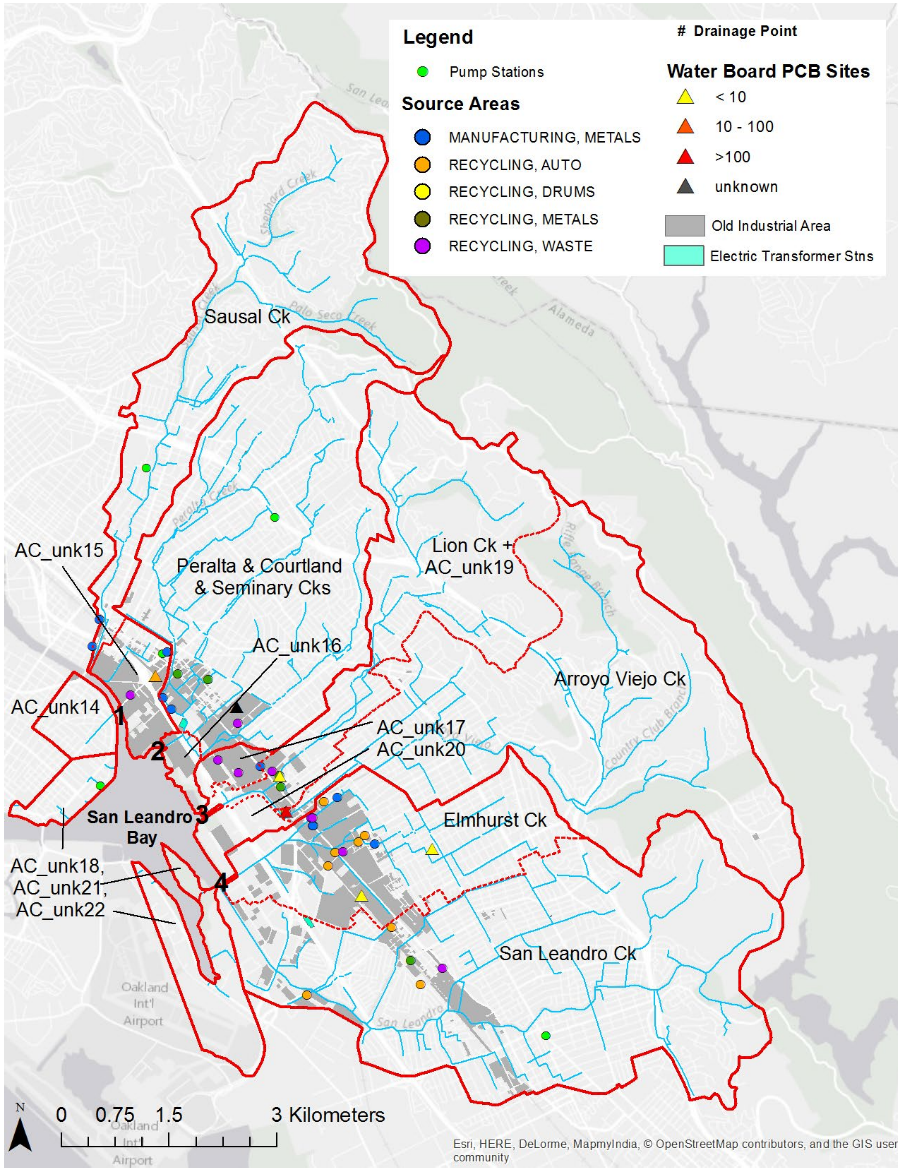

Figure 4. Main tributary watersheds to the San Leandro Bay PMU and watershed drainage points. Water Board PCB sites soil concentration data in mg/kg.

Clean Up Actions in San Leandro Bay Watersheds: General Electric and Union Pacific Railroad Sites

Two major clean-up efforts are currently underway in the San Leandro Bay watershed (Figure 5). First, the California Department of Toxic Substances Control (DTSC) is leading a clean-up at the GE site located at 5441 E. 14th St. in Oakland between 54th and 57th Avenues (pers. comm. Katherine Baylor, USEPA; Geosyntec Consultants, 2011) (Figure 5). This location was formerly a transformer and electrical equipment facility from the mid-1920s until nearly 2000. Surface soil samples at this site measured PCB concentrations up to 11,000 mg/kg. The area has been nearly completely capped and there is almost no remaining exposed soil.

Table 2. Average annual load estimates for the San Leandro Bay Margin Unit watersheds.

Watershed	Total Area (km^2)	Total Runoff Volume (Mm^3)	PCB Load - Low Estimate (g)	PCB Load -Best Estimate (g)	PCB Load -High Estimate (g)	PCB Yield - Best Estimate (ug/m^2)
Sausal Ck, AC unk14, AC unk15	13.2	4.4	64	136	242	10.3
Peralta and Courtland and Seminary Creeks, AC unk16	15.0	4.9	82	175	307	11.6
Arroyo Viejo Ck, Lion Ck, AC unk17, ACunk19 and AC unk20	26.6	9.4	106	234	389	8.8
San Leandro Ck and Elmhurst Ck	25.7	7.1	166	350	635	13.6
AC unk18, AC unk21, AC unk22	2.9	0.8	44	91	175	31.2
Total for Margin Unit	83.4	26.6	462	986	1,747	11.8

Second, the USEPA is leading the cleanup of an old UPRR site at 701 73rd Avenue just east of the Coliseum in Oakland (pers. comm. Janet O'Hara, SFBRWQCB). This location was formerly a rail station and then an auto salvage yard. Soil samples at this site measured PCB concentrations of up to 3,000 mg/kg, and sediment samples collected in the adjacent channel ranged up to 3,300 µg/kg (GHD, 2017). Clean-up at the UPRR site is expected in the future.

Figure 5. Major clean-up sites (approximate location at red pins) in the watershed draining to San Leandro Bay.

Prior Sampling in this Area

In August 2016, sediment samples were collected in channels downstream of each of these clean-up sites. Figure 6 shows the concentrations of select sediment samples downstream of the clean-up sites. Sediment PCB concentrations were particularly high in East Creek Channel, downstream of the GE site and Peralta, Courtland, and Seminary Creeks. The congener profiles in East Creek Channel were dominated by congeners indicative of Aroclor 1260, except for the site furthest from the Creek mouth (ECM100m) which was dominated by Aroclor 1254. A primary use of Aroclor 1260 was in electrical transformers, which were processed at the GE facility. Concentrations in Damon Channel downstream of the UPRR site on Arroyo Viejo Creek were not as high, and were dominated by congeners indicative of Aroclor 1254. Aroclor 1254 had a wider variety of uses than Aroclor 1260, including use in capacitors, hydraulic fluids and vacuum pumps, as plasticizers (including in sealants and caulking), and other uses. Similar sediment concentration patterns were seen in an earlier study by Daum et al. (2000).

Stormwater data collected in a single storm event in 2017 along each tributary to San Leandro Bay also corroborate these patterns (Gilbreath et al., 2018). There are three channels that drain into East Creek Channel: Peralta, Courtland, and Seminary creeks (known to the County Flood Control District as Zone 12 Lines F, H and I). PCB concentrations on suspended sediment particles in stormwater samples collected from those three channels measured 180, 2,600, and 400 µg/kg, respectively. The highest concentration (2,600 µg/kg) was collected in

Courtland Creek/Zone 12 Line H downstream of the GE plant, which is the third highest concentration collected in the entire Bay Area in a dataset of 94 sites.

Of the two clean-up sites, GE is likely to have a greater influence on load export to the PMU. The highest concentrations sampled in soil on that site are greater than those sampled at the UPRR location. Conceptually this makes sense: PCB handling and usage was a primary activity at the GE location. Even with the majority of the site now capped, drainage off the property may still be functioning as a continuing source to the channel. Contaminated sediment stored in the channels downstream of the property is likely also contributing to continued loading. In addition to the concentration patterns, the congener profiles of the suspended and bed sediment samples in East Creek Channel are consistent with the GE property being an important source of PCBs to sediment in East Creek Channel.

Given the high concentrations in stormwater and sediment for the watersheds downstream of the GE property, and the possibility that management efforts will serve to substantially reduce PCB loads to the PMU over the long-term, the goal of this project was to develop a baseline of concentrations downstream of GE in stormwater runoff to which comparisons may be made in the future to assess the effectiveness of those management actions.

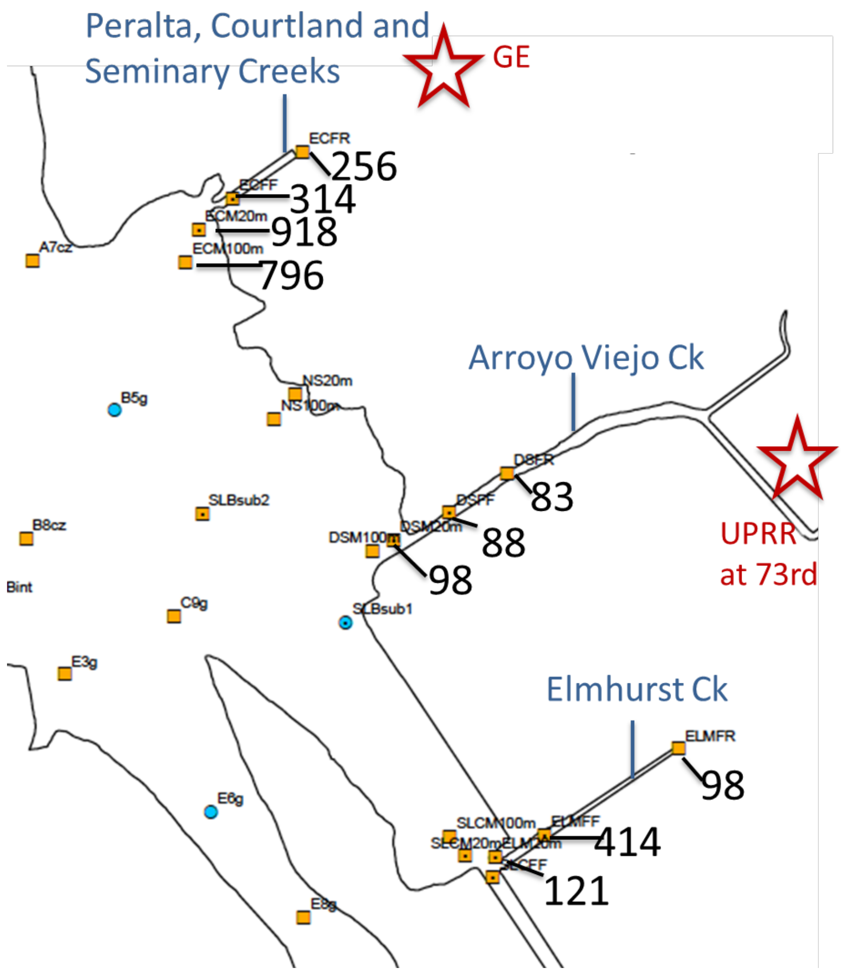

Figure 6. Major known clean-up sites (approximate location at red stars) in the watershed draining to San Leandro Bay, and PCB concentrations in sediment (µg/kg) for select samples collected by the RMP in 2016.

Methods

Sampling locations

Three watersheds draining into the Emeryville Crescent PMU and two watersheds downstream of the GE plant and draining into the San Leandro Bay PMU were sampled (Figures 7 and 8). The five sampling sites were located at the following coordinates (in WGS 1984):

- Temescal Creek: 37.83424, -122.29352
- Emeryville Crescent North: 37.827305, -122.285908
- Ettie St. Pump Station: 37.826043, -122.288942
- Zone 12 Line H: 37.76238, -122.21217
- Zone 12 Line I: 37.75998, -122.21020

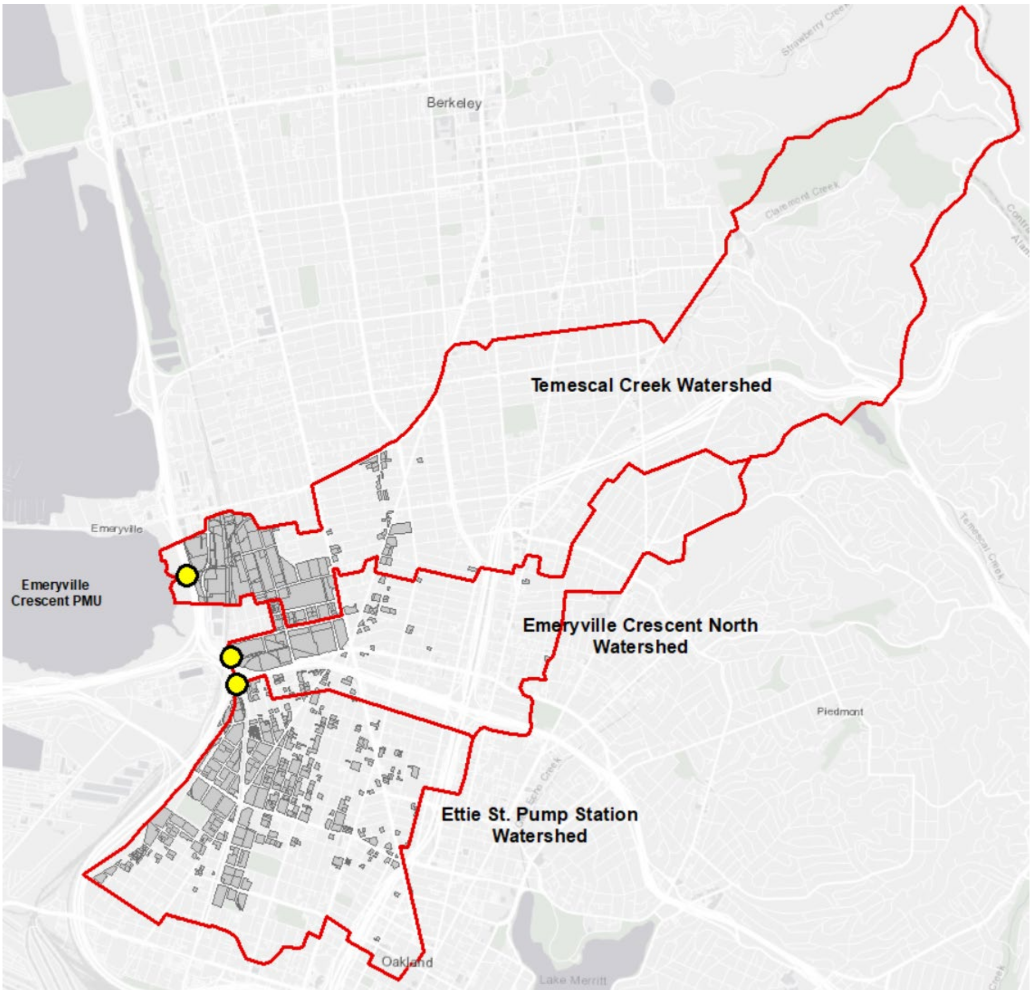

Figure 7. The three sampling locations in the Emeryville Crescent PMU. Sampling locations shown as yellow circles.

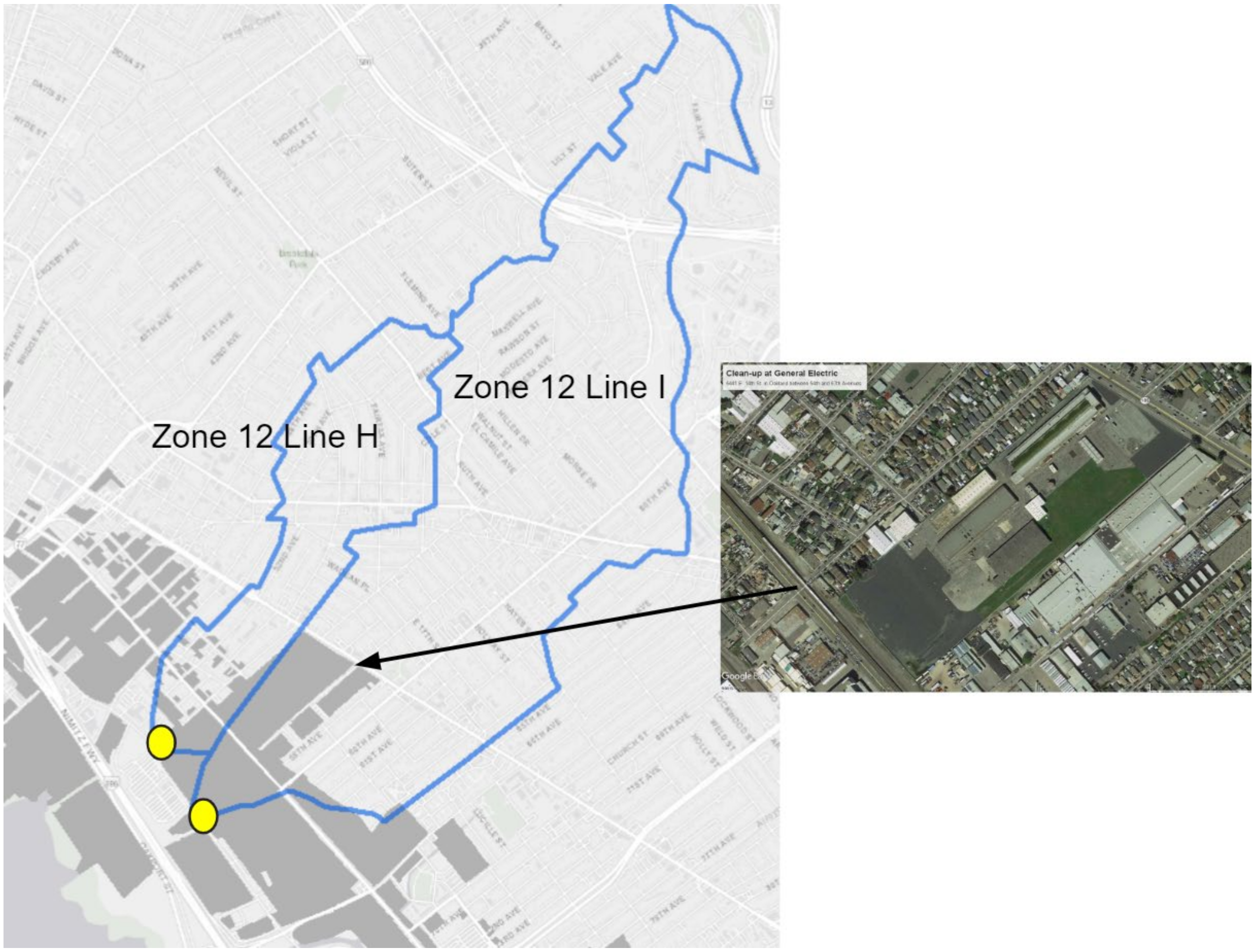

Figure 8. The two watersheds that drain the GE property. Sampling locations shown as yellow circles.

Field Methods

Staff mobilization for sampling was typically triggered when a minimum rainfall of at least one-half inch over 6 hours was forecast. Sites were sampled by attaching laboratory-cleaned Teflon sampling tubing to a painter's pole and a peristaltic pump with laboratory-cleaned silicone pump tubing. During sampling, the tube was dipped into the channel or drainage line at mid-channel mid-depth (if shallow) or if the depth was more than 0.5 m, the tube was passed up and down through the water column to obtain a depth integrated sub-sample. At each site, a time-paced composite sample was collected with a variable number of sub-samples (aliquots that were composited to make a single sample). Based on the weather forecast, prevailing on-site conditions, and radar imagery, field staff estimated the duration of the storm and selected an aliquot volume for each analyte and number of aliquots (typically 3-5 total) to ensure the minimum volume requirements for each analyte (SSC 0.3 L; PCBs 1 L) were reached before the end of the storm. The final volume of the aliquots was determined just before the first aliquot was taken and remained fixed for the sampling event. Similarly, the time period between aliquots was decided just before the second aliquot was taken and then remained the same for the rest of the event. Sample then continued until either the minimum sample volume was obtained or if the storm ended up longer than predicted, until the storm passed or until the capacity of the sample storage bottle was reached. All aliquots for a storm were collected into the same bottle, kept in a cooler on ice during sampling, and then refrigerated at 4 °C before transport to a laboratory (see Yee et al., 2017 for information about bottles, preservatives and hold times).

Laboratory Analytical Methods

Composite samples collected during each monitoring event were analyzed by USGS (Pacific Coastal and Marine Science Center, Santa Cruz, California) for suspended sediment concentration (mg/L) using ASTM D3977, and by SGS AXYS (British Columbia, Canada) for the sum of 40 PCBs using EPA 1668. The sum of 40 PCB congeners includes the following: PCB-8, PCB-18, PCB-28, PCB-31, PCB-33, PCB-44, PCB-49, PCB-52, PCB-56, PCB-60, PCB-66, PCB-70, PCB-74, PCB-87, PCB-95, PCB-97, PCB-99, PCB-101, PCB-105, PCB-110, PCB-118, PCB-128, PCB-132, PCB-138, PCB-141, PCB-149, PCB-151, PCB-153, PCB-156, PCB-158, PCB-170, PCB-174, PCB-177, PCB-180, PCB-183, PCB-187, PCB-194, PCB-195, PCB-201, PCB-203.

Sample results were evaluated for quality assurance (QA) along with samples for another RMP project (Pollutants of Concern Reconnaissance Monitoring), in which field collection was identical and therefore QA samples were combined. The following represents the QA information for the two project datasets combined.

QA of Suspended Sediment Concentration

In WYs 2019 and 2020, the SSC data from USGS-PCMSC were acceptable, aside from failing hold-time targets specified in the RMP QAPP. Minimum detection limits (MDLs) were sufficient, with zero non-detects (NDs) reported. Four method blanks were analyzed; three were below the MDL and the fourth was only slightly above MDL, but their average was not >MDL. Spiked samples are not typically reported for SSC. A blind field replicate was used to evaluate precision in the absence of any other replicates. The relative standard deviation (RSD) for the blind field replicate of SSC was 0%, below the 10% target.

QA Sum of 40 PCBs

In WY 2019, SGS AXYS analyzed total water samples for the sum of 40 PCBs. Method detection limits (MDLs) were satisfactory for the PCBs with only four non-detects reported (one each for PCB008, PCB019, PCB049 and PCB15). PCB concentrations above the MDL were reported for the one method blank for PCB 028, PCB 031, PCB 033, PCB 044, PCB 049, PCB 052, PCB 066, PCB 070, PCB 105, PCB 110, PCB 149, PCB 153, and PCB 180. As a consequence, one PCB 049 result was flagged with the censoring QA code of “VRIP” (Data rejected - Analyte detected in field or lab generated blank, flagged by QAO) for blank contamination. The other blank contaminated results were flagged by the analyzing laboratory so no additional flags had to be added. PCB concentrations above the MDL were reported in the field blanks for PCB 018, PCB 028, PCB 031, PCB 033, PCB 044, PCB 049, PCB 052, PCB

066, PCB 070, PCB 095, PCB 132, PCB 138, and PCB 149. But the average concentrations in the field blanks were less than 1% of the average field sample concentrations. No certified reference material samples, and no matrix spike samples were analyzed/reported. The percent error for the three PCBs included in the single laboratory control sample (PCB 105, PCB 118, and PCB 156) were 2%, 3%, and 3%, respectively (recoveries were 102%, 103%, and 97%) all well below the 35% target MQO. No qualifiers were added. Lab replicates were not analyzed/reported so blind field replicates were used to decide whether precision flags were needed for the PCB results. The RPDs were all below the MQO target of 35%, ranging from 1.87% to 29.58%. No qualifiers were needed.

In WY 2020, the dataset included 7 field samples, and 1 each of a lab blank, lab rep, MS, and LCS sample. Nearly all of the data were quantitative, aside from a handful of congeners in a few samples of the same concentration range as blank contamination (<3x higher), which were flagged as estimated despite being above MDL and RL. Method detection limits (MDLs) were sufficiently sensitive that most of the dominant congeners in Aroclors were detected in all samples. Only PCB 201 was ND in one sample. Twenty-two of the congeners were found in the lab blank, but most at concentrations less than ⅓ those in field samples. Only PCB 008, 033, and 044 were found to have blank concentrations within ⅓ of those in the lowest concentration field samples. Lab reps had RPDs ranging 38-95% for the various congeners, with one of the replicates consistently higher than the other. Due to the systematic nature of the bias between samples, it may be an issue of subsampling or composite creation leading to the bias rather than measurement precision (which would tend to be randomly higher, not always in the same replicate). The entire batch was flagged with a “VIL” QACode indicating this uncertain precision for all the congeners reported in replicates, as all had RPDs > the target 35%. Recovery of congeners in the LCS was very good, with 2-19% deviation from target expected values. No added recovery flags were needed.

Results and Discussion

Emeryville Crescent

Five samples were collected at the Emeryville Crescent sites during water years 2019 and 2020, through the duration of this Supplemental Environmental Project (Table 3) (note: seven samples are reported in the table but the two denoted with the single “*” were collected before this study began). Measured concentrations were lowest in the Emeryville Crescent and the highest observed was in Zone 12 Line A (Table 3). Note however that there was also a wide variation of SSC, and that the highest and lowest concentrations of PCBs are correlated with the highest and lowest concentrations of SSC. Therefore, on a particle basis (the ratio of the sum of PCBs to SSC), PCBs were highest at Ettie St. Pump Station. The particle ratio method of interpretation is discussed in the Recommendations and Next Steps section at the end of this report.

Based on the average of the samples collected in each subwatershed, load estimates to the Emeryville Crescent PMU were updated (Table 4) using the average concentration multiplied by the average annual flow volume determined using the RWSM. Compared to the previous estimate, the load estimate for ESPS WS went down slightly due to a new data point collected in 2020 that was lower than previously sampled. This lower concentration may just be inter-storm variation, or there may actually be a reduction of PCB export from the watershed due to management actions in the area. The load estimate for Emeryville Crescent North went down substantially. Data has only been received for one storm sampled there to date and that storm had a concentration of only 7 ng/L, much lower than the previously modeled estimate. The previously modeled estimate was relatively elevated due to a large area of old industrial landscape in the land use dataset used for the analysis. However, as discussed previously, a substantial area of that mapped as old industrial has actually been redeveloped, which has likely lowered PCB exports from the area. This updated estimate is based on one sample point and should be revisited once the data from two additional sampling events in WYs 2021 and 2022 are received. And finally, the load estimated for Zone 12 Line A (Temescal Creek) was much higher than modeled. There was one storm in which the SSC and PCBs were very high, which raised the average concentration for the watershed such that the load estimate was quite high. Empirical estimates for this watershed could be improved greatly with additional sampling or by using a concentration on sediment and modeled sediment loads as the basis for load estimation (discussed further in the Recommendations and Next Steps section at the end of this report). In total, the estimated load to the Crescent increased by 20% as the result of this study and the load estimation method used.

Table 3. PCB and SSC data collected in the Emeryville Crescent watersheds.

Sampling Site	Date Sampling	Sum of 40 PCBs (ng/L)	SSC (mg/L)	Sum of 40 PCBs/SSC (ng/g)
Ettie St. PS*	2/17/2011	59	78	759
Ettie St. PS	2/13/2019	56	84	667
Ettie St. PS	1/16/2020	37	117	318
Emeryville Crescent North**	1/16/2020	7	55	131
Zone 12 Line A (Temescal Ck)*	1/8/2018	11	114	95
Zone 12 Line A (Temescal Ck)	11/28/2018	111	1840	60
Zone 12 Line A (Temescal Ck)	2/13/2019	33	496	66

*This data was collected prior to the start of this project but reported here because the updated load analysis (presented below) will draw upon all of the data available for these sites.
**PCB concentrations from two storms sampled in WYs 2021 and 2022 are yet to be analyzed and will be reported in a future version of this report for the RMP.

Table 4. PCB concentrations and loads previously reported and updated as the result of this project.

Sampling Site	Old Modeled Average Concentration (ng/L)	Old Modeled Load (g/year)	New Measured Average Concentration (ng/L)	New Modeled Load (g/year)
Ettie St. PS	58*	87	50	75
Emeryville Crescent North	32	39	7	8.4
Zone 12 Line A (Temescal Ck)	27	88	52	172
Total		214		255

*Used the old average measured concentration data

San Leandro Bay - Zone 12 Lines H and I

One sample was collected in November of 2019 at each of the locations in Zone 12 (Lines H and I) as part of this Supplemental Environmental Project. Measured concentrations were much higher than previously observed in WY 2017, but SSC concentrations were also much higher (Table 5). On a per particle basis, PCBs were actually higher for each site for the WY 2017 storm event. The particle ratio method of interpretation is discussed in the Recommendations and Next Steps section at the end of this report.

Table 5. PCB and SSC data collected in the Zone 12 Lines H and I watersheds.

Sampling Site	Date Sampling	Sum of 40 PCBs (ng/L)	SSC (mg/L)	Sum of 40 PCBs/SSC (ng/g)
Zone 12 Line H*	12/15/2016	156	60	2601
Zone 12 Line H	11/26/2019	679	534	1271
Zone 12 Line I*	12/15/2016	37	93	398
Zone 12 Line I	11/26/2019	158	600	263

*This data was collected prior to the start of this project but reported here for comparison.

Recommendations and Next Steps for the RMP

The sampling completed in this study provides an improved dataset to use for load estimates in the Emeryville Crescent, as well as a baseline for comparison for future runoff concentrations after additional management efforts are applied in relation to the former GE property. However, the dataset is still limited to just a few storms per site. Ideally, numerous PCB concentration data points during storms coupled with flow data would serve as calibration points for modeling loads into the PMUs. Short of recommending sampling several more storm events per site, we have five recommended next steps, detailed below.

1) Update the modeled estimates using the RWSM once the land use dataset is updated.

As noted when discussing the Emeryville Crescent North dataset, quite a lot of area in that watershed as well as Temescal Creek has been redeveloped and therefore is not accurately represented in the land use layer that was used to model loads. A new land use dataset is currently being developed (nearly completed) for the region. It is likely that the updated land use dataset, with land use information from the years 2019-2021 as the basis, will more accurately reflect the land uses in the watersheds at the time of sampling (fall 2016 to the present). The model should therefore be re-run with the revised land use dataset and a comparison can be made between those estimated loads and the concentrations measured during this study.

2) Model PCB loading using suspended sediment load as the basis rather than runoff volume.

The RWSM assumes a constant event mean concentration value multiplied by the modeled annual runoff for a given watershed. But as we can see in the data tables above, measured PCB and SSC concentrations at a site can have large inter-storm variability depending on storm size, intensity, and antecedent conditions, as observed from previous studies when a large number of storms were sampled (Gilbreath et al., 2015). However, variability can be reduced if concentrations are normalized to SSC, which produces an estimate of the pollutant concentration associated with particles in the sample. The estimated particle concentration (EPC; ratio of mass of a given pollutant of concern to mass of suspended sediment) has been demonstrated to have less inter-storm variability than whole water concentrations, and therefore the EPC is likely a better characterization of water quality at a site than water concentration alone (McKee et al., 2012; McKee et al., 2015). A sediment module for the Watershed Dynamic Model (Zi et al., in prep), a recently developed and more sophisticated model than the RWSM, could serve as a basis for estimating PCB loads based on average particle concentrations multiplied by average annual sediment load. Alternatively, this could be accomplished with the RWSM if a calibrated sediment model for the RWSM were to be developed.

3) Review data when we receive it from North Emeryville Crescent.

To date, the North Emeryville Crescent watershed has been sampled three times but data has only been received for the first event. Data for the other two events sampled in WYs 2021 and 2022 are expected in fall 2022. Once the additional data are received, we will review it and make a recommendation as to whether additional sampling should be conducted. At this time, the watershed appears to contribute a minor PCB load to the PMU.

4) Conduct additional sampling in Ettie St. Pump Station in the future to investigate whether concentrations are decreasing.

The last data point measured in WY 2020 at Ettie St. Pump Station was lower—both in terms of water concentration and particle ratio—than previous sampling conducted by EBMUD in WY 2009, by the RMP in WY 2011, and again for this study in WY 2019. There have been management efforts in the ESPS WS and it is possible these efforts may be having an impact, but the data is far too limited to be sure. We recommend additional sampling (approximately 12-16 samples over a variety of storm sizes (Melwani et al., 2018)) in the watershed in 5 to 10 years to assess reductions in PCB loads from the watershed. Coupled with the dataset developed by EBMUD, the current dataset will serve as a strong baseline from which to compare future concentrations.

5) Additional sampling is planned in Zone 12 Lines H and I, both at the previously occupied sampling locations as well as locations just upstream of the GE property.

To date, two storms have been sampled in each Zone 12 Lines H and I. More data will support a stronger baseline to use for comparison after additional management actions are completed. The RMP has provided additional funding to sample two additional storm events for each site, as well as sampling upstream of the GE property along both drainage lines (Figure 9). This data could help identify where the high concentrations and loads of PCBs are originating from, whether at or near the GE property, or in the watershed upstream of the property. RMP staff have also been in communication with staff at the Water Board and USEPA about cleanup actions related to the GE and UPRR properties. Based on the RMP data, USEPA is requiring additional monitoring by GE. The Water Board is also requiring additional monitoring related to the UPRR property. The RMP will continue to coordinate with the Water Board and USEPA on monitoring related to the impact of these properties on the recovery of San Leandro Bay.

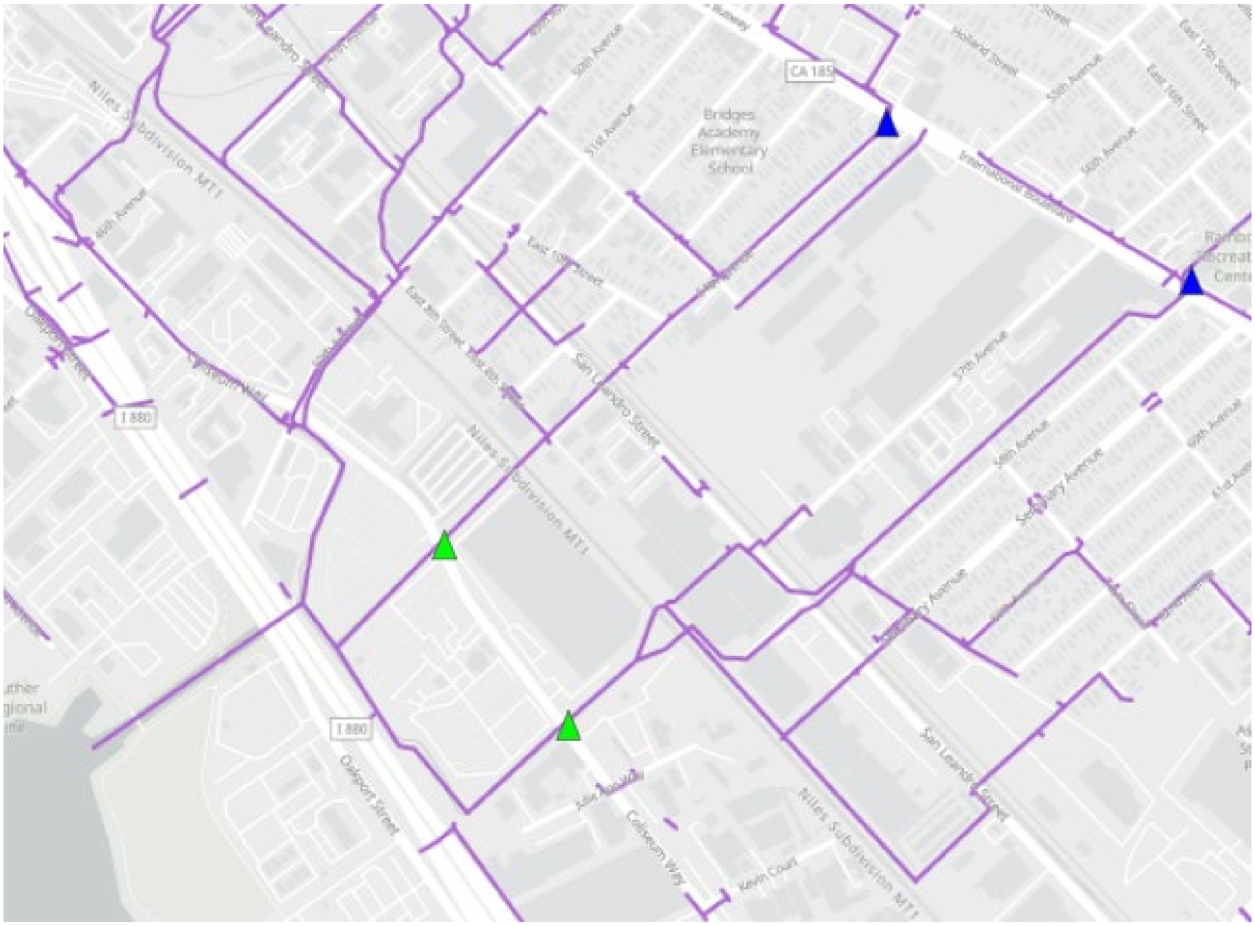

Figure 9. The two sampling locations on Lines H and I in green, and the two additional sites to be sampled upstream of the GE property in blue. The drainage lines are in purple, and the more northern of the two lines is Line H while the more southern is Line I.

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