Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Investigative Monitoring Project

Potential Sources and Causes of Toxicity in Stevens Creek, Santa Clara County, California

September 15, 2009

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EXECUTIVE SUMMARY

The San Francisco Bay Regional Water Quality Control Board's (Water Board) Surface Water Ambient Monitoring Program (SWAMP) and the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) have conducted water and sediment bioassays (i.e., toxicity tests) at numerous sites in San Francisco Bay area urban creeks over the last eight years. Results indicate that sediment toxicity is present at a number of sites, while water toxicity is less prevalent. Due to the aquatic toxicity observed by SWAMP (FY 02-03), the steelhead population present, and the resulting listing on the 303(d) list, the Program developed a study designed to evaluate the extent, magnitude, and cause(s) of aquatic toxicity observed in Stevens Creek. During FY 07-08, the SCVURPPP initiated an investigative monitoring study to identify potential sources and causes of toxicity in Stevens Creek watershed.

The Program collected sediment samples at three sites on January 21, which was subsequently analyzed for chemistry (i.e., pyrethroids and metals) and toxicity, and at seven sites on May 20 that were analyzed for pyrethroid pesticides. Sampling sites were located downstream of major storm drain outfalls that discharge to the study area. Two water samples were also collected at Stevens Creek Blvd on May 11, one sample from an outfall discharge on west side of culvert, and second sample from receiving water about 10 feet downstream of outfall.

Total recoverable metal concentrations were below corresponding threshold effect levels (SQQs < 1.0), with the exception of nickel. In contrast to metals, pyrethroid pesticides were observed at detectable levels at 8 of 10 sites sampled either in January or May 2009. Specific pesticides detected during the study include bifenthrin, cyflurin, cypermethrin, esfenvalerate and permithrin. During the first sampling event, bifenthrin concentrations were highest at site STE063, which was also the site where 100% mortality was observed. The combination of 100% mortality of test organisms and the high concentration of bifenthrin (85 ng/g) in sediment collected at site STE063 suggested that pyrethroid pesticides were likely the contaminant causing the observed toxicity.

Further chemical analysis of sediment collected at seven sites upstream of STE063 indicate that five pyrethroid pesticides (including bifenthrin) were present at concentrations that one would expect to observe some degree of toxic response. This information provides strong support to the conclusion that pyrethroid pesticides are causing toxicity in bedded sediments in this reach of Stevens Creek.

The longitudinal pattern of SQQ values observed in May 2009 suggests that sources of pyrethroid pesticides reaching Stevens Creek are present within the watershed area draining to the two stormwater outfalls directly upstream of site STE066. Based on reconnaissance, it appears that this watershed area is primarily comprised of single-family residential land uses. Based on the results from this study, recommended actions include conducting enhanced public outreach and education to residents and landscape maintenance staff in the watershed area in an effort to reduce the potential impacts of pyrethroid pesticides on Stevens Creek water quality and beneficial uses.

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1.0 INTRODUCTION

Episodic aquatic and sediment toxicity has been observed in a variety of urban creeks in California (Water Board 2005a) and the San Francisco Bay area (Water Board 2007) over the last decade. In the mid-1990's, aquatic toxicity attributable to the organophosphate pesticide diazinon was observed in many Bay area urban creeks, including those monitored in the Santa Clara Basin (Water Board 2005b). Monitoring data from Bay area studies provided cause for listing all Bay area urban creeks on the Federal Clean Water Act's 303(d) list of water quality limited water bodies (303(d) List), which spawned the adoption of the Water Quality Attainment Strategy (WQAS) for pesticide-related toxicity in 2005.[1] With the phase-out of most urban uses of diazinon by the U.S. EPA in 2001, however, aquatic toxicity observed in urban creeks decreased dramatically in the Bay area (Ruby 2005, SCVURPPP 2007a). Sediment toxicity likely due to the change in active ingredients in pesticides used in urban areas (i.e., pyrethroids) began appearing in urban creeks throughout California in roughly the same timeframe as the diazinon phase-out (Weston 2004).

With regard to Santa Clara Basin creeks and rivers, the San Francisco Bay Regional Water Quality Control Board's (Water Board) Surface Water Ambient Monitoring Program (SWAMP) and the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) have conducted water and sediment bioassays (i.e., toxicity tests) at numerous sites in San Francisco Bay area urban creeks over the last eight years. Results indicate that sediment toxicity is present at a number of sites, while water toxicity is less prevalent (SCVURPPP 2007a, 2007b). Due to the aquatic toxicity observed by SWAMP (FY 02-03), the steelhead population present, and the resulting listing on the 303(d) list, the Program developed a study designed to evaluate the extent, magnitude, and cause(s) of aquatic toxicity observed in Stevens Creek.

During FY 07-08, the SCVURPPP initiated an investigative monitoring study to identify potential sources and causes of toxicity in Stevens Creek watershed. This report summarizes the results from the second year of toxicity source identification studies conducted in Stevens Creek.

1.1 BACKGROUND

1.1.1 Previous SCVURPPP Monitoring Activities

In response to the monitoring requirements in the current municipal stormwater NDPES permit issued to participants of the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)[2] in 2001, the SCVURPPP developed a Multi-Year Receiving Waters Monitoring Plan (Multi-Year Plan). The Multi-Year Plan presents a monitoring and assessment approach that includes the collection of environmental indicators that can be categorized into two tiers; screening-level monitoring and assessments (i.e. Tier I) and investigative monitoring (i.e., Tier II) (SCVURPPP 2004).

Screening level monitoring and assessments include more general measurements made at various sampling locations, providing an initial characterization of the physical, chemical, and biological integrity of a particular water body. Screening level monitoring is

[1] The WQAS includes a Total Maximum Daily Load (TMDL) for pesticide-related toxicity in urban creeks.

[2] The Santa Clara Valley Urban Runoff Pollution Prevention SCVURPPP is comprised of Santa Clara County, thirteen municipalities and the Santa Clara Valley Water District (i.e., Co-permittees).

conducted in each watershed identified in the Multi-Year Plan for one to two fiscal years (FY) on a rotating watershed basis. To-date, the SCVURPPP had conducted screening level monitoring in 12 of the 13 watersheds within the Program's boundaries[3]. SCVURPPP (2007a) provides a summary of data collected during the first five years (FY 02-03 to FY 06-07) of the Multi-Year Plan.

Investigative monitoring or studies conducted by SCVURPPP include more detailed measurements typically taken in a more defined area (e.g., stream reach). Investigative monitoring is intended to address specific questions of impairment, such as:

- *What are the causes and sources of sediment toxicity observed in Stevens Creek?*

In FYs 05-06 and 06-07, the SCVURPPP collected and analyzed water quality samples from sites on Stevens Creek, to further assess the condition of beneficial uses (i.e., aquatic life and recreational) and possible exceedances of water quality objectives. Results from these two years of monitoring found chronic toxicity at two locations (STE020 and STE060). Water chemistry results, however, indicated no detectable concentrations of organophosphate pesticides or exceedences of metal concentrations in any of the samples (SCVURPPP 2007a).

During FY 07-08, the Program conducted toxicity testing for both water and sediment collected at three locations during 4 sampling events (i.e., dry, wet (x2) and spring season). Unlike the results of SWAMP (Water Board 2007a), neither acute nor chronic toxicity was observed in water during this study. Significant acute toxicity in sediment, however, was observed at all sites sampled in Stevens Creek during at least one sampling event (Figure 1). Specifically, significant toxicity was observed at one site during the dry season, three sites during the wet season, and one site during the spring season. For all sites sampled, the greatest degree of sediment toxicity was observed during the sampling event that followed the largest rainfall event of the wet weather season (January 15, 2008). Amphipods (*H. azteca*) exposed to sediments collected during this sampling event exhibited nearly complete mortality (i.e., 0 to 7% survival compared to control) at all three sites.

[3]SCVURPPP did not conduct monitoring in San Francisquito Creek watershed due to extensive monitoring efforts being conducted by other agencies and stakeholder groups.

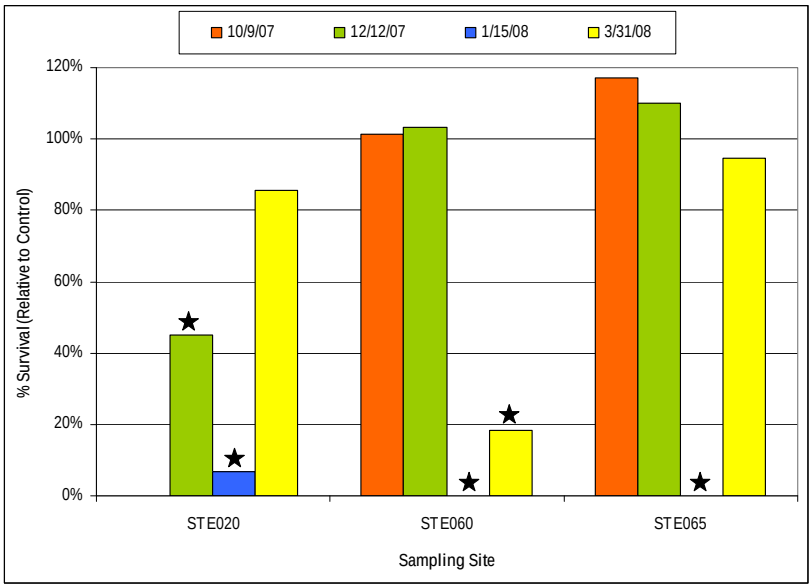

Figure 1. *Hyalella azteca* 10-day survival bioassay results (tars indicate significantly reduced survival compared to laboratory control).

1.1.2 Citizen Monitoring Activities

The Stevens & Permanente Creeks Watershed Council (SPCWC), formed in August of 2003, is a collection of community residents, city representatives, agency officials, scientists, environmental advocates, and other interested stakeholders with a common vision for a better watershed (SPCWC 2009). The mission of the SPCWC is "*to engage the community in wise stewardship of our watershed, furthering the protection, restoration, and community appreciation of creeks and associated habitats. This will be accomplished through collaboration and consensus in a manner that is sensitive to the needs of the entire community*."

The SPCWC initiated its Volunteer Monitoring and Outreach Program (VMOP) to guide water quality monitoring activities in Stevens and Permanente Creek watersheds. Since 2003, the VMOP has conducted monthly water quality testing (i.e., water temperature, dissolved oxygen, pH, conductivity and turbidity) at selected locations in Stevens Creek. In 2008, the VMOP initiated a special study to conduct aquatic toxicity testing in Stevens Creek. The toxicity testing method being used is called Qwiklite™, developed by Assure Controls[4]. This method employs sensitive bioluminescent plankton to indicate the presence and level of toxicity in water. The method measures the bioluminescence of dinoflagellates exposed to a sample, with the level of bioluminescence being inversely related to the amount of toxicity in the sample.

Water toxicity results from 11 sampling events conducted by SPCWC at 11 monitoring sites between December 7, 2008 to May 27, 2009 is shown in Figure 2. A total of 10 of the 29 water samples resulted in less than 50% survival compared to the control. A complete summary of sampling locations and water and sediment toxicity results for SCVURPPP and SPCWC from 2007 through 2009 is included in Appendix A.

[4] This method has not been approved by the USEPA and there is currently limited information on the comparison between this and USPEA approved methods used by SCVURPPP.

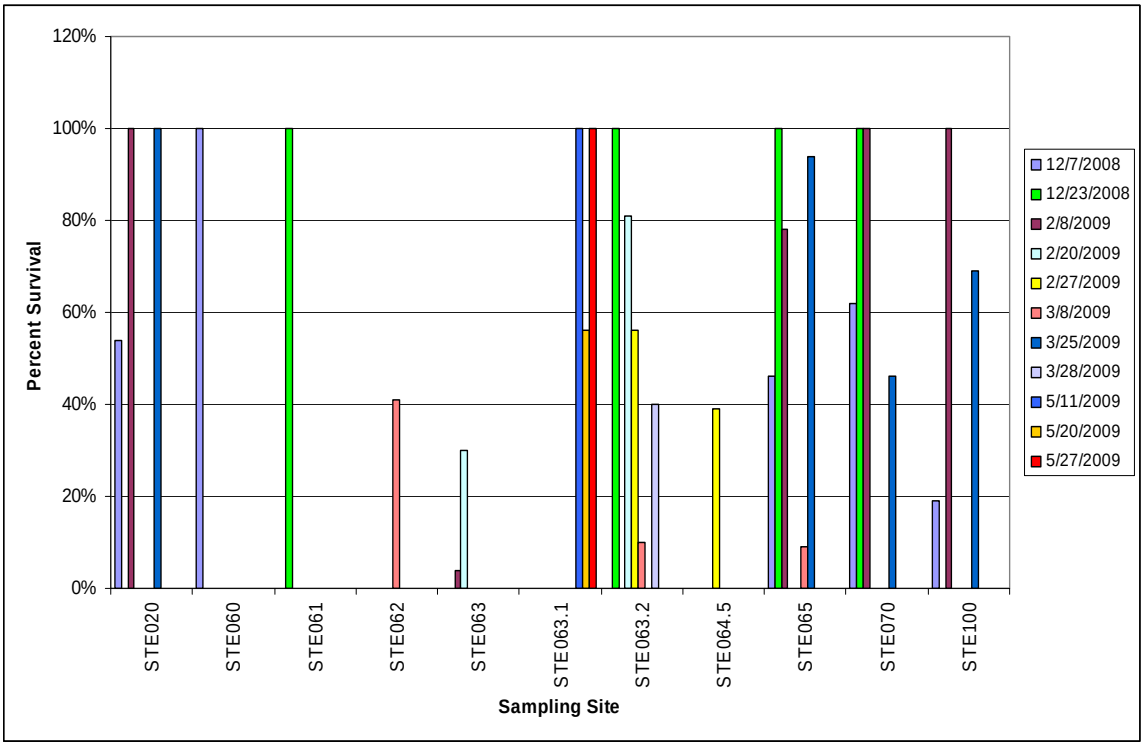

Figure 2. Aquatic toxicity measured using the Qwiklite™ bioluminescence method in 29 water samples collected at 11 sites by SPCWC from December 2008 to May 2009.

2.0 SAMPLING DESIGN AND METHODS

2.1 MONITORING DESIGN

The Program implemented an adaptive monitoring approach to further investigate potential sources and causes of sediment toxicity in Stevens Creek (Figure 3). The sampling design included an initial evaluation of sediment chemistry and toxicity testing during the wet season. If results from the sediment chemistry analyses indicated high concentrations of metals or pyrethroid pesticides AND low survival during toxicity testing (< 50% relative to control), then the next step would be to conduct additional sediment chemistry analyses at a greater number of sites to evaluate potential sources of contaminant(s).

If initial sediment chemistry analyses did not result in high concentration of contaminant, but sediment sample exhibited significant toxicity when compared to control, the next step would involve conducting a Toxic Evaluation (TIE) to evaluate potential causes of toxicity. If samples did not exhibit significant toxicity, a second monitoring event evaluating sediment chemistry and toxicity would be conducted, followed by TIE for samples exhibiting significant toxicity. The project allowed up to two TIEs.

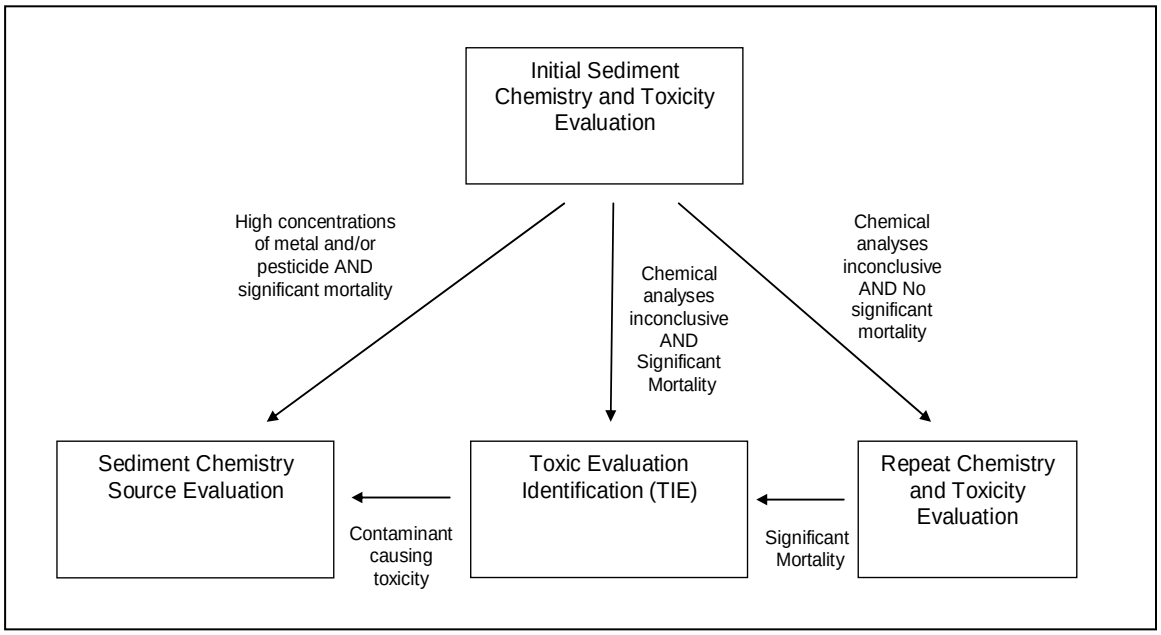

Figure 3. Monitoring approach used to investigate potential causes and sources of sediment toxicity in Stevens Creek.

2.2 TOXIC IDENTIFICATION EVALUATION (TIE) PROCESS

Previous studies suggested pyrethroid pesticide contamination is present in freshwater systems in California, including in the Central Valley (Weston et al. 2004), the Central Coast (Anderson et al. 2006, Hunt et al. 2006) and in the San Francisco Bay area (Lowe et al 2006). Some of these studies have indicated pyrethroid pesticides are a source of sediment toxicity to amphipods (Weston 2004, Water Board 2005a).

To better understand potential causes of sediment toxicity in Steven Creek watershed, the Program included a Toxic Identification Evaluation (TIE) step in its monitoring approach during FY 08-09. TIEs are a series of treatments typically applied in three phases designed to identify specific chemicals causing toxicity (Anderson 2009). Phase I manipulations characterize the classes of chemicals causing toxicity and typically differentiate between toxicity caused by organic chemicals, metals, or ammonia. Phase II TIE manipulations identify the individual chemicals causing toxicity, and Phase III TIEs are designed to confirm the Phase II chemical identification.

The Program adopted Phase I TIE methods that have been previously used to evaluate toxicity caused by pyrethroid pesticides in other freshwater drainages (Anderson 2009). The TIE method follows two tracks: 1) identification of toxicants in sediment interstitial water, and 2) identification of toxicants in solid-phase sediment. The TIE process selected is illustrated in Appendix B.

2.3 Study Area and Sampling Sites

Monitoring activities were focused on an approximately 2-mile reach of Stevens Creek between Stevens Creek Blvd (STE065) and USGS Gauging station in Lower Stevens Creek County Park (STE070) (Figure 4). Adjacent land uses in this reach include two golf courses (Blackberry Farm and Deep Cliffs), an urban park (Blackberry Farm), agricultural areas (Stocklmeir orchard), undeveloped forest and rangeland (McClellan Ranch and Lower Stevens County Park), and high density residential areas. There are 13 storm drain outfalls within this reach that drain residential areas from City of Cupertino.

The Program collected sediment samples at three sites on January 21, which were subsequently analyzed for chemistry (i.e., pyrethroids and metals) and toxicity, and at seven sites on May 20 that were analyzed for pyrethroid pesticides. Sampling sites were located downstream of major storm drain outfalls that discharge to the study area. Two water samples were collected at site STE063.1 on May 11, one sample from an outfall discharge on west side of culvert, and second sample from receiving water about 10 feet downstream of outfall. Sample locations are summarized in Table 1 and shown in Figure 4.

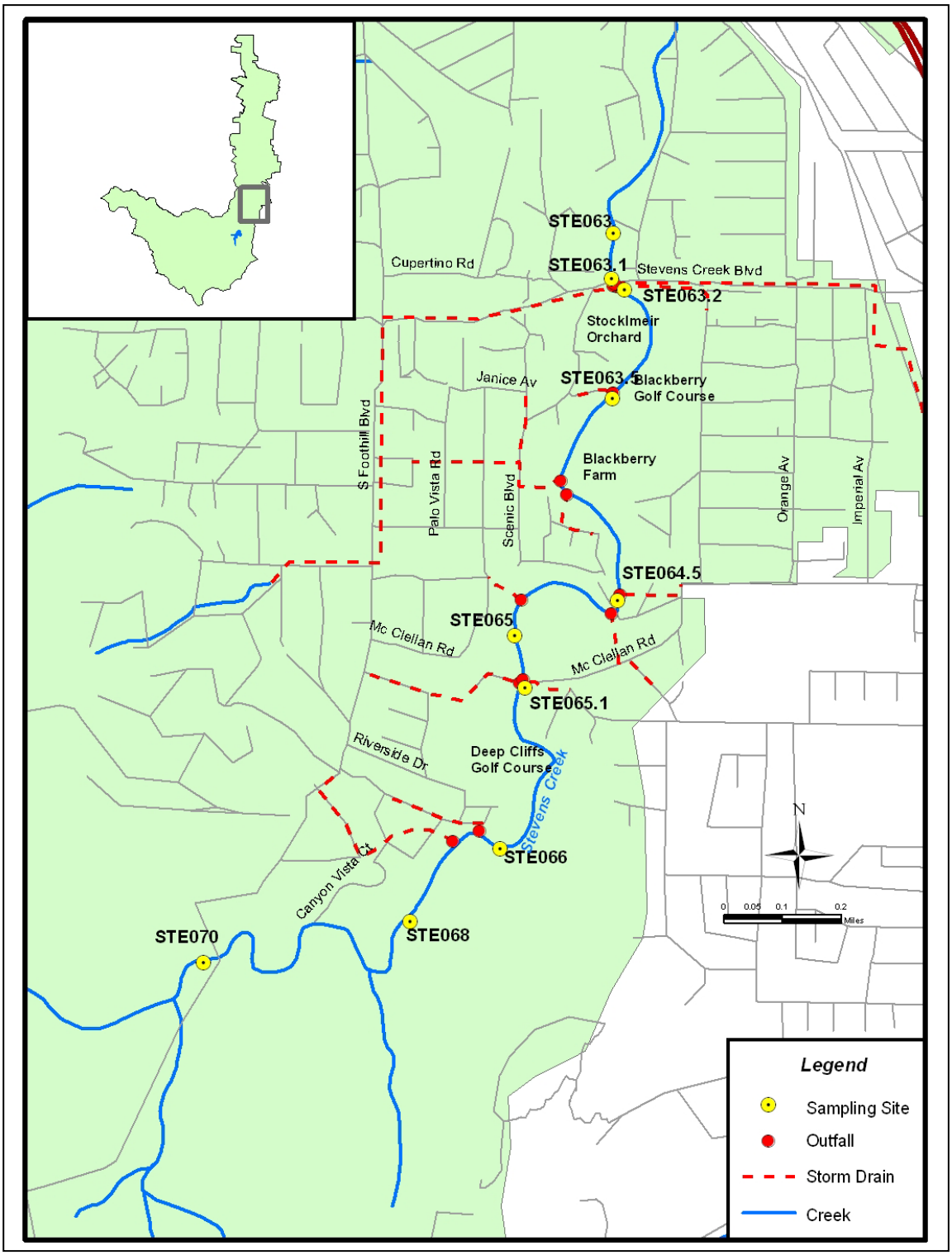

Figure 4. SCVURPPP sediment sampling locations in FY 08-09.

Table 1. Sampling sites and parameters sampled in Stevens Creek during FY 08-09.				
Site	Site Description	Sample Event		
		1/21/09	5/11/09	5/20/09
STE063	Downstream Stevens Creek Blvd	SQ, ST		SQ
STE063.1	At Stevens Creek Blvd Bridge (below outfall)		WQ	SQ
STE063.2	Upstream Stevens Creek Blvd Bridge (upstream of outfalls)			SQ
STE063.5	Downstream edge of Blackberry Farm			SQ
STE064.5	Upstream edge of Blackberry Farm			SQ
STE065	Stevens Cr at McClellan Ranch	SQ, ST		SQ
STE065.1	At McClellan Rd (below outfall)			SQ
STE066	Deep Cliff Golf Course (below outfall)			SQ
STE068	Deep Cliff Golf Course (above outfall)			SQ
STE070	Stevens Cr at Chestnut Picnic Area	SQ, ST		SQ
SQ = Sediment Quality; ST = Sediment Toxicity; WQ = Water Quality				

The January sampling event was preceded by a couple of small storm events, including a 2.0" rainfall event on November 1st, 2008 and about 3.0 inches of rain over two week period during December 2008 (Figure 5). A series of large storms occurred in February and March, including a 5.0" rainfall event on February 15th. Spring precipitation resulted in nearly full capacity of Stevens Creek Reservoir and high stream flows persisted until early May, when dam releases were reduced from 10 to 3.5 cfs. The May sampling events occurred during the reduction in stream flow that allowed safe access to stream for sediment and water collection.

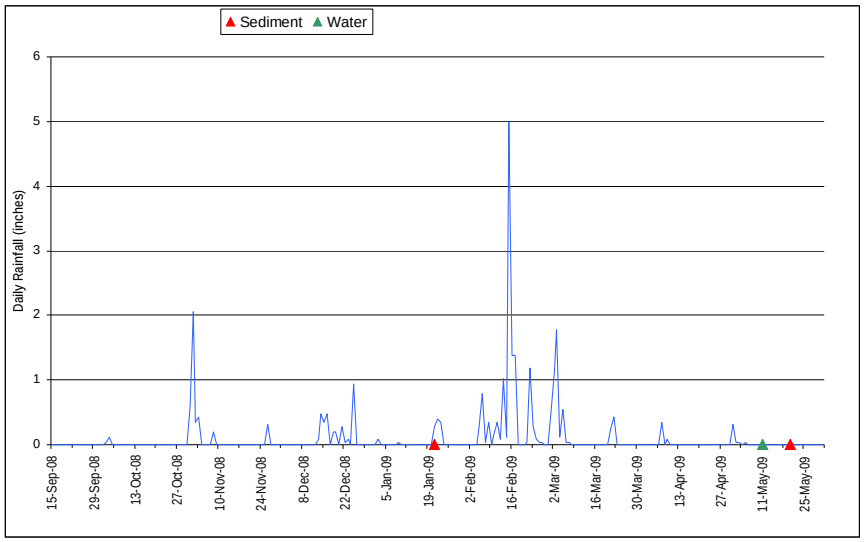

Figure 5. Daily rainfall in the Stevens Creek watershed (SCVWD Station #1510-Stevens Creek RF100) during the study and timing of sampling events.

2.4 BEDDED SEDIMENT QUALITY

Sediment samples were collected from three sites in January 2009 and seven sites in May 2009 (Table 1 and Figure 2). Approximately seven liters of fine grained sediment was collected from each site during the January sampling event to provide enough sediment to perform sediment chemistry analyses, toxicity testing and TIEs. The sediment for TIEs was stored until chemistry and toxicity results were available to determine next steps. During the May 20th sampling event, about 1.0 liter of sediment was collected at each site to perform analyses of pyrethroid pesticides (i.e., toxicity and TIEs were not planned for this event).

At each site, sediment samples were preferentially collected in areas with fine sediment deposition. Sediment samples were collected with a Tefzel-coated stainless spoon, lifted slowly through overlying water and placed into a Tefzel-coated steel pan. Samples were pooled at each site, homogenized, placed in sample containers.

Bedded sediment collected at sediment sampling sites was analyzed for total recoverable metals (January event only) and a suite of pyrethroid pesticides (both events). Additionally, each sample was analyzed for total organic carbon (TOC), grain size, and piperonyl butoxide (PBO) - a pesticide synergist that increases the potency of pyrethroid pesticides. Analytical methods, reporting limits and holding times for each analyte are provided in Appendix C.

To assess sediment quality, total recoverable metal concentrations in bedded sediment were compared to ecotoxicological effects-based thresholds for freshwater ecosystems developed by MacDonald et al. (2000). Thresholds include Probable Effect Concentrations (PECs), which represent concentrations above which one would expect to observe some degree of toxic response; and, Threshold Effect Concentrations (TECs), which represent concentrations below which one would not expect to observe toxic responses (Table 2). For pyrethroid pesticides, PEC and TEC guidelines have not been developed. However, LC50s[5] have been published for seven pyrethroids (Maund et al 2002, Amweg et al 2006) and were used in the absence of PEC/TEC guidelines to assess sediment contamination (Table 2).

To compare the measured concentrations of metals and pyrethriod pesticides to effects-based thresholds (i.e., PECs and LC50s), sediment quality quotients (SQQs) were developed. For metals, SQOs were developed by dividing the observed concentration of into the associated PEC. For pyrethroids, the observed concentration was divided into its associated LC50. Therefore, an SQQ that is >1.0 is above a published effects threshold.

[7] Concentrations lethal to 50% of organisms exposed.

Table 2. Probable and threshold effects concentrations for total recoverable metals in freshwater sediments (MacDonald et al 2000) and LC50s for pyrethroids (Maund et al 2002, Amweg et al 2006).			
Chemical	Probable Effects Concentration (PEC)	Threshold Effects Concentration (TEC)	LC50s (Normalized to TOC)
Total Metals (mg/kg)			
Arsenic	33	9.79	-
Cadmium	4.98	0.99	-
Chromium	111	43.4	-
Copper	149	31.6	-
Lead	128	35.8	-
Mercury	1.06	0.18	-
Nickel	48.6	22.7	-
Zinc	459	121	-
Pyrethroid Pesticides (ug/kg)			
Bifenthrin	-	-	520
Cyflurin	-	-	1,080
Cypermethrin	-	-	380
Deltamethrin	-	-	790
Esfenvalerate	-	-	1,540
L-Cyhalothrin	-	-	450
Permethrin	-	-	10,830

2.5 SEDIMENT TOXICITY

The toxicity of samples collected at three sites (STE063, STE063, and STE070) on January 21st was evaluated by exposing the amphipod *Hyalella azteca* to sediment in a standard ten-day survival test. This test uses eight replicates per site, with ten amphipods per replicate. The tests were conducted at 15 °C water temperature[6]. Analytical methods, reporting limits and maximum holding times for each analysis conducted are included in Appendix C.

2.6 TOXIC IDENTIFICATION EVALUATION (TIE)

A TIE was planned when significant mortality occurred during toxicity testing AND metal and/or pesticide concentrations in sediment were not present at levels known to cause a toxic response. Sediment collected and stored during the initial sampling event would be used for TIE treatments, if needed. Treatments would involve identification of contaminants in both interstitial water (i.e., pore water) and solid phase sediment. TIE process flow chart is shown in Appendix B. Analytical methods, reporting limits and maximum holding times for each analysis conducted are included in Appendix C.

2.7 WATER QUALITY

In addition to sediment, two water samples were also collected at site STE063.1 and from the stormwater outfall draining directly to this site under the Stevens Creek Blvd Bridge. Water samples were analyzed for pyrethroid pesticides to assist the SPCWC in determining potential causes of toxicity observed in water samples taken from the

[6] Although standard toxicity methods recommend that test organisms are exposed to water with higher temperatures (i.e., 20 °C), 15 °C was selected because this temperature more closely reflects actual temperatures in Santa Clara Valley Creeks.

Stevens Creek Blvd. outfall using the Qwiklite™ method. Analytical methods, reporting limits and maximum holding times for pyrethroid pesticide analyses are included in Appendix C.

2.8 DATA QUALITY ASSESSMENT

Quality Assurance/Quality Control (QA/QC) activities associated with the field data collection and laboratory analyses are described in more detail in the SCVURPPP Draft Quality Assurance Project Plan (QAPP). The major goal for these QA/QC procedures is to have representative, comparable, accurate and precise data, to the extent possible under the given limitations. QA/QC activities associated with water quality field sampling and laboratory analysis included the following:

- Employing analytical chemists trained in the procedures to be followed;
- Adherence to documented procedures, USEPA methods and written SOPs;
- Calibration of analytical instruments;
- Use of quality control samples, internal standards, surrogates, and SRMs
- Complete documentation of sample tracking and analysis.

Data validation was performed in accordance with the National Functional Guidelines for Organic Data Review (EPA540/R-99/008) and Inorganic Data Review (EPA540/R-01/008). For bioassays to meet basic quality control requirements, the lab control had to achieve a mean survival of 80%. Tests for reduced survival compared to a lab control were done using Dunnett's one-way Analysis of Variance (ANOVA) test ($p = 0.05$).

3.0 RESULTS

3.1 SEDIMENT TOXICITY

The magnitude of toxicity observed in bedded sediments is based on the percentage of organisms that survive a bioassay, relative to the percentage of organisms that survive the control. As illustrated in Figure 6, exposure of *Hyalella azteca* to sediments from Stevens Creek collected on January 21, 2009 significantly reduced survival at one of the three sites sampled (STE063).

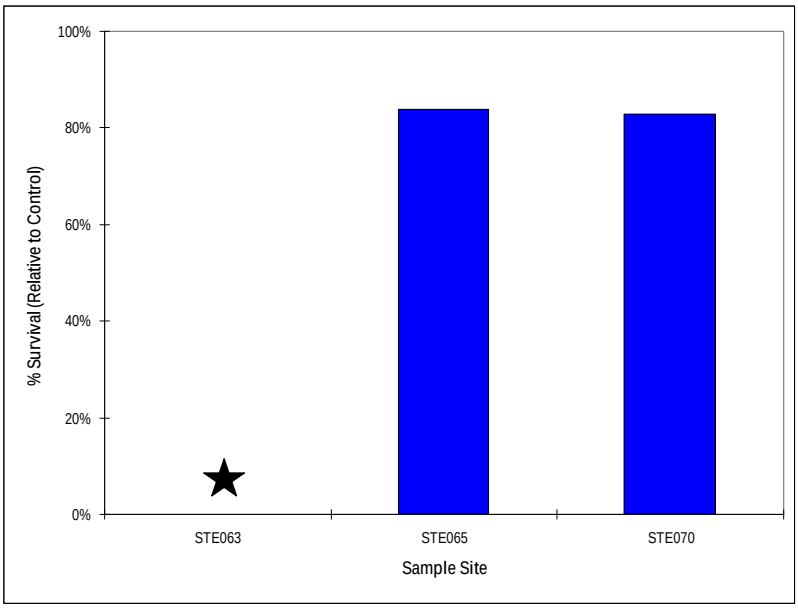

Figure 6. Percent survival of *Hyalella azteca* (10-day test) in bedded sediment collected at three Stevens Creek sites on January 21, 2009 (star indicates significantly reduced survival compared to lab control).

3.2 SEDIMENT QUALITY

Total recoverable metal concentrations observed during the January 2009 sampling event are presented in Table 3. With the exception of nickel, metal concentrations had SQQs <1.0 (i.e., lower than corresponding threshold effect levels). Results for nickel are not surprising, as previous analyses from Santa Clara Valley Basin creek sediments indicate that nickel (and chromium) is consistently above SQQs at sites draining entirely open space land uses (SCVURPPP 2007b).

In contrast to metals, pyrethroid pesticides were observed at detectable levels at 8 of 10 sites sampled either in January or May 2009. Specific pesticides detected during the study include bifenthrin, cyflurin, cypermethrin, esfenvalerate and permithrin. During the first sampling event (January 21st), only bifrenthin was detected (two of three sites). During that sampling event, bifenthrin concentrations were highest at STE063, the site where 100% mortality was observed (see Figure 7). The combination of 100% mortality of test organisms and the high concentration of bifenthrin (85 ng/g) in sediment collected at site STE063 suggested that pyrethroid pesticides were likely the contaminant causing the observed toxicity. As a result, a TIE was determined to not be necessary, and further

monitoring efforts were be made to evaluate potential sources of pyrethroid pesticides upstream of site STE063.

Table 3. Concentration of total recoverable metals (mg/kg) and associated Sediment Quality Quotients (SQQs) in bedded sediments collected in Stevens Creek on January 21, 2009 (numbers in bold represent concentrations above SQQ value).

Metal	STE063		STE065		STE070	
	Measured (mg/kg)	SQQ	Measured (mg/kg)	SQQ	Measured (mg/kg)	SQQ
As	4.0	0.12	3.2	0.10	7.4	0.22
Cd	0.44	0.09	0.22	0.04	0.23	0.05
Cr	73	0.66	72	0.65	110	0.99
Cu	52	0.35	31	0.21	45	0.30
Pb	17	0.13	7.8	0.06	10	0.08
Hg	0.22	0.21	0.12	0.11	0.15	0.14
Ni	76	1.56	65	1.34	95	1.95
Zn	170	0.37	65	0.14	76	0.17

Seven monitoring sites were selected in the reach between sites STE063 and STE070 for further sampling and pyrethroid analyses, which occurred on May 20, 2009. The selection of sites was primarily based on the location of major storm drain outfalls. Results indicated that five pyrethroid pesticides were detected at these seven sites during the May sampling event. Bifenthrin was detected in four of the seven sites sampled. Piperonyl butoxide (PBO) was not detected in sediment samples collected during the study. Pyrethroid concentrations, total organic carbon (TOC) and the percent fine-grained sediment measured during both sampling events are shown in Table 5.

Sediment quality quotient (SQQ) values for pyrethroids are shown in Table 6. Of the 130 results (i.e., detects and non-detects) obtained for pyrethroid pesticides, 21 had detectable concentrations (16.2%) and 16 (12.3%) had a SQQ >1.0. The highest SQQ values were observed at the most downstream site (STE063) during the January 21st event, and at the most upstream site during the May 20th event. In May, SQQ values for bifenthrin, cyflurin, cypermethrin and permithrin increased longitudinally with increasing elevation (Figure 7). The highest concentrations of these four pyrethroids observed during May 20th event occurred at sites STE065.1 and STE066.

Table 4. Concentrations of total organic carbon (TOC), fine sediment (<63um), and pyrethroid pesticides (ng/g) in Stevens Creek bedded sediments collected in 2009.

Site	Date	TOC (%)	Fines (%)	Bifenthrin	Cyfluthrin	Cypermethrin	Esfenvalerate	Permethrin	Allethrin	Danitol	Deltamethrin	Fenvalerate	Fluvalinate	L-Cyhalothrin	Prallethrin	Resmethrin	Piperonyl Butoxide
STE063	21-Jan-09	0.24	25.00	105.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE063.1	20-May-09	0.17	44.40	2.30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE063.2	20-May-09	0.12	46.30	ND	0.60	0.70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE063.5	20-May-09	0.48	65.40	8.60	10.10	9.60	2.90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE064.5	20-May-09	0.18	30.90	3.50	3.40	ND	0.80	5.90	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE065	21-Jan-09	0.08	14.40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE065.1	20-May-09	0.17	25.60	10.20	7.00	7.70	1.90	13.30	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE066	20-May-09	0.08	75.40	ND	10.50	5.60	0.60	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE068	20-May-09	0.06	9.90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE070	21-Jan-09	0.04	33.50	1.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 5. Sediment Quality Quotiens (SQQs) for pyrethroid pesticides (ng/g) in sediment collected at all sites during 2009. Numbers in bold represent concentrations above an LC50 value.

Site	Date	Bifenthrin	Cyfluthrin	Cypermethrin	Esfenvalerate	Permethrin	Allethrin	Danitol	Deltamethrin	Fenvalerate	Fluvalinate	L-Cyhalothrin	Prallethrin	Resmethrin
STE063	21-Jan-09	84.13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE063.1	20-May-09	2.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE063.2	20-May-09	ND	0.46	1.54	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE063.5	20-May-09	3.45	1.95	5.26	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE064.5	20-May-09	3.74	1.75	ND	0.3	7.28	ND	ND	ND	ND	ND	ND	ND	ND
STE065	21-Jan-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE065.1	20-May-09	11.54	3.81	11.92	0.7	17.39	ND	ND	ND	ND	ND	ND	ND	ND
STE066	20-May-09	ND	12.96	19.65	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE068	20-May-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STE070	21-Jan-09	5.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

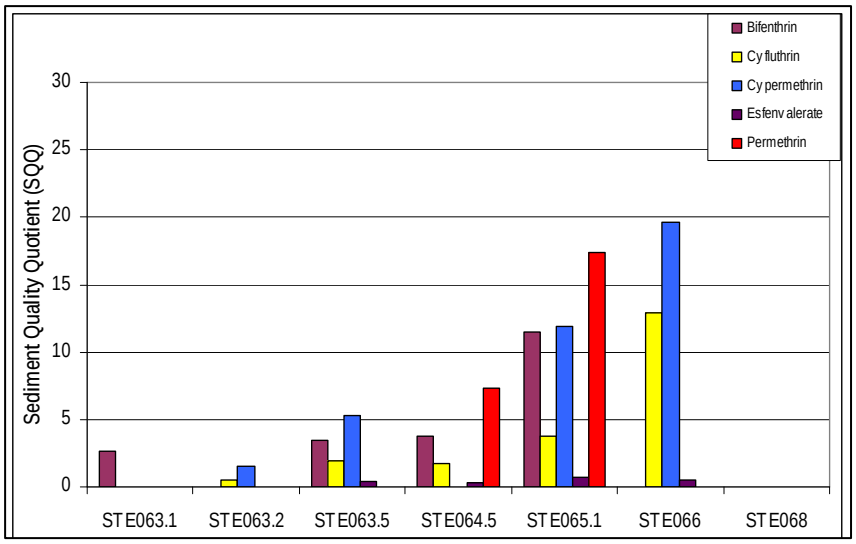

Figure 7. Sediment quality quotients (SQQ) for pyrethroid pesticides observed in bedded sediment collected from Stevens Creek on May 20, 2009.

Total organic carbon (TOC) is associated with materials derived from decaying vegetation, bacterial growth, and metabolic activities of living organisms or chemicals. The percentage of TOC in sediment samples collected in 2009 was relatively low (0.04 to 0.48%) compared to other environmental samples collected in Santa Clara Basin creeks (SCVURPPP 2007a). Furthermore, as illustrated in Figure 8, TOC and percent fines in sediment were not well correlated ($p < 0.05$). Bedded sediment in the fine-grained size class (< 63μm) ranged from 10 to 75%, with the highest percentage at site STE066 (75%) and the lowest at the next upstream site STE068 (10%).

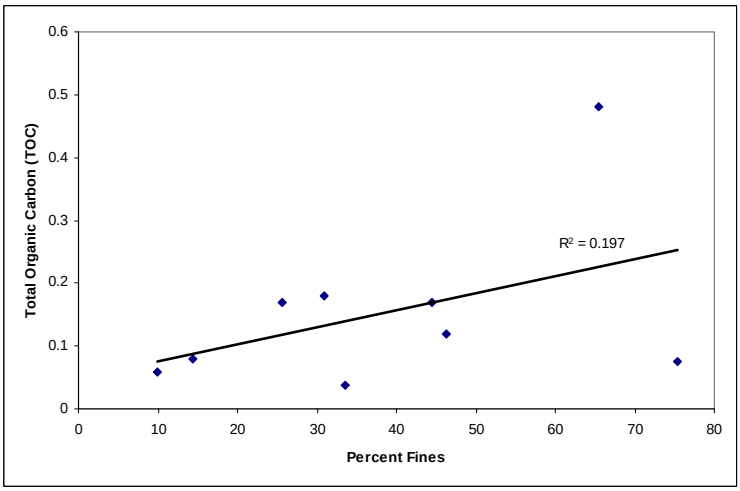

Figure 8. Relationship between Total Organic Carbon and Total % Fines at all sampling events.

3.3 WATER QUALITY

Water samples collected at site STE063.1 and the Stevens Creek Blvd stormwater outfall did not have detectable concentrations of pyrethroid pesticides, with the exception of esfenvalerate and fenvalerate (1.0 and 1.2 ng/L, respectively).

4.0 CONCLUSIONS AND NEXT STEPS

Contaminated sediments or water can adversely affect natural populations of aquatic organisms in urban creeks. Sediment-dwelling organisms may be exposed directly to contaminants by the ingestion of sediments, or by the uptake of sediment-associated contaminants from interstitial and overlying water. Bedded sediments can also serve as a source of contaminates to the overlying water column and possibly adversely affect water column species.

Since SCVURPPP began conducting sediment bioassays in Stevens Creek (i.e., 2007), toxicity has been observed during at least one sampling event at a majority of sites sampled (Table 7). Specific to this investigation, sediment toxicity was observed at site STE063 (directly below Stevens Creek Blvd. Bridge), and sediment chemistry results indicate that the pyrethroid pesticide bifenthrin was the likely cause of the toxicity[7]. Further chemical analysis of sediment collected at seven site upstream of STE063 indicate that five pyrethroid pesticides (including bifenthrin) were present at concentrations that one would expect to observe some degree of toxic response. This information provides strong support to the conclusion that pyrethroid pesticides are causing toxicity in bedded sediments in this reach of Stevens Creek.

Table 6. Number of Stevens Creek bedded sediment samples exhibiting significant acute toxicity to test organism (*Hyalella azteca*) between 2002 and 2009.

Sampling Site	Samples with Significant Toxicity	Total # Samples
STE020	2	3
STE060	2	4
STE063	1	1
STE065	1	5
STE070	0	1
Total	6	14

Pyrethroids are used in many types of urban pesticide applications, but are primarily focused on ant control in and around buildings. Due to the primarily urban residential and commercial land uses within the watershed area draining directly to the reach of Stevens Creek that was investigated during this study, one can imagine that there are a numerous potential applications of pyrethroid pesticides. The degree of these potential applications make source identification studies challenging at best. That said, the longitudinal pattern of SQQ values observed in May 2009 (see Figure 7) suggests that sources of pyrethroid pesticides reaching Stevens Creek are present within the watershed area draining to the two stormwater outfalls directly upstream of site STE066 (see Figure 4). Based on reconnaissance, it appears that this watershed area is primarily comprised of single-family residential land uses.

[7] The bifenthrin concentration, normalized for TOC, was over 85 times greater than the LC50 concentration.

Next steps identified by staff from SCVURPPP, the City of Cupertino and SPCWC include:

- Conducting enhanced public outreach and education to residents and landscape maintenance staff within the watershed area draining to the two stormwater outfalls directly upstream of STE066, in an effort to reduce the potential impacts of pyrethroid pesticides on Stevens Creek water quality and beneficial uses; and
- Enhancing collaborative monitoring activities between SCVURPPP and SPCWC to improve our collective understanding of the condition of water quality and beneficial uses in Stevens Creek, and identifying and reducing impacts associated with urban runoff.

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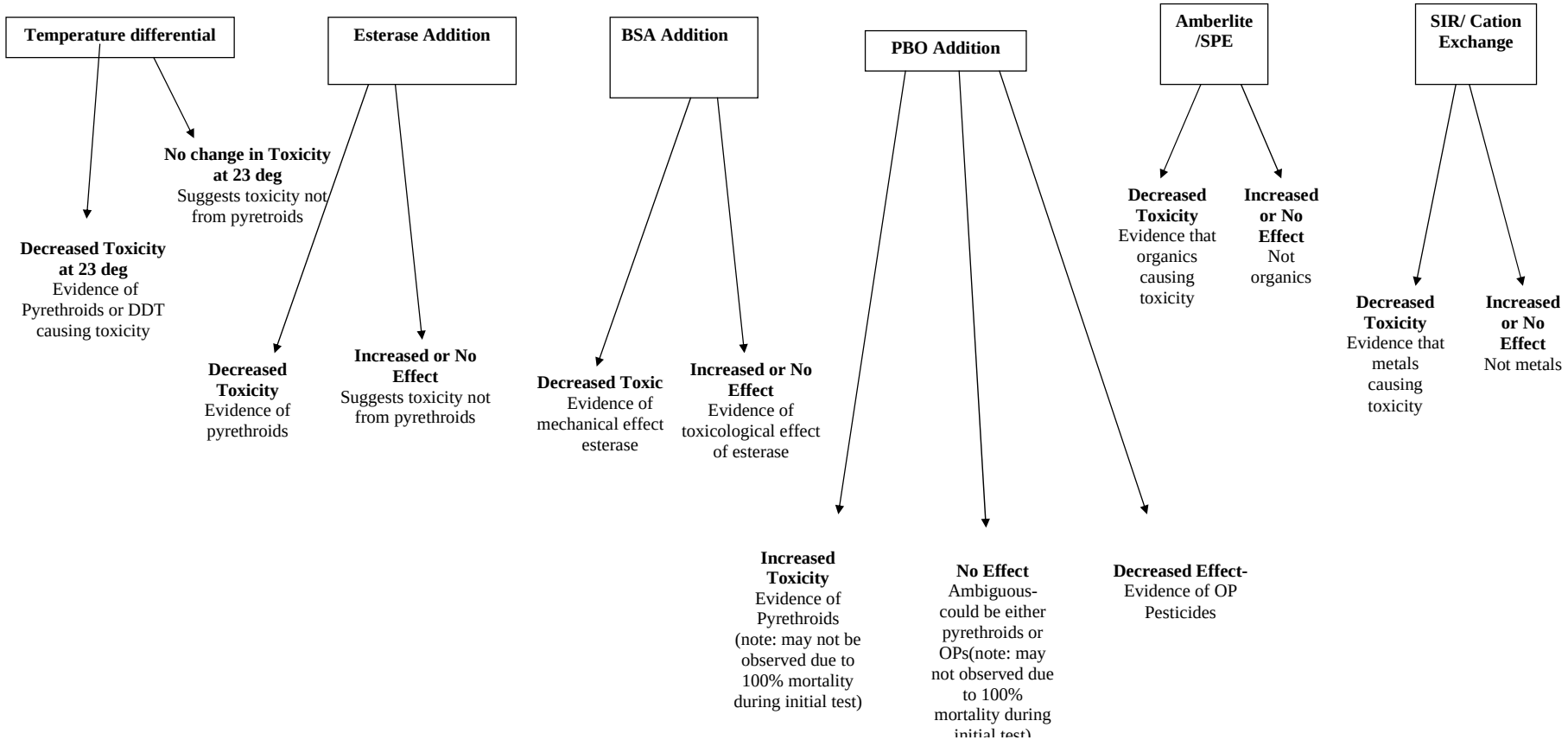
Appendix A. Toxicity Results for Sediment and Water Samples Collected in Stevens Creek Monitoring Sites by SCVURPPP and SPCWC between 2007 and 2009.

Station ID	Station Name	Date	% Survival (Relative to Control)		
			SCVURPPP Sediment Tox	SCVURPPP Water Tox	SPCWC Water Tox
STE020	La Avenida	12/12/07	34%		
		12/7/08			54%
		1/15/08	5%		
		3/31/08	81%		
		2/8/09			100%
		3/25/09			100%
STE060	Barranca (Downstream 280)	10/9/07		100%	
		12/12/07		100%	
		12/7/08			100%
		1/15/08	0%	100%	
		3/31/08	18%	100%	
STE061	Barranca (Upstream 280)	12/23/08			100%
STE062	Florence Drive	3/8/09			41%
STE063	Below Stevens Cr Blvd Bridge (Cresent)	10/9/07		100%	
		12/12/07		100%	
		1/15/08		80%	
		3/31/08		100%	
		2/6/09	0%		
		2/8/09			4%
		2/20/09			30%
STE063.1	Stevens Creek Bridge	5/11/09			100%
		5/20/09			56%
		5/20/09			65%
		5/27/09			100%
		5/27/09			100%
STE063.2	Above Strevens Cr. Blvd Bridge	12/23/08			100%
		2/20/09			81%
		2/27/09			56%
	(a bit upstream)	2/27/09			69%
		3/8/09			10%
		3/28/09			40%
STE064.5	Below McClellan Ranch (McClellan Steps)	2/27/09			39%
STE065	McClellan Ranch (Below McClellan Rd.)	10/9/07	94%	100%	
		12/12/07	83%	100%	
		12/7/08			46%
		12/23/08			100%
		1/15/08	0%	100%	
		3/31/08	90%	90%	
		2/6/09	100%		
		2/8/09			78%
		3/8/09			9%
		3/25/09			94%
STE070	Chestnut Picnic Area	12/7/08			62%
		12/23/08			100%
		2/6/09	100%		
		2/8/09			100%
		3/25/09			46%
STE100	Moss Rock	12/7/08			19%
		2/8/09			100%
		3/25/09			69%

APPENDIX B: TIE PROCESS FLOW DIAGRAM

TIE Phase 1 Treatments



Appendix C: Chemical, Toxicity Testing and Toxicity Identification Evaluation Methods, Reporting Limits and Holding Times followed by SCVURPPP in FY 08-09			
Analyte	Analytical Method	Reporting Limit	Hold Time
SEDIMENT SAMPLES			
TOTAL RECOVERABLE METALS (mg/kg)			
Aluminum	EPA 6020	1	6 months
Arsenic	EPA 6020	0.1	6 months
Cadmium	EPA 6020	0.1	6 months
Chromium	EPA 6020	0.1	6 months
Copper	EPA 6020	0.1	6 months
Lead	EPA 6020	0.1	6 months
Mercury	EPA 7471M	0.02	6 months
Manganese	EPA 6020	0.1	6 months
Nickel	EPA 6020	0.1	6 months
Selenium	EPA 6020	0.1	6 months
Silver	EPA 6020	0.1	6 months
Zinc	EPA 6020	1	6 months
Total Organic Carbon	EPA 9060	0.1%	28 days
Percent Solids	EPA 160.3	0.1%	28 days
Sediment Grain Analysis	Plumb, 1981	NA	6 months
Pyrethroid Pesticides (ng/g)	EPA 8270C(m)	2	40 days
TOXICITY TESTING			
Hyalella azteca	EPA-600-R-99-064 2nd Edition	NA	8 weeks
WATER SAMPLES			
Pyrethroid Pesticides (ng/L)	EPA 625mNCI	2	3 day
TOXICITY IDENTIFICATION EVALUATION			
Solid Phase	EPA/600/R-07/080 Anderson et al. 2008	NA	8 weeks
Temperature differentiation (15°C and 23°C)			
Amberlite and Amberlite Elution			
PBO			
Esterase			
Bovine Serum Albumin (BSA)			
SIR and SIR Elution			
Porewater	EPA/600/R-07/080 Anderson et al. 2008	NA	8 weeks
Temperature differentiation (15°C and 23°C)			
SPE and SPE Elution			
PBO			
Esterase			
Bovine Serum Albumin (BSA)			
Cation Exchange and Cation Exchange Elution			