Department of Pesticide Regulation
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STUDY 320: Ambient Surface Water and Mitigation Monitoring in Urban Areas in Southern California during Water Year 2022-2023

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1. Introduction

Southern California urban areas have considerable pest pressures which result in high urban pesticide use. According to the Pesticide Use Report (PUR) over 17,250,000 pounds of pesticide active ingredient were applied for non-agricultural use in 2018 (CDPR, 2021). Non-agricultural use includes applications for residential, industrial, institutional, structural, or vector control purposes (CDPR, 2014). These PUR data do not account for non-professional applications by residents and homeowners, so actual use is higher. Los Angeles, Orange, and San Diego counties, all counties in Southern California, accounted for 19.9% of the statewide total reported non-agricultural use in 2018. Specifically, approximately 2.3 million pounds of pesticides were applied for professional structural pest control or landscape maintenance in Los Angeles, Orange, and San Diego counties in 2018. Urban areas in Southern California are highly developed, with a high percentage of impervious surfaces. Impervious surfaces enhance surface water runoff, which increases the potential for pesticides to enter urban creeks and rivers via storm drains (Gan et al., 2012).

The California Department of Pesticide Regulation's (CDPR) Surface Water Protection Program (SWPP) has been monitoring pesticides in urban waterways since 2008. Study 320 is a continuation of CDPR's urban surface water monitoring in Southern California (Budd, 2018, Burant 2019, Burant, 2020). The work described herein complements Study 329, which monitors for pesticides in urban surface water areas of Northern California (Ensminger, 2019, Smith, 2020). These studies have shown that urban-use pesticides (e.g., pyrethroids, fipronil, imidacloprid, and synthetic auxin herbicides) are commonly detected in urban waterways (Burant, 2021, Ensminger, 2021). The SWPP is particularly interested in cases where pesticide concentrations repeatedly reach or exceed USEPA Aquatic Life Benchmarks, which are a type of toxicity threshold used to gauge potential risks to sensitive aquatic organisms (Gan et al., 2012; Oki and Haver, 2009; Weston et al., 2014; Weston et al., 2005; Weston et al., 2009, Budd, et al., 2020). Numerous urban waterways are listed on the 2018 Federal Clean Water Act Section 303(d) list due to the confirmed presence of pyrethroid and organophosphate pesticides (Cal EPA, 2021). High use, high potential for pesticide runoff to enter urban waterways, and historical exceedances of aquatic life benchmarks justify the need to continue monitoring California's urban waterways.

Study 320 is also designed to evaluate water quality trends that could show changes in pesticide concentrations over time particularly at long-term monitoring sites. In recent years, CDPR has taken significant mitigation actions to address water quality exceedances for pyrethroids and fipronil. Surface water regulations (Chapter 3, Sections 6970 and 6972 in the California Code of Regulations) went into effect in July 2012 to address pyrethroid concentrations in California surface waters (CDPR, 2013); and in 2018, new California-specific labels were adopted for fipronil-containing products registered for outdoor use. These mitigation actions were designed to reduce loading of pyrethroids and fipronil to surface waters. Long-term monitoring data allows CDPR to assess water quality improvements, such as downward trends in pesticide concentrations or fewer exceedances of Aquatic Life Benchmarks. These monitoring activities assist CDPR in assessing the effectiveness of regulations and label changes.

A recent evaluation was conducted of the SWPP's urban pyrethroid monitoring data in relation to the implementation of the surface water regulations (Budd, et al., 2020). This study showed decreasing trends in bifenthrin and cypermethrin concentrations in Northern California, complemented by an increase in deltamethrin concentrations. Pyrethroids were still detected at levels that exceed Aquatic Life Benchmarks. There were few observed trends in pyrethroid concentrations in Southern California (Budd, et al., 2020). Continued monitoring for pyrethroids supports the ongoing evaluation of trends in pyrethroid concentrations in relation to the surface water regulations.

This protocol details proposed sampling at SWPP monitoring locations receiving urban runoff in Southern California for Water Year (WY; October 1st – September 30th) 2022-2023. Specific modifications from the Study 320 Fiscal Year (FY) 20 – 21 sampling plan are presented in Section 4.9.

2. Objectives

The goal of this project is to assess pesticide concentrations found in runoff at drainages and receiving waters within Southern California urbanized areas during rain events and dry season conditions. Specific objectives include:

1) Determine presence and concentrations of selected priority pesticides in runoff and receiving waters of Southern California urban watersheds during dry and storm conditions;
2) Compare measured concentrations of pesticides to aquatic toxicity thresholds;
3) Evaluate pesticide concentration trends through long-term monitoring;
4) Determine the acute toxicity of water samples using laboratory tests conducted with the amphipod *Hyalella azteca* and midges *Chironomus spp*;
5) Monitor deposition of sediment-bound pyrethroids within selected watersheds;
6) Evaluate land-use gradients to evaluate source contributions of pesticides to urban waterways;
7) Evaluate effectiveness of carbon-filled socks to reduce pesticides in urban runoff under field - conditions; and

8) Evaluate effect of filtering samples on pyrethroid concentrations and *Hyalella azteca* toxicity.

3. Personnel

The study will be conducted by staff from the CDPR's Environmental Monitoring Branch under the general direction of Jennifer Teerlink, Environmental Protection Manager I. Key personnel are listed below:

Project Leader: Robert Budd, Ph.D.
Field Coordinator:
Laboratory Liaison: Josh Alvarado
Statistician: Xuyang Zhang
Analytical Chemistry: Center for Analytical Chemistry, Department of Food and Agriculture (CDFA)

Collaborators: University of California - Cooperative Extension Orange County – South Coast Research and Extension Center, Los Angeles Public Works, Los Angeles Sanitation District, City of San Diego, County of San Diego, and Orange County Public Works.

Please direct questions regarding this study to Robert Budd, Research Scientist, at (916) 445-2505 or Robert.Budd@cdpr.ca.gov.

4. Study Plan

4.1 Site Selection

The sites described in this protocol have been previously sampled by SWPP (Burant, 2020). These sites were selected using the watershed prioritization component of the Surface Water Monitoring Prioritization (SWMP) Model. The SWMP model, which is extensively described in Luo et al. (2017), identifies priority hydrologic-unit codes (HUC) based on reported pesticide use and toxicity data. Using the SWMP Model and its aggregation tool (Luo et al., 2017), the top ten priority HUC8s are identified for Southern California (Appendix 1). Of these, the SWPP currently has monitoring sites within seven of the top HUC8s. These watersheds, located throughout heavily urbanized areas of Southern California, provide data to evaluate the spatial distribution of priority pesticides in Southern California surface waters (Budd et al., 2013; Luo et al., 2013). Other factors such as site accessibility, contributing land use, perennial flow, other monitoring agency representation, and budgetary constraints direct site selection in the remaining HUCs. Sampling locations in receiving water sites are located near the base of their respective watersheds (i.e., the downstream portion of the watersheds), with a few notable exceptions.

4.1.1 Los Angeles County

Ballona Creek (BAL), Bouquet Canyon Creek (BOQ), Los Angeles River (LAR1, LAR3, and LAR4), and San Gabriel River (SGR), are the watersheds of interest in Los Angeles County (Figure 1). All sites are located within concrete-lined sections of the waterway. These sites are large watersheds with mixed residential and commercial land-use. Within the Santa Monica Bay HUC8, BAL drains mostly residential land-uses with single- and multi-family homes whereas BOQ consists of predominantly single-family homes with a small amount of commercial land-use. Although not in a HUC8 prioritized by the SWMP Model, BOQ has historically high pesticide detections. The BOQ site is not located at the base of the watersheds, but below the confluence of Bouquet Canyon Creek and Dry Canyon, a tributary of BOQ. In the Los Angeles River HUC8, LAR1 drains residential land-uses, but has a higher percentage of commercial and industrial land-uses than BAL or BOQ. Two storm drain sites along the LA River (LAR3 and LAR4) are included to determine relative contributions from commercial-dominated land-use sites. These sites drain from downtown Los Angeles. Water collected at the San Gabriel River (SGR) station consists primarily of wastewater effluent during low flows.

4.1.2 Orange County

Ambient water quality monitoring will be conducted at six sampling locations within Salt Creek (SC, Figure 2), three locations within Wood Creek Canyon (WC, Figure 3), one site in the Anaheim-Barber City Channel (ABCC), and one site along Peters Canyon Channel (PCC, Figure 4) in Orange County.

Sampling stations within Salt Creek (SC1, SC2, SC3, SC4, SC5, and SC7) have been monitored consistently since 2009 as part of SWPP's urban monitoring program. The surrounding drainage areas within the Salt Creek watershed consist of single-family dwellings, multiple-family dwellings, light commercial buildings, parks, schools, and two golf courses. Sites SC1–SC4 are located directly below storm drains that receive runoff from residential neighborhoods. In contrast, SC5 and SC7 are located at the receiving waters of urban inputs and will allow evaluation of pesticide concentrations in the watershed as well as downstream transport of pesticides. Finally, SC5 is located upstream of SC7, which is located at the base of the Salt Creek watershed. All SC sites are located in the Aliso-San Onofre HUC8. Sediment pyrethroid sampling at SC3 and SC5 will continue during the dry season.

Monitoring locations within Wood Creek, all located in the Aliso-San Onofre HUC8, have been monitored since 2009 as part of SWPP's mitigation evaluation monitoring in urban settings. Two sites are situated at the inlet (WC1) and outlet (WC2) of a small (~0.18 acres) constructed wetland designed to reduce pollutants in urban runoff (Budd, et al., 2012). The wetland receives urban runoff from a drainage area consisting entirely of single- and multiple-family residential units. The primary objective of monitoring at these stations is to observe the efficacy of pesticide removal within the wetland system. Efficacy will be evaluated through comparisons in average pesticide concentrations between the inlet and outlet. Sediment sampling will continue at WC1. Site WC3 receives runoff from a small residential neighborhood to the north of the wetland. A carbon sock will be deployed at the outfall of WC3 during dry season conditions. Effectiveness of this treatment technology will be measured by comparing pre- and post- carbon sock pesticide concentrations.

Sampling along the Anaheim-Barber City Channel is a concrete-lined watershed draining mixed residential, commercial, and industrial areas. The watersheds are located within the Seal Beach HUC8, the highest priority HUC8 in Southern California based on estimated urban pesticide use within the delineated HUC.

Peters Canyon Channel within the Newport Bay HUC, just upstream of the confluence of Peters Canyon Channel and San Diego Creek, explores the relative contributions from commercial-dominated land-use sites. This site is situated upstream of a site monitored by the State Water Resources Control Board's Stream Pollution Trends (SPoT) Monitoring Program (San Diego Creek at Alton Parkway) and has historic detections of pyrethroids in sediment (SWAMP, 2017).

4.1.3 San Diego County

Two stations within the San Diego River watershed, as well as one within the Chollas Creek watershed, will be monitored in San Diego County (Figure 5, Table 1, and Appendix 2). San Diego River is not channelized or concrete-lined, which may account for historically lower pesticide concentrations (Budd, 2018). Both sites are located within high priority HUC8s in Southern California (Appendix 1).

4.1.4 Collaborative Monitoring

For several years, the SWPP has been engaged in a collaborative effort with the State Water Resources Control Board through its SPoT Monitoring Program to increase the data available for trend analysis of current-use pesticides (SWAMP, 2017). The synergistic partnership allows each agency to maximize information gained with limited resources. In coordination with the SWPP, the SPoT Program also collects sediments throughout California for pyrethroid and fipronil analyses, which greatly adds to the spatial representation of pesticide monitoring data. Several sites described in this protocol also serve as SPoT monitoring locations for sediments, including BAL, BOQ, LAR1, and SGR. Staff from SWPP collects and analyzes the aqueous samples, while SPoT monitors for pyrethroids and fipronil in sediment. Both sets of data are considered in long-term trend analysis.

4.2 Selection of Pesticides for Monitoring

The SWMP model is utilized to prioritize pesticides for monitoring. From the generated list, pesticides needing analytical method development can be identified. Luo et al. (2013) describes the SWMP Model in detail, but briefly, the model is based on current pesticide reported professional use patterns and aquatic toxicity threshold values. Use data from Los Angeles, Orange, and San Diego counties and Aquatic Life Benchmarks set by the U.S. EPA are considered. The product of use score × toxicity score yields a final score that represents a relative prioritization of pesticides. Additionally, the output generates a monitoring recommendation based on physical-chemical properties such as half-life and solubility. Pesticides that receive a final score of nine or higher are given priority for method development. Pesticides with lower scores have either low use in urban environments or low associated aquatic toxicity. All pesticides in the liquid chromatography (LC) multi-analyte screen and the pyrethroid screen will be analyzed for at each aqueous sampling site. The dinitroaniline screen and phenoxy screen will be analyzed for at selected sampling sites (Table 2). These screens represent pesticides that historically have had lower detection frequencies in previous monitoring efforts (e.g., the dinitroaniline screen) or pesticides that have not previously exceeded benchmarks (e.g., synthetic auxin herbicides) (Appendix 3). All suites cannot be analyzed at every monitoring location due to budgetary and space constraints. (Table 2). In addition to the analytes included in the present analytical suites, the SWMP identified seven analytes in need of method development: dichlorvos, dithiopyr, imazapyr, glufosinate-ammonium, PCNB, prallethrin, and sulfometuron-methyl.

4.3 Water Sampling

Whole water samples will be collected during two dry-season and two storm sampling events according to Deng and Ensminger, 2021. Dry-season sampling will occur in June and August 2023. SWPP will attempt to collect storm samples during the first major storm (rain) event of WY 22–23 and during a second major storm in the winter or early spring of 2023 (Table 2).

Dry-season water samples will be collected as grab samples directly into 1-L amber bottles (Deng and Ensminger, 2021). Where the stream is too shallow to collect water directly into these bottles, a stainless-steel container will be used to initially collect the water samples. Water samples collected during storm events at up to five locations within Salt Creek or Wood Creek watersheds may be collected as time-weighted composite samples utilizing automated sampling equipment set up by UC Cooperative Extension (CDPR, 2011; Sisneroz et al., 2012). Flow-weighted storm runoff will be collected at BAL and LAR1 by the Los Angeles County Public Works Department. Storm runoff composite samples collected at SDR1, SDR4, and CHO1 will be collected by the County and City of San Diego, respectively. Samples will be stored and transported on wet ice or refrigerated at 4°C until analyzed. Duplicate samples will be collected at two sites during first storm and both dry season events. These duplicate samples will be filtered through a glass fiber prior to submission for pyrethroid analysis and toxicity testing on *H. azteca*. Field duplicates, field blanks, or both will be collected during each sampling event for quality assurance.

4.4 Sediment Sampling

Sediment samples will be collected at three locations (Table 2). Enough sediment will be collected to fill ½ pint (237 mL) Mason jars using stainless-steel scoops from the top of the bed layer, biasing for fine sediments where possible (Deng and Ensminger, 2021). All sediments will be passed through a 2-mm sieve to remove plant debris and then homogenized (Deng and Ensminger, 2021). Samples will be analyzed for pyrethroids.

4.5 Toxicity Sampling

Water samples will be collected at a subset of sampling sites for toxicity analysis (Table 3). Grab samples will be collected in 1-L amber I-Chem certified 200 bottles (or equivalent) and transported to the Aquatic Health Program at the University of California, Davis. Toxicity testing will measure percent survival of the amphipod *Hyalella azteca* or the midge *Chironomus spp.* in water over 96-hours (Table 3). Several sites described in this protocol also serve as SPoT monitoring locations for sediment toxicity, including BAL, BOQ, LAR1, SGR, and SC5. Other sites, such as LAR3, LAR4, SC3, SDR1, DC, and ABCC will be considered for sampling. Data will be shared between monitoring programs.

4.6 Field Measurements

Physical-chemical properties of water column will be determined using a YSI-EXO 1 Multi-parameter Sonde or Aqua TROLL® 400 Multiparameter Probe according to the methods describe by Edgerton (2020) and In-Situ (2019). At each site, water chemistry parameters measured *in situ* will include pH, temperature, salinity, total dissolved solids, and dissolved oxygen. Storm drain flow rates will be measured to characterize the flow regime and to estimate the total loading of target pesticides. Discrete time flow estimations will be determined using either the float method, or fill-bucket method. Continuous flow rates will be obtained at SC2, SC3, and WC3 using an installed Hach Sigma 950 flow meter (Sisneroz et al., 2012; Oki and Haver, 2009).

4.7 Sample Transport

SWPP staff will transport samples following the procedures outlined in CDPR SOP QAQC004.01 (Jones, 1999). A chain-of-custody record will be completed and accompany each sample.

4.8 Organic Carbon and Suspended Sediment Analyses

SWPP staff will analyze water and sediment samples for total organic carbon (TOC) and dissolved organic carbon (DOC) using a TOC-V CSH/CNS analyzer (Shimadzu Corporation, Kyoto, Japan) (Ensminger, 2013b). Water samples will also be analyzed for suspended sediment (Ensminger, 2013c). Lab blanks and calibration standards will be run before every sample set to ensure the quality of the data.

4.9 Modifications from Study 320 FY 20-21

The current sampling plan is an extension of Study 270 conducted during fiscal years 2009–2019 and Study 320 conducted in 2019-2022. Details of the previous year's sampling protocol are described in the document titled "Ambient Surface Water and Mitigation Monitoring in Urban Areas in Southern California during Fiscal Year 2020-2021" (Burant, 2020). The sampling and analysis schedule is similar to that for FY21-21, with a few notable modifications (Table 4).

5. Chemical Analysis

Pesticide analysis will be conducted by the Center for Analytical Chemistry at the California Department of Food and Agriculture, Sacramento, CA (CDFA). CDFA will analyze six analytical suites (Appendix 3). Laboratory QA/QC will follow CDPR guidelines and will consist of laboratory blanks, matrix spikes, matrix spike duplicates, surrogate spikes, and blind spikes (Segawa, 1995). Laboratory blanks and matrix spikes will be included in each extraction set.

6. Data Analysis

Data generated by this project will be entered into a central database that holds all data including field information, field measurements, and laboratory analytical data. We will use various non-parametric statistical methods to analyze the data. The data collected from this project may be used to develop or calibrate urban pesticide runoff models.

Preliminary analysis (Budd et al., 2020) indicated that the sample data are skewed and contain a number of non-detects with multiple reporting limits, which may violate the normality and equal-variance assumptions of the parametric procedures (e.g., ANOVA and *t*-tests). The application of non-parametric procedures to skewed and censored environmental data is most appropriate for this study (Helsel, 2012). The data will be analyzed by using the R statistical program (R Core Team, 2014), specifically the Non-detects And Data Analysis for environmental data (NADA) package for R (NADA Package for R).

Based on the study objectives, preliminary analysis, and data availability, we propose the following statistical procedures for data analysis (Table 5).

1) Explanatory data analysis will be performed to summarize the characteristics of the sample data. Urban monitoring data have been collected since 2008 for a variety of analytes (Appendix 3) at multiple

locations (e.g., Salt Creek, Wood Creek) with different site types (i.e., storm drain outfalls and receiving waters), and between different seasons (i.e., dry and wet seasons) (Tables 1 and 2). Boxplots, histograms, probability plots, and empirical distribution functions will be produced to explore any potential patterns demonstrated by the data.

2) Hypothesis tests will be conducted to compare the concentration between groups of interest. For example, we will test whether there is significant difference in concentration between the dry and wet seasons, or between the different locations. Non-parametric procedures will be used to compute the statistics for hypothesis testing. Data with multiple reporting limits will be censored at the highest limit before proceeding if the test procedure allows only one reporting limit.

3) Trend analysis will be included to demonstrate changes in concentration over time (if any). For the trend analysis, we will use Akritas-Thenil-Sen non-parametric regression, which regresses the censored concentration over time, or the Kaplan-Meier method, which tests the effects of year, month, and location by developing a mixed linear model between the censored concentration and spatial-temporal factors.

7. Timeline

Field Sampling: Oct 2022 – Sept 2023

Chemical Analysis: Oct 2022 – Dec 2023

Report to Management: Jan 2024 – Mar 2024

Data Entry into SURF: Mar 2024 – Jun 2024

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Table 1. Summary of urban pesticide monitoring locations in Southern California.

County	Watershed	Stormdrain Outfall	Receiving Water/ Mitigation Outfall	Total Sites
Los Angeles	Ballona Creek	-	1	1
Los Angeles	Bouquet Creek	-	1	1
Los Angeles	Los Angeles River	2	1	3
Los Angeles	San Gabriel River	-	1	1
Orange	Anaheim-Barber City Channel	-	1	1
Orange	Salt Creek	4	2	6
Orange	Wood Creek	2	1	3
Orange	Peters Canyon Channel	1	-	1
San Diego	San Diego River	1	1	2
San Diego	Chollas Creek	-	1	1
	Total	**10**	**10**	**20**

Table 2. Ambient surface water and mitigation sampling schedule. Subject to change. Samples with asterisks (*) are collected by our sampling partners.

Site	First Storm	Second Storm	First Dry	Second Dry
BOQ	LC, PY	LC, PY, DN, PX, GL	LC, PY, DN, PX, GL	LC, PY
LAR1	LC, PY*	LC, PY*	LC, PY	LC, PY, DN, PX, GL
LAR3			LC, PY	LC, PY
LAR4			LC, PY	LC, PY
BAL	LC, PY*	LC, PY*	LC, PY	LC, PY
SGR	LC, PY, DN, PX, GL	LC, PY	LC, PY, DN, PX, GL	LC, PY
ABCC	LC, PY, DN, PX, GL	LC, PY	LC, PY	
PCC	LC, PY	LC, PY, DN, PX, GL		LC, PY
SC1	LC, PY	LC, PY	LC, PY	LC, PY
SC2	LC, PY	LC, PY	LC, PY	LC, PY
SC3	LC, PY,	LC, PY	LC, PY	LC, PY, PY-SED
SC4	LC, PY, DN, PX, GL	LC, PY, DN, PX, GL	LC, PY, DN, PX, GL	LC, PY, DN, PX, GL
SC5	LC, PY	LC, PY		LC, PY, PY-SED
SC7	LC, PY, DN, PX, GL	LC, PY, DN, PX	LC, PY	LC, PY, DN, PX, GL
WC1	LC, PY, GL	LC, PY	LC, PY, GL	LC, PY, PY-SED
WC2	LC, PY	LC, PY	LC, PY	LC, PY
WC3	LC, PY	LC, PY	LC, PY	LC, PY
SDR1	LC, PY*			LC, PY
SDR4	LC, PY*			LC, PY
CHO	LC, PY*			
SC3_BMP			LC, PY	LC, PY
WC3_BMP			LC, PY	LC, PY
Filt #1	PY		PY	PY
Filt #2	PY		PY	PY

Table 3. Toxicity sampling schedule: sites will be rotated.

Site	Test Species	First Storm	Second Storm	First Dry		Second Dry
LAR1, BOQ, SC3, SC7, ABCC, SDR1, BAL, SGR, LAR4, CHO1	*Hyalella azteca*	6	0	7		7
LAR1, BOQ, SC3, SDR1, BAL, SGR, LAR4	*Chironomus spp.*	0	0	3		3

Table 4. Modifications from sampling plan for fiscal year 2020-2021

Change from FY 20-21	Justification
Change in sampling schedule from fiscal to water year	Alignment of sampling schedule with annual precipitation patterns
Addition of glyphosate analysis	Provides supporting information on presence of high interest pesticide in surface waters
Removal of BCC, CC1, DC sites	Lower priority sites removed to focus on additional study objectives
Addition of SC3-BMP and WC3-BMP	Provides data to evaluate efficacy of carbon socks to remove pesticides in urban runoff
Addition of two filter samples	Provides data to compare whole water and dissolved concentrations and associated toxicity

Table 5. Non-parametric procedures frequently used for comparing paired data, two samples and three or more samples**.**

Data	Non-Parametric Procedure
Paired data	*Wilcoxon signed-rank test* for uncensored data *Sign test* (modified for ties) for censored data with one reporting limit *Score tests* for censored data with multiple RLs (the PPW test and the Akritas test)
Two samples	*Wilcoxon rank-sum (or Mann-Whitney) test* or *Kolmogorov-Smirnov test* for censored data with one reporting limit *Score tests* for censored data with multiple reporting limits (the *Gehan test* and generalized *Wilcoxon test*)
Three or more samples in one-way layout	*Kruskal-Wallis test* (for unordered alternative) or *Jonckheere-Terpstra test* (for ordered alternative) for censored data with one reporting limits *Generalized Wilcoxon score test* for censored data with multiple reporting limits *Multiple comparison* to detect which group is different
Three or more samples in two-way layout	*Friedman's test* (for unordered alternative) or *Page's test* (for ordered alternative) for censored data with one reporting limits Multiple comparison to detect which group is different

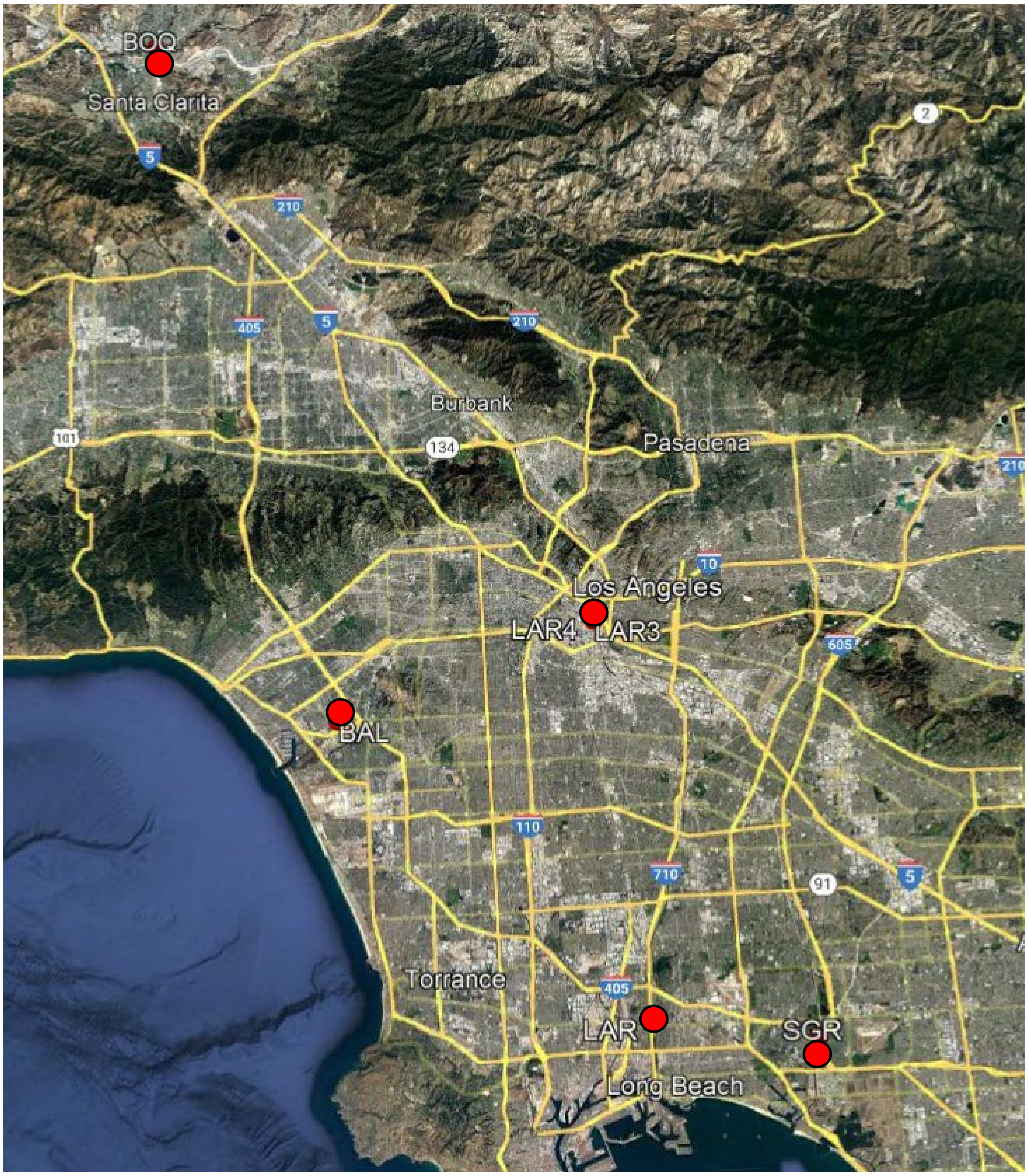

Figure 1. Sampling locations within Los Angeles County, CA. Map from Google Maps.

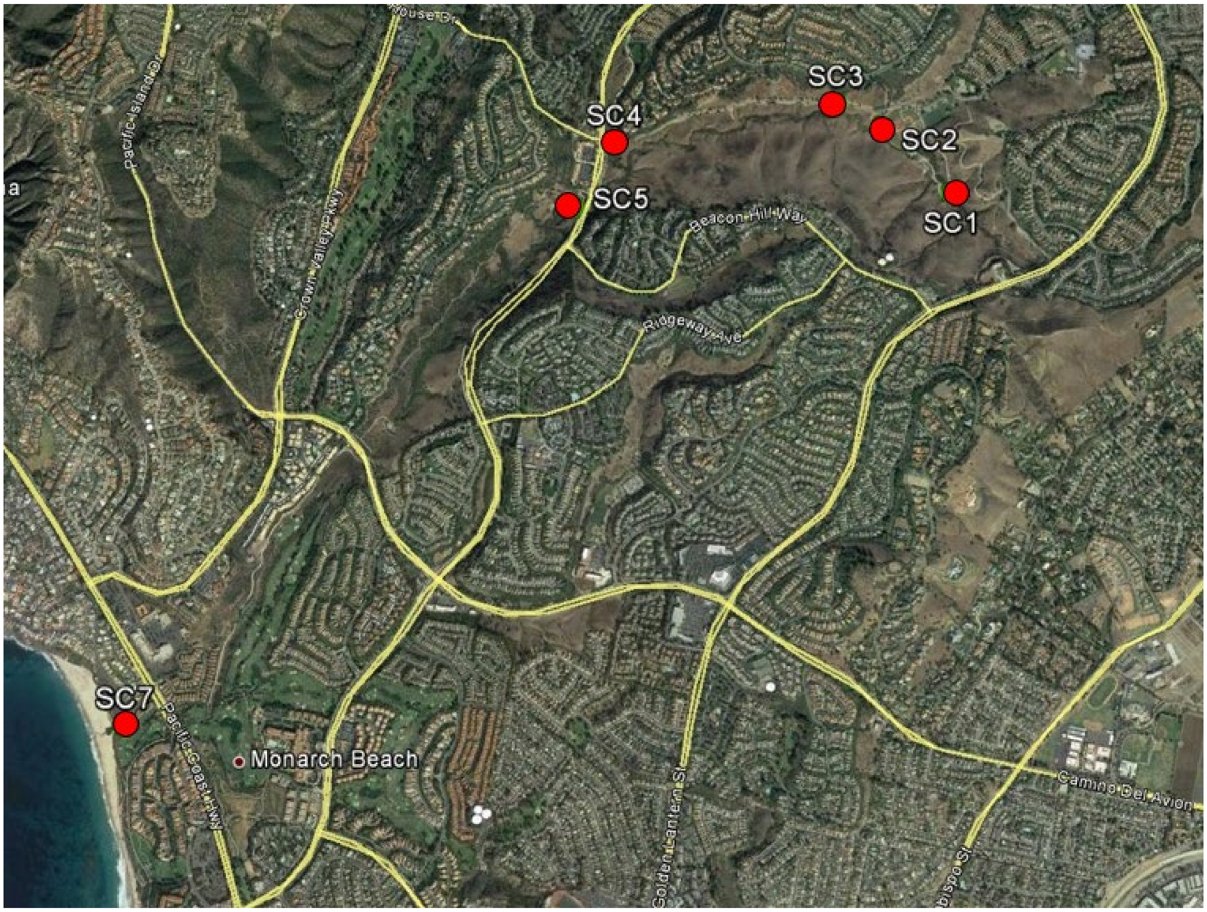

Figure 2. Sampling locations within Salt Creek Watershed, Orange County, CA.

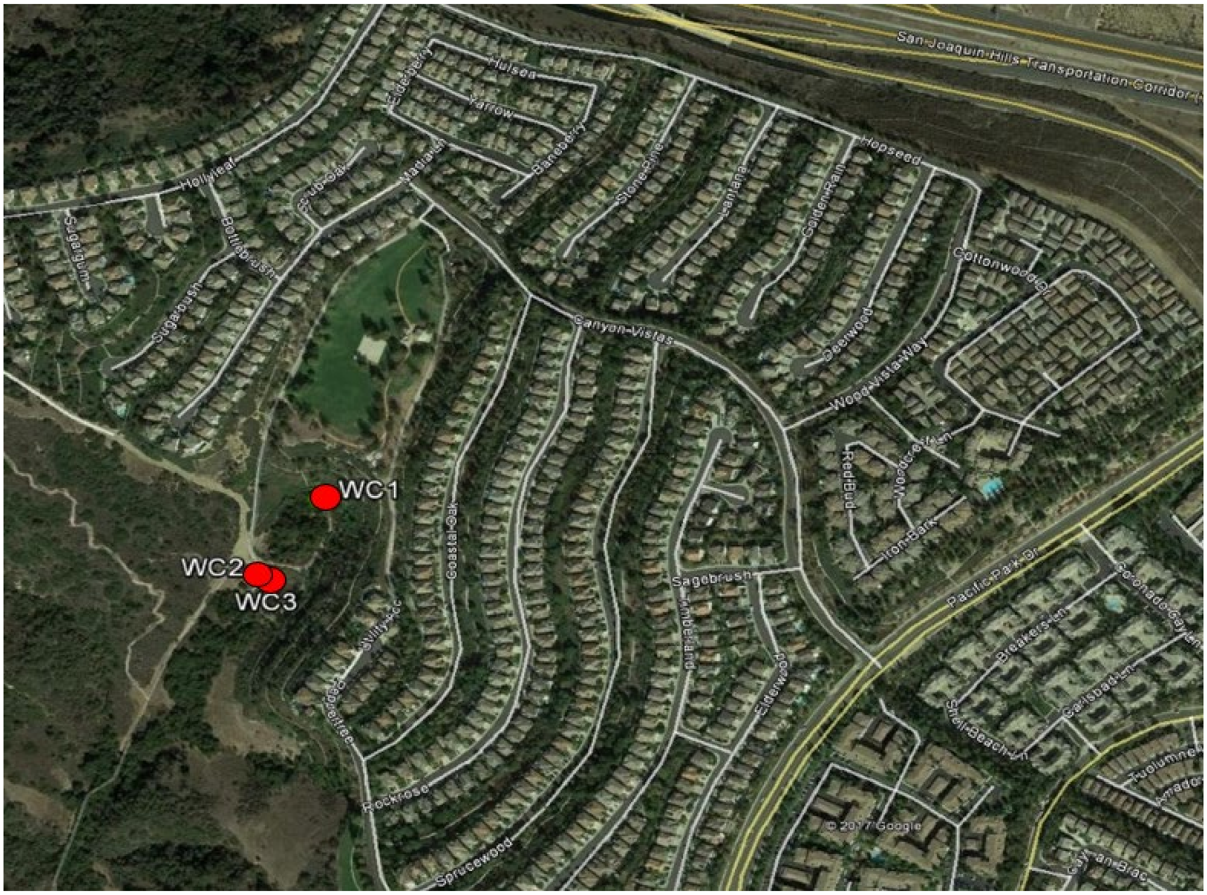

Figure 3. Sampling locations within Wood Creek Watershed, Orange County, CA.

Figure 4. Sampling location with Anaheim-Barber City Channel, Bolsa-Chica Channel, and Peters Canyon Channel in Orange County, CA. Map from Google Maps.

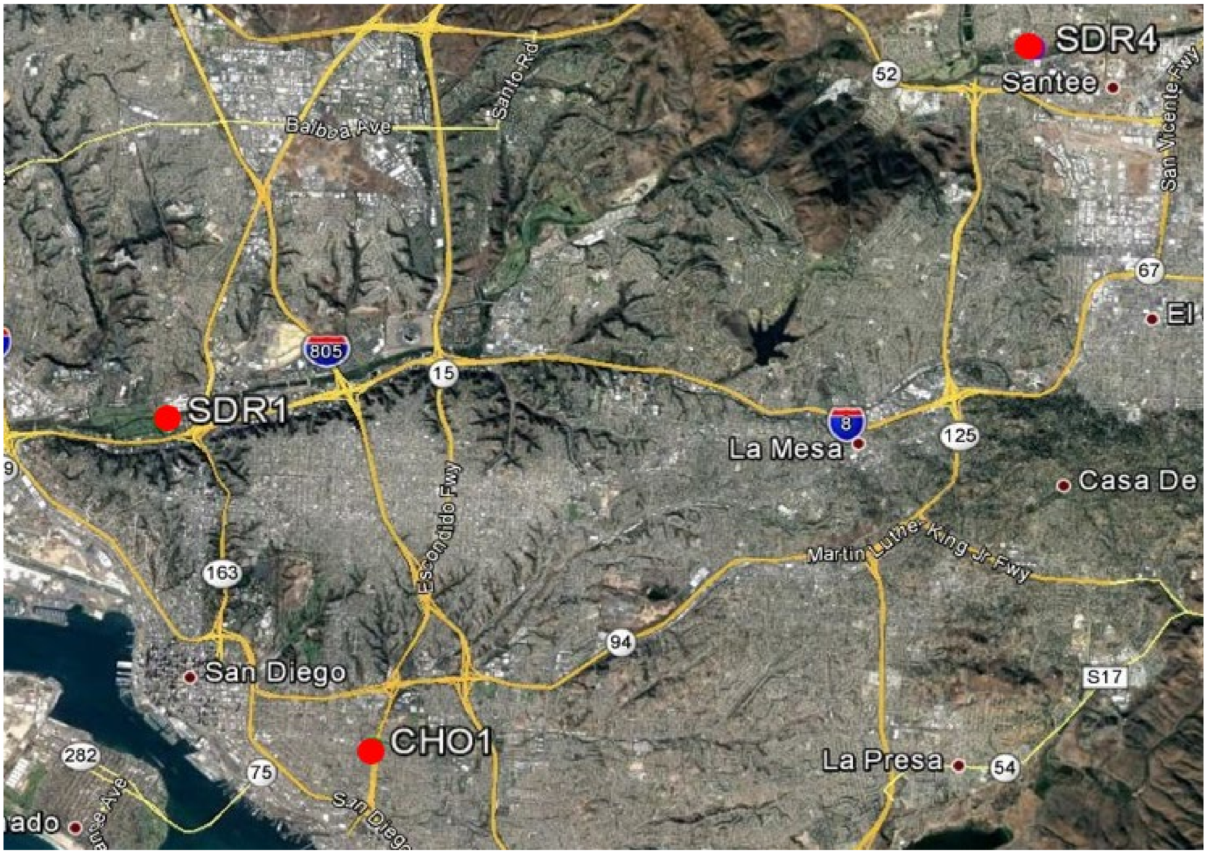

Figure 5. Sampling locations within San Diego County, CA. Map from Google Maps.

Appendix 1.

Table 1. Top ten HUC8's identified for urban monitoring in Southern California, ordered by the ranking process.

HUC8 Code	HUC8 Name	CDPR Monitoring Location	Comments
18070201	Seal Beach (Anaheim Bay)	ABCC	
18070204	Newport Bay	PCC1	SWAMP location, NPDES permit monitoring at several locations along San Diego Creek*
18070105	Los Angeles	LAR1, LAR3, LAR4	
18070106	San Gabriel	SGR, DC	
18070104	Santa Monica Bay	BAL	
18070202	San Jacinto		SWAMP monitoring location along Santa Margarita River*
18070203	Santa Ana		Southern California Bight Project monitoring site at base of Santa Ana River*
18070301	Aliso-San Onofre	SC1, SC2, SC3, SC4, SC5, SC7, WC1, WC2, WC3	
18070304	San Diego	SDR1, SDR4, CHO1	
18070103	Calleguas		SWAMP monitoring location Calleguas Creek*

*Non-CDPR monitoring locations evaluated using California Environmental Data Exchange Network (CEDEN) available at: http://www.ceden.org/

Appendix 2.

Table 1. Detailed sampling site information

Watershed	Site ID	Northing	Easting	Site type
Salt Creek	SC1	33.3032.92	-117.4126.53	Stormdrain
Salt Creek	SC2	33.3040.57	-117.4140.67	Stormdrain
Salt Creek	SC3	33.3043.02	-117.4149.55	Stormdrain
Salt Creek	SC4	33.3031.00	-117.4226.34	Stormdrain
Salt Creek	SC5	33.3020.23	-117.4230.87	Receiving water
Salt Creek	SC7	33.2853.97	-117.4326.55	Receiving water
Ballona Creek	BAL	33.5912.92	-118.2455.90	Receiving water
Bouquet Creek	BOQ	34.2542.05	-118.3223.45	Receiving water
Los Angeles River	LAR1	33.8058.09	-118.2054.53	Receiving water
Los Angeles River	LAR3	34.0385676	118.228332	Storm Drain
Los Angeles River	LAR4	34.0385676	118.228332	Storm Drain
San Gabriel River	SGR	33.7751.08	-118.0974.18	Receiving water
Anaheim-Barber City Channel	ABCC	33.750297	-118.042183	Receiving water
Peters Canyon Channel	PCC	33.690339	-117.824827	Stormdrain
San Diego River	SDR4	32.8450.37	-116.9912 06	Stormdrain
San Diego River	SDR1	32.4551.79	-117.1012.24	Receiving water
Chollas Creek	CHO1	32.704850	-117.121143	Receiving water
Wood Creek	WC1	33.3456.56	-117.4443.02	Stormdrain
Wood Creek	WC2	33.5815.83	-117.7457.72	Wetland outfall
Wood Creek	WC3	33.5815.7	-117.7457.27	Stormdrain

Appendix 3. Analytical Suites

Pesticide	Pesticide Class	Method Detection Limit (µg/L)	Reporting Limit (µg/L)
Abamectin	Botanical, Macrocyclic Lactone	0.004	0.02
Acetamiprid	Neonicotinoid	0.004	0.02
Atrazine	Triazine	0.004	0.02
Azoxystrobin	Strobin	0.004	0.02
Bensulide	Organophosphorus	0.004	0.02
Boscalid	Carboxamide	0.004	0.02
Bromacil	Uracil	0.004	0.02
Carbaryl	Carbamate	0.004	0.02
Chlorantraniliprole	Anthranilic diamide	0.004	0.02
Chlorpyrifos	Organophosphorus	0.004	0.02
Clothianidin	Neonicotinoid	0.004	0.02
Cyprodinil	Anilinopyrimidine	0.004	0.02
Desulfinyl Fipronil	Fiprole	0.004	0.01
Desulfinyl Fipronil Amide	Fiprole	0.004	0.01
Diazinon	Organophosphorus	0.004	0.02
Diflubenzuron	Benzoylurea	0.004	0.02
Dimethoate	Organophosphorus	0.004	0.02
Diuron	Urea	0.004	0.02
Ethoprop	Organophosphorus	0.004	0.02
Etofenprox	Pyrethroid Ether	0.004	0.02
Fenamidone	Imidazole	0.004	0.02
Fenhexamid	Hydroxyanilide	0.005	0.02
Fipronil	Fiprole	0.004	0.01
Fipronil Amide	Fiprole	0.004	0.01
Fipronil Sulfide	Fiprole	0.004	0.01
Fipronil Sulfone	Fiprole	0.004	0.01
Fludioxonil	Unclassified	0.004	0.02

Pesticide	Pesticide Class	Method Detection Limit (µg/L)	Reporting Limit (µg/L)
Hexazinone	Triazinone	0.004	0.02
Imidacloprid	Neonicotinoid	0.004	0.01
Indoxacarb	Oxadiazine	0.004	0.02
Isoxaben	Amide	0.004	0.02
Kresoxim-methyl	Strobin	0.004	0.02
Malathion	Organophosphorus	0.004	0.02
Mefenoxam	Xylylalanine	0.004	0.02
Methidathion	Organophosphorus	0.004	0.02
Methomyl	Carbamate	0.004	0.02
Methoxyfenozide	Diacylhydrazine	0.004	0.02
Metribuzin	Triazinone	0.004	0.02
Norflurazon	Pyridazinone	0.004	0.02
Oryzalin	2,6-Dinitroaniline	0.004	0.02
Oxadiazon	Unclassified	0.004	0.02
Prometon	Triazine	0.004	0.02
Prometryn	Triazine	0.004	0.02
Propanil	Anilide	0.004	0.02
Propargite	Unclassified	0.004	0.02
Propiconazole	Azole	0.004	0.02
Pyraclostrobin	Strobin	0.004	0.02
Pyriproxyfen	Juvenile hormone mimic	0.004	0.015
Quinoxyfen	Quinoline	0.004	0.02
Simazine	Triazine	0.004	0.02
S-Metolachlor	Chloroacetanilide	0.004	0.02
Tebuconazole	Azole	0.004	0.02
Tebufenozide	Diacylhydrazine	0.004	0.02
Tebuthiuron	Urea	0.004	0.02
Thiabendazole	Benzimidazole	0.004	0.02
Thiacloprid	Neonicotinoid	0.004	0.02

Pesticide	Pesticide Class	Method Detection Limit (µg/L)	Reporting Limit (µg/L)
Thiamethoxam	Neonicotinoid	0.004	0.02
Thiobencarb	Thiocarbamate	0.004	0.02
Trifloxystrobin	Strobin	0.004	0.02

Table 2. Dinitroaniline Screen: EMON-SM-05-006

Pesticide	Pesticide Class	Method Detection Limit (µg/L)	Reporting Limit (µg/L)
Oxyfluorfen	Dinitroaniline	0.01	0.05
Pendimethalin	Dinitroaniline	0.012	0.05
Prodiamine	Dinitroaniline	0.012	0.05
Trifluralin	Dinitroaniline	0.014	0.05
Chlorfenapyr	Pyrrole	0.0333	0.10

Table 3. Phenoxy Screen: EMON-SM-05-012

Pesticide	Pesticide Class	Method Detection Limit (µg/L)	Reporting Limit (µg/L)
2,4-D	Phenoxy	0.015	0.05
Dicamba	Benzoic acid	0.017	0.05
MCPA	Phenoxy	0.022	0.05
Triclopyr	Pyridine	0.02	0.05

Table 4. Pyrethroid Screen: EMON-SM-05-022

Pesticide	Pesticide Class	Method Detection Limit (µg/L)	Reporting Limit (µg/L)
Bifenthrin	Pyrethroid	0.00091	0.001
Cyfluthrin	Pyrethroid	0.00146	0.002
Cypermethrin	Pyrethroid	0.00154	0.005
Deltamethrin/Tralomethrin	Pyrethroid	0.00177	0.005
Fenvalerate/Esfenvalerate	Pyrethroid	0.00166	0.005
Lambda-cyhalothrin	Pyrethroid	0.00174	0.002
Permethrin cis	Pyrethroid	0.00105	0.002
Permethrin trans	Pyrethroid	0.00105	0.005

Table 5. Sediment Pyrethroid Screen: EMON-SM-52-9

Pesticide	Pesticide Class	Method Detection Limit (µg/kg)	Reporting Limit (µg/kg)
Bifenthrin	Pyrethroid	0.108	1
Cyfluthrin	Pyrethroid	0.183	1
Cypermethrin	Pyrethroid	0.107	1
Deltamethrin/Tralomethrin	Pyrethroid	0.0661	1
Fenvalerate/Esfenvalerate	Pyrethroid	0.0661	1
Lambda-cyhalothrin	Pyrethroid	0.115	1
Permethrin cis	Pyrethroid	0.116	1
Permethrin trans	Pyrethroid	0.135	1

*Full analytical methods are available at: **Analytical Method Page on CDPR Website**