Street Flush and Capture Pilot Study

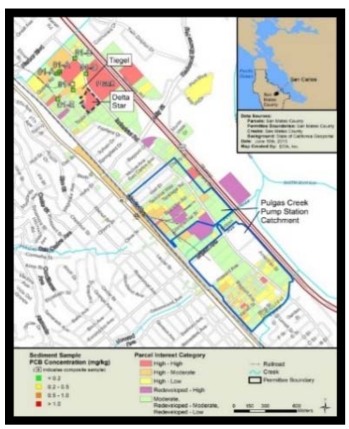
Pulgas Creek Pump Station Watershed

San Carlos, California

A Pilot Project of the

Clean Watersheds for a Clean Bay (CW4CB)

USEPA Grant-Funded Project



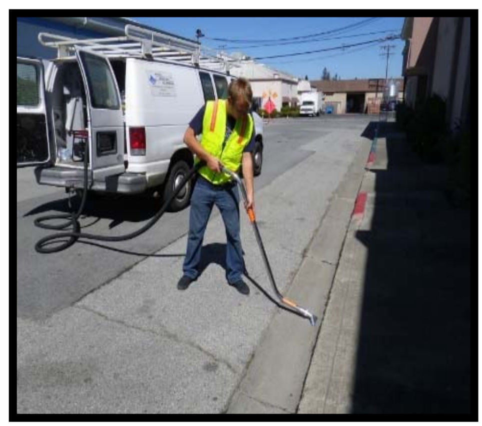


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Table of Contents

List of Tables

List of Figures

1.0 INTRODUCTION

Provisions C.11.e and C.12.e of the Municipal Regional Permit (MRP) for stormwater discharges in the San Francisco Bay Area required that Permittees perform pilot projects to evaluate and quantify the removal of mercury and polychlorinated biphenyls (PCBs) through various stormwater controls.[1] The pilot projects were intended to inform future efforts to achieve the stormwater runoff load allocations set forth in the San Francisco Bay PCBs and mercury Total Maximum Daily Load (TMDL) water quality restoration programs. One type of these pilot projects was designed to test enhancements to municipal operation and maintenance (O&M) activities. The O&M actions tested remove sediments and associated particle-bound pollutants (e.g., PCBs and mercury) during routine activities such as street sweeping and pump station maintenance and non-routine activities such as street and pipeline flushing and capture. This report documents the street flush and capture pilot project that was conducted in the Pulgas Creek Pump Station (PCPS) watershed in the City of San Carlos, California, including the project background, methods, and results, including a summary of the monitoring data collected and documentation of the costs to conduct the project.

The PCPS watershed is one of five drainages in the Bay Area with old industrial land uses and elevated PCBs concentrations in street dirt and municipal separate storm sewer system (MS4) sediment samples that was selected for pilot testing the effectiveness of controls for PCBs and mercury in stormwater runoff. The pilot projects were implemented through a regional project called Clean Watersheds for a Clean Bay (CW4CB). CW4CB was funded by a grant from the U.S. Environmental Protection Agency (EPA) to the Bay Area Stormwater Management Agencies (BASMAA) and matching funds from Bay Area countywide stormwater management programs. The San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) provided in-kind matching funds, and along with the City of San Carlos, was a partner for the CW4CB projects conducted in San Mateo County. The mercury and PCBs load reduction effectiveness evaluations for the PCPS watershed street flush and capture pilot study and other CW4CB pilot projects are presented separately in the CW4CB final project report (basmaa.org/Clean-Watersheds-for-a-Clean-Bay-Project/CW4CB-Overall-Project-Report).

1.1 Background

The PCPS watershed was selected as the location for this pilot project primarily based on elevated PCBs concentrations in street dirt and MS4 sediment samples collected in the watershed during previous studies. In 2000 and 2001, a collaborative project among BASMAA member agencies referred to as the Joint Stormwater Agency Project (JSAP) measured concentrations of PCBs, mercury and other pollutants in embedded sediments collected from stormwater conveyance systems throughout the Bay Area. The JSAP investigations initially identified the PCPS watershed as having elevated PCBs concentrations in MS4 sediments (KLI and EOA 2002). In 2002 and 2003, follow-up PCBs case studies were conducted in the watershed by SMCWPPP which involved both new sampling and re-sampling of previous JSAP locations (SMSTOPPP 2003). These studies identified two potential PCBs source properties in the watershed. However, based on the spatial distribution of PCBs in the watershed's MS4 sediments, it appeared that other sources remained unidentified. More recently, results from a 2010 study by the San Francisco Estuary Institute (SFEI) identified the watershed as one of 15 locations in the Bay Area with clusters of elevated PCBs concentrations in street dirt and MS4 sediment samples (Yee and McKee 2010).

[1]These requirements were found in the version of the MRP that was adopted in October 2009 and expired in November 2014. The MRP was reissued with updated requirements in November 2015.

1.2 Description of Project Location

The PCPS watershed is located in the City of San Carlos (Figure 1). The geographic area of the PCPS is approximately 260 acres and a stormwater pump station is located at the bottom of the drainage. Old industrial land use comprises about 60 percent of the total watershed area. The pilot study focused on an area in the southern part of the PCPS watershed where four street segments were selected for flushing and capture. The segments were located on Center, Washington, Varian, and Bing Streets (Figure 2).

1.3 Project Objectives

The overall objective of this study was to determine the benefits of a pilot street flush and capture project in terms of the mass of sediment-bound mercury and PCBs removed and the associated costs. In addition, the data collected and lessons learned may be used to inform planning of future control measure implementation, including the design of enhancements to O&M activities that increase pollutant removal.

Figure 1. Location of the Pulgas Creek Pump Station Watershed in San Carlos, CA.

Figure 2. Street Flush and Capture Street Segments in the Pulgas Creek Pump Station Watershed

2.0 METHODS

A detailed study design and monitoring plan for this pilot project (BASMAA 2013a) was developed with guidance and review from the CW4CB Project Management Team and Technical Advisory Committee and is available on the CW4CB website (basmaa.org/CW4CB-Project_Reports).

2.1 Overview

Four street segments in the southern part of the PCPS watershed were selected for flushing and capture. The segments were located on Center, Washington, Varian, and Bing Streets (Figure 2). These segments were selected based on a number of factors, including the location of previous storm drain system or street sediment samples with elevated PCBs and/or mercury concentrations and logistical considerations such as the locations of storm drain inlets, pavement/curb conditions, and traffic conditions.

Following the study design, the project team and City of San Carlos staff completed a total of four street flush and capture events in September 2013 (Table 1). Each flush event covered the complete width of the street (i.e., curb to curb) and the segments flushed varied in length from 500 to 550 feet. Two City of San Carlos Vactor trucks and four municipal maintenance staff were used for each flush event. The first Vactor truck was the water source and a wand attachment on the truck was used to flush the streets at a rate of 15 gallons/minute. The storm drain inlets in the study area were blocked during flushing to prevent the flush water from returning to the storm drain system. The second Vactor truck used its vacuum to capture the debris and wash water from the gutters in its truck-mounted tank. The wastewater from each flush event was decanted and disposed of into the sanitary sewer system. A wastewater discharge permit was obtained from the South Bayside System Authority treatment plant prior to the start of the study. The remaining sediment slurry was removed from the tank, dried at the municipal corporation yard, and disposed of with other debris routinely collected by municipal maintenance staff.

To evaluate the potential impact of street sweeping on the flushing effectiveness, routine weekly street sweeping was continued throughout the study on two of the street segments (Center and Washington). Street sweeping was discontinued at the other two segments (Varian and Bing) about three months before the flushing events (i.e., from June 7, 2013 until the completion of the study on September 20, 2013). On the two streets where sweeping was continued, one flush event (Washington Street segment) occurred immediately after a weekly sweeping event, to minimize the time between sweeping and flushing, and the other flush event (Center Street segment) occurred just before a sweeping event, to maximize the time between sweeping and flushing.

2.2 Monitoring

Kinetic Laboratories, Inc. (KLI) of Santa Cruz, one of the CW4CB monitoring contractors, conducted monitoring during each flush and capture event. The objective was to use the methods and procedures documented in the CW4CB QAPP (BASMAA 2012) and CW4CB Task 4 SAP (BASMAA 2013b) to measure the mass of PCBs and mercury removed. KLI prepared a detailed field monitoring methods report, including photographic documentation, which is available on the CW4CB website (basmaa.org/CW4CB-Project_Reports).

Table 1. Details of four street flush and capture events in San Carlos, CA.

Parameter	Units	Street			
		Center	Washington	Varian	Bing
Flush event date	NA	9/13/2013	9/16/2013	9/18/2013	9/20/2013
Street sweeping status	NA	Swept 5 days prior	Swept same day (flush immediately followed sweeping	No street sweeping for approximately three months prior to flush	
Length of street flushed	Feet	530	500	550	500
Width of street flushed	Feet	36	36	36	40
Total area flushed	$Feet^2$	18,974	18,000	19,800	20,000
Curb-miles flushed	Curb-mile	0.20	0.19	0.21	0.19
Linear miles flushed	Linear mile	0.10	0.09	0.10	0.09
Flush rate	GPM	15	15	15	15
Total flush water volume	Gallons	900	900	1,100	1,400
Debris volume remaining after decant of flush wastewater to sanitary sewer	Gallons	5	5	10	15

Two monitoring methods were applied during this pilot study:

1. Direct measurement of mass of pollutants in the flush wastewater.
2. Evaluation of street dirt loading by comparison of pollutant mass on the street before and after flushing.

The direct measurement method entailed collection of a sample of the flush wastewater from the curb prior to removal by the Vactor truck. During each flush event, four aliquots of the flush wastewater were collected over the course of the event and composited prior to analysis. In addition, a sample of the clean flush water was collected prior to the start of flushing each day, and a laboratory provided blank water sample was flushed through the monitoring equipment prior to sampling each day. To satisfy the wastewater discharge permit conditions, a sample of the wastewater discharge from the Vactor truck to the sanitary sewer was also collected for each flush event.

The street dirt loading comparison method entailed vacuum collection of surface street dirt from randomly selected strips of the street both before and after flushing. The length of each strip covered the entire width of the street from curb-to-curb, while the width of each strip was equivalent to the six inch width of the vacuum head. Ten randomly selected strips were vacuumed and composited immediately before the flush event, to quantify the pre-flush mass of street dirt and associated pollutants. After flushing was completed, as soon as the street was dry another ten randomly selected strips were vacuumed and composited to quantify the post-flush mass of street dirt and associated pollutants. The vacuum equipment was cleaned in the field between the pre- and post-flush sample collections, as well as between flush events.

All flush wastewater and street dirt samples collected were analyzed for PCBs, mercury, total organic carbon (TOC), total solids, bulk density (sediment only) and grain size, following the methods and procedures described in the CW4CB QAPP (BASMAA 2012) and CW4CB Task 4 SAP (BASMAA 2013b), and using the analytical methods and laboratories identified in Tables 2 and 3. The 40 PCBs congeners routinely reported by the Regional Monitoring Program (RMP) for Water Quality in the San Francisco Estuary[2] were reported. With the exception of samples for grain size analysis, all sediment samples were passed through a 2 mm sieve in the laboratory prior to analysis, consistent with previous BASMAA sediment studies (KLI and EOA 2002, SMSTOPP 2003, Yee and Mckee 2010).

The extensive field and laboratory data quality assurance and control program established in the CW4CB QAPP (BASMAA 2012) and Task 4 SAP (BASMAA 2013b) was implemented. The program established equipment cleaning methods, sampling protocols, sample hold times, minimum analytical reporting limits, and included the use of blind field duplicates, method blanks, matrix spike/spike duplicates, surrogate spikes, laboratory control samples, certified reference materials, and laboratory replicates. Measurement quality objectives (MQOs) were established along with procedures for flagging any data not meeting established criteria. The field and laboratory data generally met project MQOs, and any exceptions and resulting data qualifications were deemed to not preclude use of the data for the intended purposes. A summary of the complete data quality review is available on the CW4CB website (basmaa.org/CW4CB-Project_Reports).

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[2]The RMP 40 list of PCBs congeners has generally been analyzed for in previous studies by BASMAA agencies and SFEI (KLI and EOA 2002, SMSTOPP 2003, Yee and Mckee 2010).

Table 2. Analytes, sampling and analytical methods, and laboratories for street dirt samples.

Analyte	Sampling Method	Analytical Method	Reporting Units	Laboratory
Total Organic Carbon (TOC)	Grab	ASTM D4129	%	ALS
Particle Size Distribution	Grab	ASTM D422M/PSEP	%	ALS
Mercury	Grab	EPA 7471	µg/kg	ALS
PCBs	Grab	EPA 1668	µg/kg	ALS
Bulk Density	Grab	ASTM E1109-86	g/cm3	ALS

Table 3. Analytes, sampling and analytical methods, and laboratories for flush water samples.

Analyte	Sampling Method	Analytical Method	Reporting Units	Laboratory
Total Organic Carbon (TOC)	Grab	EPA415.1 or EPA 9060	%	ALS
Particle Size Distribution	Grab	SSC plus Nephelometric PSD (Soil Control Lab SOP#W-72)	%	Soil Control Laboratory
Total Mercury	Grab	EPA 1631	µg/kg	ALS
PCBs	Grab	EPA 1668A	µg/kg	ALS
Total Solids	Grab	SM2540G	%	ALS

3.0 RESULTS

The results of the PCPS watershed street flush and capture pilot project are presented in the following sections.

3.1 Pilot Project Costs

The approximate costs to implement the street flush and capture pilot project, from planning through reporting, are summarized in Table 4. It is important to note that these costs are site-specific for this pilot project and may not be relevant to other locations or settings. In addition, given the pilot nature of this project, the total costs presented may be upper-bound. For example, the start-up and planning costs shown may be relatively high for implementing new actions that have not been conducted routinely in the past. In general, planning and implementation costs may decrease over time as experience conducting these types of actions is gained and if economies of scale are realized. In addition, the study design and monitoring effort to evaluate the pollutant mass removal effectiveness and associated reporting could likely be scaled back or even eliminated in the future.

Table 4. Approximate Costs to Implement the Street Flush and Capture Pilot Project

Project Phase	Description	Costs			
		City of San Carlos	SMCWPPP	Contractors	Subtotal
Planning	Development of study design and sampling plans, selection of project location, hiring contractors to implement, etc.		$25,000	$20,000	**$45,000**
Implementation	Implementation of the project by city staff.	$16,000			**$16,000**
Monitoring	Field sample collection and laboratory analysis.			$50,000	**$50,000**
	QA/QC Review of all field and lab data.			$11,000	**$11,000**
Reporting	Data analysis and reporting.		$30,000		**$30,000**
	Subtotal	**$16,000**	**$55,000**	**$81,000**	
	Total	**$152,000**			

3.2 Monitoring

Summaries of the chemistry results for all flush water and street dirt samples are presented in Table 5. The complete chemistry data for all flush water and street dirt samples are provided in Tables 6 through 8. All 40 PCB congeners were detected in all flush wastewater samples and all pre-flush and post-flush street dirt samples. Flush wastewater concentrations ranged from 251 to 1,360 ng/L (total PCBs) and 343 to 3,120 ng/L (mercury). Total PCBs in pre-flush and post-flush street dirt samples ranged from 0.08 to 0.24 and 0.02 to 0.09 mg/kg, respectively. Mercury concentrations in pre-flush and post-flush street dirt samples ranged from 0.08 to 0.82 and 0.02 to 0.47 mg/kg, respectively.

PCBs homolog profiles were similar across all samples, and were especially similar for all samples collected on a given street. The PCBs homolog profiles (Figure 3) showed all samples were dominated by higher chlorinated homologs (e.g., penta, hexa, and hepta chlorinated biphenyls), which is suggestive of Aroclor 1260. However, potential weathering, the possibility that multiple Aroclors were used and released into the environment, and the lack of information on specific Aroclor usage in the area precludes identification of specific Aroclor sources.

The grain size distribution for all of the pre- and post-flush street dirt samples are shown in Figure 4. All of the street dirt samples were dominated by the sand fraction (0.075 mm to < 2 mm). Generally, the sand fraction increased and the silt/clay fractions decreased between the pre and post-flush samples. Further, the distribution of grain sizes in the flush water samples were dominated by silt, which ranged from 73% to 94% of the total solids < 2 mm (Figure 5). These results suggest smaller particles (silt/clay) were preferentially removed during the flush event.

Table 5. Summary of flush wastewater and street dirt chemistry data for four street flush and capture events.

Flush Wastewater Samples

Parameter	Units	*n*	Average	Range
Total solids	mg/L	4	3,790	2,740 - 5,300
Mass of solids in flush water	kg	4	15	9 - 20
TOC	mg/L	4	101	84 - 145
PCBs	ng/L	4	768	251 - 1,360
Mercury	ng/L	4	1,319	343 - 3,120
Particle Size Distribution				
Sand (>0.063 mm)	mg/L	4	220	14 - 518
Silt & Clay (< 0.063mm)	mg/L	4	2,000	1,792 - 2,210
Total Particles (< 2 mm)	mg/L	4	2,220	1,974 - 2,566

Street Dirt Samples

Parameter	Units	Pre-Flush			Post-Flush		
		n	Average	Range	*n*	Average	Range
Total sediment sample volume	cm^3	4	838	500 - 950	4	388	300 - 490
Bulk density	g/cm^3	4	1.3	1.2 - 1.3	4	1.4	1.0 - 1.6
Percent solids	%	4	1.0	0.96 - 1.0	4	1.0	0.92 - 1.0
Sediment mass per curb-mile	lbs/curb-mile	4	1,208	735.6 - 1,428	4	590	504 - 755
Sediment mass in flushed area	kg	4	107	70 - 130	4	53	43 - 69
PCBs	mg/kg	4	0.14	0.08 - 0.24	4	0.06	0.02 - 0.09
Mercury	mg/kg	4	0.32	0.08 - 0.82	4	0.17	0.02 - 0.47
TOC	mg/kg	4	4.3	3.8 - 5.3	4	2.6	1.1 - 5.7
Grain Size Distribution				-			
Clay <0.005 mm	%	4	0.89	0.33 - 1.4	4	0.29	0.22 - 0.39
Silt (0.005 to <0.075 mm)	%	4	12	7.1 - 16	4	4.8	1.3 - 7.0
Sand (0.075 to <2mm)	%	4	87	81 - 92	4	93	89 - 97
Sand/Gravel > 2 mm	%	4	0.64	0.26 - 1.6	4	0.79	0.08 - 1.4

Table 6. Chemistry data for flush wastewater samples collected from Center and Washington Streets.

	Center Street					Washington Street		
Parameter	Flush Water	Equipment Blank	Flush Wastewater	Flush Waste Water - Dup	Vactor Truck	Flush Water	Flush Waste	Vactor Truck
Grain Size (mg/L)								
Clay -Fine <0.00098 mm			38	39			49	
Clay -Medium 0.00098 to <0.00195 mm			32	32			51	
Clay -Coarse 0.00195 to <0.0039 mm			18	36			109	
Silt -V. Fine 0.0039 to <0.0078 mm			310	351			532	
Silt -Fine 0.0078 to <0.0156 mm			419	720			927	
Silt Medium 0.0156 to <0.031 mm			874	792			491	
Silt -Coarse 0.031 to <0.0625 mm			260	60			50	
Sand -0.0625 to <2.0 mm			24	35			14	
Total Solids (mg/L)			5,300	6,060			2,740	
TOC (mg/L)			90	76			145	
Copper (ug/L)					178			481
Mercury (ng/L)	0.001	0.0004	742	857	307	0.008	3,120	965
PCBs (ng/L)								
PCB 008		-	0.41	0.27	0.04		0.09	0.08
PCB 018/30		-	1.03	0.61	0.07		0.28	0.10
PCB 020/28		-	0.94	0.80	0.14		0.43	0.25
PCB 021/33		-	0.54	0.47	0.07		0.29	0.15
PCB 031		-	0.98	0.80	0.13		0.40	0.21
PCB 044/47/65		0.02	3.53	2.06	0.34		0.74	0.36
PCB 049/69		-	1.78	0.99	0.17		0.39	0.19
PCB 052		-	5.25	3.18	0.41		1.04	0.42
PCB 056		-	1.52	0.99	0.18		0.65	0.31
PCB 060		-	0.74	0.49	0.09		0.38	0.17
PCB 061/70/74/76		-	5.9	4.1	0.6		2.1	0.8
PCB 066		-	2.8	2.1	0.3		1.3	0.5
PCB 083/99		-	4.8	3.8	0.6		1.5	0.7
PCB 086/87/97/109/119/125		-	8.1	6.7	1.1		2.7	1.2
PCB 090/101/113		-	10.0	8.5	1.4		6.3	2.7
PCB 095		-	9.5	8.0	0.8		5.1	1.3
PCB 105		-	6.5	5.3	1.1		2.1	1.0
PCB 110/115		-	11.9	10.0	1.7		4.9	2.2
PCB 118		-	13.2	10.4	2.3		5.0	2.6
PCB 128/166		-	3.9	3.6	0.6		2.2	1.0
PCB 129/138/163		-	26.5	22.4	4.3		28.4	13.9
PCB 132		-	7.9	6.6	1.1		7.4	3.3
PCB 135/151		-	7.5	6.3	0.9		11.9	3.9
PCB 141		-	5.8	4.7	0.9		8.0	3.9
PCB 147/149		-	16.3	12.9	2.3		21.8	9.7
PCB 153/168		0.01	19.3	16.1	3.2		26.6	12.8
PCB 156/157		-	3.9	3.0	0.7		2.6	1.4
PCB 158		-	2.8	2.4	0.5		2.8	1.3
PCB 170		-	8.8	6.7	2.2		16.0	10.0
PCB 174		-	7.6	5.8	1.8		14.5	8.8
PCB 177		-	4.9	3.6	1.1		8.9	5.5
PCB 180/193		0.01	18.7	13.8	4.5		34.1	20.9
PCB 183		-	5.1	3.8	1.2		9.2	5.6
PCB 187		-	10.2	8.2	1.8		19.2	8.0
PCB 194		-	6.3	5.3	1.3		10.5	4.9
PCB 195		-	2.0	1.5	0.4		3.6	1.8
PCB 201		-	0.6	0.5	0.1		1.0	0.5
PCB 203		-	3.6	2.9	0.7		5.5	2.5
Total PCBs		0.04	251	200	41		270	135

Table 7. Chemistry data for flush wastewater samples collected from Varian and Bing Streets.

	Varian Street			Bing Street		
Parameter	Flush Water Blank	Flush Waste Water	Vactor Truck Sample	Flush Water Blank	Flush Waste Water	Vactor Truck Sample
Grain Size (mg/L)						
Clay -Fine <0.00098 mm		35			61	
Clay -Medium 0.00098 to <0.00195 mm		38			72	
Clay -Coarse 0.00195 to <0.0039 mm		27			44	
Silt -V. Fine 0.0039 to <0.0078 mm		455			627	
Silt -Fine 0.0078 to <0.0156 mm		643			702	
Silt Medium 0.0156 to <0.031 mm		464			451	
Silt -Coarse 0.031 to <0.0625 mm		130			90	
Sand -0.0625 to <2.0 mm		324			518	
Total Solids (mg/L)		3,270			3,850	
TOC (mg/L)		84			86	
Copper (ug/L)			331			642
Mercury (ng/L)	0.002	1,070	297	0.001	343	470
PCBs (ng/L)						
PCB 008		0.67	0.18		0.80	0.49
PCB 018/30		0.82	0.17		1.60	0.60
PCB 020/28		1.72	0.49		2.15	1.33
PCB 021/33		0.89	0.23		1.25	0.82
PCB 031		1.53	0.39		1.98	1.21
PCB 044/47/65		4.59	0.98		10.50	2.65
PCB 049/69		2.15	0.50		4.63	1.17
PCB 052		9.50	1.47		25.50	4.29
PCB 056		2.95	0.72		3.55	1.47
PCB 060		1.19	0.28		1.52	0.66
PCB 061/70/74/76		13.3	2.7		30.7	7.2
PCB 066		5.4	1.3		9.5	3.0
PCB 083/99		16.8	3.9		32.9	6.4
PCB 086/87/97/109/119/125		30.7	6.8		53.9	12.4
PCB 090/101/113		44.8	10.5		69.8	15.8
PCB 095		26.8	5.2		66.1	10.6
PCB 105		27.7	6.2		33.8	8.6
PCB 110/115		55.6	12.7		81.0	20.3
PCB 118		64.4	14.7		82.5	18.4
PCB 128/166		21.5	4.8		17.7	6.0
PCB 129/138/163		152.0	35.2		112.0	33.7
PCB 132		39.3	9.0		35.6	10.8
PCB 135/151		35.6	8.5		33.8	8.8
PCB 141		32.3	7.6		23.8	6.7
PCB 147/149		88.8	20.6		71.3	21.6
PCB 153/168		120.0	28.7		80.4	23.6
PCB 156/157		19.8	4.7		14.1	4.5
PCB 158		16.0	3.7		12.7	4.1
PCB 170		76.7	17.9		30.7	14.5
PCB 174		67.2	15.7		31.9	15.7
PCB 177		38.7	9.0		17.3	8.0
PCB 180/193		151.0	34.5		71.4	33.3
PCB 183		44.6	10.0		20.5	10.2
PCB 187		67.7	16.0		45.3	16.3
PCB 194		39.8	9.7		29.5	11.8
PCB 195		13.7	3.2		9.6	3.9
PCB 201		3.9	0.8		3.3	1.4
PCB 203		21.9	5.0		18.1	7.6
Total PCBs		1,360	314		1,190	360

Table 8. Chemistry data for street dirt samples collected before and after street flush and capture.

	Equipment	Center Street			Washington Street		Varian Street		Bing Street	
Parameter	**Blank**	**Pre (Dup)**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Grain Size (%)										
Clay - <0.005 mm		1.11	1.10	0.22	0.33	0.39	1.39	0.26	0.73	0.30
Silt - 0.005 to <0.075 mm		14.74	16.26	4.48	7.07	6.54	15.97	7.03	8.88	1.28
Fine Sand - 0.075 to <0.106 mm		6.89	6.45	4.68	4.79	4.65	6.59	5.38	3.81	0.80
Fine Sand - 0.106 to <0.250 mm		23.39	22.48	21.77	21.31	19.11	22.39	26.26	14.65	6.93
Fine Sand - 0.250 to <0.425 mm		15.65	15.29	17.13	16.69	14.94	15.99	22.05	12.46	9.78
Med Sand - 0.425 to <0.850 mm		20.60	17.81	25.27	21.79	23.76	19.60	20.46	23.62	21.27
Med Sand - 0.850 to <2.0 mm		16.38	19.30	24.70	27.26	30.81	17.97	15.29	36.62	58.63
Coarse Sand - 2.0 to <4.75 mm		0.41	0.34	0.55	0.41	1.13	0.26	0.08	1.55	1.38
Gravel - 4.75 to <75 mm		-	-	-	-	-	-	-	-	-
Total Solids (%)		98.70	98.50	99.70	96.00	91.50	98.50	99.60	98.20	99.20
TOC (%)		4.97	4.11	1.42	3.84	5.72	4.11	1.12	5.30	2.03
Density (g/cm^3)		1.36	1.32	1.56	1.21	0.98	1.29	1.51	1.30	1.48
Mercury (mg/Kg dw)	-	0.063	0.084	0.023	0.824	0.469	0.301	0.088	0.081	0.084
PCB Congeners (mg/Kg dw)										
PCB 008	-	0.0001	0.0002	0.0001	0.00004	0.00004	0.0002	0.00003	0.0016	0.00002
PCB 018/30	-	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.00003	0.0016	0.00002
PCB 020/28	0.000002	0.0002	0.0003	0.0002	0.0002	0.0002	0.0003	0.0001	0.0016	0.0001
PCB 021/33	-	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0009	0.00004
PCB 031	-	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0001	0.0017	0.00004
PCB 044/47/65	0.00001	0.0005	0.0005	0.0003	0.0003	0.0003	0.0005	0.0002	0.0021	0.0002
PCB 049/69	-	0.0002	0.0002	0.0001	0.0001	0.0001	0.0002	0.0001	0.0010	0.0001
PCB 052	0.000003	0.0007	0.0009	0.0003	0.0004	0.0003	0.0009	0.0003	0.0030	0.0005
PCB 056	-	0.0003	0.0004	0.0002	0.0002	0.0003	0.0003	0.0001	0.0010	0.0001
PCB 060	-	0.0002	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0005	0.0001
PCB 061/70/74/76	0.000002	0.0012	0.0015	0.0007	0.0008	0.0009	0.0013	0.0004	0.0046	0.0008
PCB 066	-	0.0006	0.0006	0.0004	0.0004	0.0005	0.0006	0.0002	0.0018	0.0002
PCB 083/99	-	0.0008	0.0016	0.0004	0.0006	0.0005	0.0017	0.0006	0.0031	0.0007
PCB 086/87/97/109/119/125	-	0.0016	0.0032	0.0008	0.0012	0.0009	0.0031	0.0011	0.0053	0.0012
PCB 090/101/113	0.000004	0.0019	0.0040	0.0009	0.0035	0.0020	0.0065	0.0022	0.0065	0.0016
PCB 095	0.000003	0.0013	0.0028	0.0006	0.0024	0.0012	0.0042	0.0015	0.0048	0.0011
PCB 105	-	0.0017	0.0028	0.0007	0.0007	0.0008	0.0023	0.0007	0.0035	0.0009
PCB 110/115	0.000003	0.0025	0.0049	0.0012	0.0024	0.0017	0.0061	0.0021	0.0078	0.0019
PCB 118	0.000002	0.0033	0.0060	0.0014	0.0020	0.0017	0.0058	0.0018	0.0079	0.0019
PCB 128/166	-	0.0008	0.0017	0.0004	0.0010	0.0007	0.0025	0.0009	0.0016	0.0005
PCB 129/138/163	0.00001	0.0045	0.0090	0.0022	0.0126	0.0080	0.0270	0.0101	0.0106	0.0033
PCB 132	0.000003	0.0014	0.0031	0.0006	0.0036	0.0022	0.0074	0.0027	0.0035	0.0010
PCB 135/151	-	0.0011	0.0019	0.0005	0.0057	0.0031	0.0092	0.0036	0.0030	0.0008
PCB 141	-	0.0009	0.0017	0.0005	0.0041	0.0025	0.0069	0.0026	0.0021	0.0007
PCB 147/149	0.000005	0.0027	0.0055	0.0013	0.0115	0.0067	0.0204	0.0076	0.0072	0.0021
PCB 153/168	0.00001	0.0032	0.0059	0.0016	0.0131	0.0078	0.0233	0.0089	0.0078	0.0024
PCB 156/157	-	0.0009	0.0018	0.0004	0.0012	0.0008	0.0027	0.0009	0.0012	0.0005
PCB 158	-	0.0005	0.0010	0.0003	0.0013	0.0008	0.0026	0.0010	0.0012	0.0004
PCB 170	-	0.0016	0.0024	0.0010	0.0079	0.0053	0.0134	0.0044	0.0026	0.0015
PCB 174	0.000003	0.0014	0.0021	0.0008	0.0082	0.0052	0.0141	0.0046	0.0031	0.0017
PCB 177	-	0.0008	0.0013	0.0005	0.0048	0.0031	0.0081	0.0027	0.0017	0.0009
PCB 180/193	0.00001	0.0029	0.0042	0.0020	0.0175	0.0112	0.0279	0.0089	0.0062	0.0034
PCB 183	-	0.0008	0.0012	0.0005	0.0051	0.0033	0.0084	0.0027	0.0018	0.0010
PCB 187	0.000003	0.0015	0.0020	0.0009	0.0093	0.0058	0.0150	0.0054	0.0038	0.0017
PCB 194	-	0.0007	0.0010	0.0006	0.0046	0.0031	0.0073	0.0025	0.0021	0.0012
PCB 195	-	0.0003	0.0003	0.0002	0.0018	0.0012	0.0030	0.0010	0.0008	0.0004
PCB 201	-	0.0001	0.0001	0.0001	0.0006	0.0004	0.0008	0.0003	0.0003	0.0001
PCB 203	-	0.0006	0.0009	0.0003	0.0028	0.0019	0.0045	0.0015	0.0014	0.0007
Total PCBs (mg/Kg dw)	**0.00006**	**0.0441**	**0.0777**	**0.0236**	**0.1320**	**0.0850**	**0.2390**	**0.0836**	**0.1220**	**0.0357**

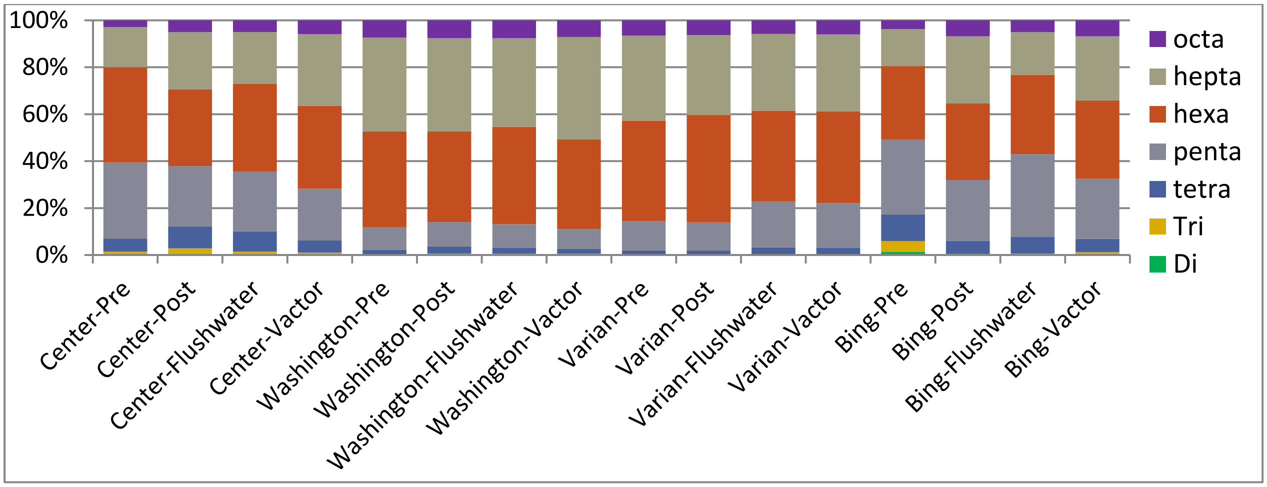

Figure 3. PCBs homolog profiles for street dirt and flush water samples collected before, during and after each street flush and capture event.

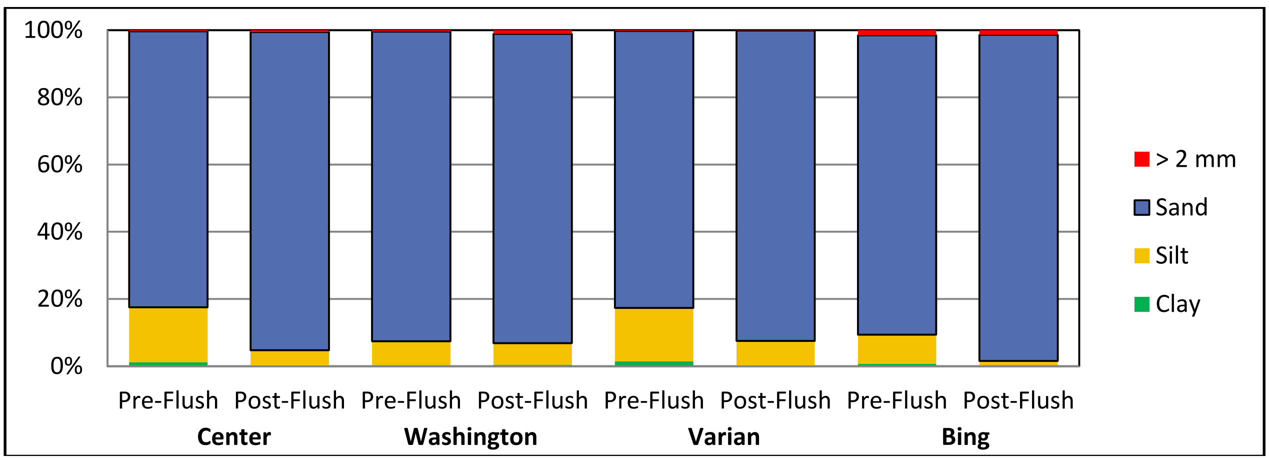

Figure 4. Grain size distribution of street dirt samples collected before and after each street flush and capture event.

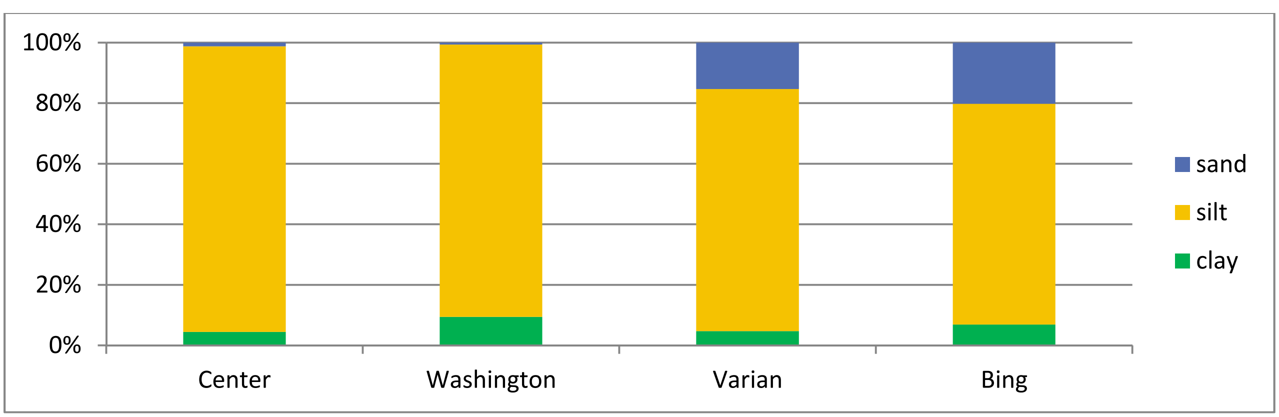

Figure 5. Grain size distribution in flush water collected during street flush and capture events.

4.0 DISCUSSION AND SUMMARY

The PCPS watershed, located in the City of San Carlos, is one of five drainages in the Bay Area with old industrial land uses and elevated PCBs concentrations in street dirt and MS4 sediment samples that was selected for pilot testing the effectiveness of controls for PCBs and mercury in stormwater runoff. The pilot projects were implemented through the regional CW4CB project. CW4CB was funded by a grant from EPA to BASMAA and matching funds from Bay Area countywide stormwater management programs, including SMCWPPP, which provided in-kind matching funds for the CW4CB projects conducted in San Mateo County.

The overall objective of this study was to determine the benefits of a pilot street flush and capture project in terms of the mass of sediment-bound mercury and PCBs removed and the associated costs. In addition, the data collected and lessons learned may be used to inform planning of future control measure implementation, including the design of enhancements to O&M activities that increase pollutant removal.

A detailed study design and monitoring plan for this pilot project (BASMAA 2013a) is available on the CW4CB website (basmaa.org/CW4CB-Project_Reports). Four street segments in the southern part of the PCPS watershed were selected for flushing and capture. Following the study design, the project team and City of San Carlos staff completed a total of four street flush and capture events in September 2013. Each flush event covered the complete width of the street (i.e., curb to curb) and the segments flushed varied in length from 500 to 550 feet. Two City of San Carlos Vactor trucks and four municipal maintenance staff were used for each flush event. The first Vactor truck was the water source and a wand attachment on the truck was used to flush the streets at a rate of 15 gallons/minute. The storm drain inlets in the study area were blocked during flushing to prevent the flush water from returning to the storm drain system. The second Vactor truck used its vacuum to capture the debris and wash water from the gutters in its truck-mounted tank.

To evaluate the potential impact of street sweeping on the flushing effectiveness, routine weekly street sweeping was continued throughout the study on two of the street segments. Street sweeping was discontinued at the other two segments about three months before the flushing events. On the two streets where sweeping was continued, one flush event occurred immediately after a weekly sweeping event, to minimize the time between sweeping and flushing, and the other flush event occurred just before a sweeping event, to maximize the time between sweeping and flushing.

Two monitoring methods were applied during the pilot study:

1. Direct measurement of mass of pollutants in the flush wastewater.
2. Evaluation of street dirt loading by comparison of pollutant mass on the street before and after flushing.

The direct measurement method entailed collection of a sample of the flush wastewater from the curb prior to removal by the Vactor truck. During each flush event, four aliquots of the flush wastewater were collected over the course of the event and composited prior to analysis. The street dirt loading comparison method entailed vacuum collection of surface street dirt from randomly selected strips of the street both before and after flushing. The length of each strip covered the entire width of the street from curb-to-curb, while the width of each strip was equivalent to the six inch width of the vacuum head. Ten randomly selected strips were vacuumed and composited immediately before the flush event, to quantify the pre-flush mass of street dirt and associated pollutants. After flushing was completed, as soon as the street was dry another ten randomly selected strips were vacuumed and composited to quantify the post-flush mass of street dirt and associated pollutants.

All flush wastewater and street dirt samples collected were analyzed for PCBs, mercury, total organic carbon (TOC), total solids, bulk density (sediment only) and grain size, following the methods and procedures described in the CW4CB QAPP (BASMAA 2012) and CW4CB Task 4 SAP (BASMAA 2013b). Flush wastewater concentrations ranged from 251 to 1,360 ng/L (total PCBs) and 343 to 3,120 ng/L (mercury). Total PCBs in pre-flush and post-flush street dirt samples ranged from 0.08 to 0.24 and 0.02 to 0.09 mg/kg, respectively. Mercury concentrations in pre-flush and post-flush street dirt samples ranged from 0.08 to 0.82 and 0.02 to 0.47 mg/kg, respectively. PCBs homolog profiles were similar across all samples, and were especially similar for all samples collected on a given street. The grain size distribution results for the pre- and post-flush street dirt suggested that smaller particles (silt/clay) were preferentially removed during the flush event. The monitoring results were used to evaluate the mercury and PCB load reduction effectiveness of this pilot project, as documented separately in the CW4CB final project report (basmaa.org/Clean-Watersheds-for-a-Clean-Bay-Project/CW4CB-Overall-Project-Report).

The approximate total cost to implement the street flush and capture pilot project, from planning through reporting, was $152,000. It is important to note that this cost was site-specific for this pilot project and may not be relevant to other locations or settings. Because street flush and capture is not currently included as a routine practice in Bay Area municipalities, the primary challenge in implementing this pilot project was that municipal staff had no experience conducting this type of activity. Additional challenges encountered included locating appropriate sites where this type of activity could be conducted while minimizing disturbances to parking, traffic flow, and business activities, and to address wastewater disposal issues, which required the project to obtain a permit from the local sanitary sewer and comply with permit requirements for wastewater quality testing. The major lesson learned through this project was a better understanding of the level of effort and logistical considerations that will need to be factored into planning for street flush and capture. Implementation of this pilot project provided important knowledge and experience on how Bay Area municipalities can implement street flush and capture using equipment and staff that are typically available. Further information, including comparisons of cost-effectiveness among the various controls pilot tested during the CW4CB project, is available in the final project report (basmaa.org/Clean-Watersheds-for-a-Clean-Bay-Project/CW4CB-Overall-Project-Report).

5.0 REFERENCES

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