Department of Pesticide Regulation
Environmental Monitoring Branch
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STUDY 299: Pesticide Monitoring in Urban Areas of Northern California (FY 2019/2020)

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1.0 INTRODUCTION

Pesticides are commonly applied in urban areas. More than two million pounds of pesticide are reported used for structural and landscape applications in the California Department of Pesticide Regulation (CDPR) Pesticide Use Reporting Database (PUR) (CDPR, 2018a). The pesticide total amount applied in urban areas is likely higher, as non-professional use is not reported in PUR. Although it is difficult to quantify the amount of non-professional use, numerous products are available to the general public and it has been estimated that up to 70% of all urban pesticide use is from non-professional application sources (Budd and Peters, 2018; Moran, 2008). With this urban load, there is high potential for pesticide runoff into urban creeks and rivers. Monitoring studies have frequently detected pesticides in urban surface waters. Toxicity testing associated with some studies have revealed that urban-use pesticides have the potential to adversely affect aquatic invertebrate organisms in urban surface waters (Holmes et al., 2008; Lao et al., 2010; Weston and Jackson, 2009; Weston and Lydy, 2014). Other studies have associated potential toxicity based on exceedances of aquatic benchmarks (Budd et al., 2015; Ensminger et al., 2013, Gan et al., 2012, Batikian et al., 2019). Label changes or regulations have been enacted to mitigate the effects of specific pesticides where toxicity was a concern (CDPR, 2018b; UC ANR, 2019, USEPA, 2017a, b, c).

To determine the pesticide exposures in urban runoff and surface waters, CDPR's Surface Water Protection Program (SWPP) began monitoring California's urban areas in 2007; the study became a statewide monitoring program in 2008 (He, 2008; Kelley, 2007). This program helped define pesticide runoff patterns from urban neighborhoods and watersheds (Budd et al., 2015; Ensminger et al., 2013). Continued high use of pesticides in urban areas, frequent detections in surface water, and implementation of mitigation actions warrant continued monitoring of the state's urban waterways. Study 299 is a continuation of CDPR's urban monitoring in Northern California from FY 2018/2019 (Ensminger, 2018). This study will continue to evaluate sources of pesticide runoff, monitor larger urban watersheds, and evaluate toxicity at selected sites.

The FY 2018/2019 Northern California study had a significant monitoring change: automated samplers were employed to capture runoff from an entire storm event rather than taking grab samples during expected high runoff peaks. This change was prompted by the CDPR's recent evaluation of its urban monitoring program (Ensminger et al., 2017). The FY 2019/2020 study will continue using automated samplers during storm events at roughly the same sites from the previous year's study. Data from all the sites will be used to evaluate urban pesticide water quality trends.

2.0. OBJECTIVES

For Study 299 (FY 2019/2020), Northern California urban monitoring, the objectives are:

1) Identify the presence and concentrations of pesticide contamination in urban runoff and waterways;
2) Evaluate the magnitude of measured concentrations relative to water quality or aquatic toxicity thresholds;
3) At selected monitoring sites, determine the toxicity of water samples in laboratory toxicity tests conducted with *Hyalella azteca* and *Chironomus dilutus*;
4) Evaluate the effectiveness of surface water regulations or label changes through long-term (multi-year) monitoring at selected sampling locations;
5) Monitor the deposition of sediment-bound pyrethroids at long-term monitoring sites.

3.0 PERSONNEL

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

- Project Leader: Michael Ensminger, Ph.D.
- Field Coordinator: Scott Wagner
- Reviewing Scientist: Robert Budd, Ph.D.
- Statistician: Dan Wang, Ph.D.
- Laboratory Liaison: Sue Peoples
- Analytical Chemistry: Center for Analytical Chemistry, California Department of Food and Agriculture (CDFA)

Please direct questions regarding this study to Michael Ensminger, Senior Environmental Scientist (Specialist), at (916) 324-4186 or michael.ensminger@cdpr.ca.gov.

4.0 STUDY PLAN

4.1 Site Selection. Historically, sites for CDPR's Northern California urban monitoring project were selected based on various criteria with professional judgement accounting for a large portion of the final site selection (Ensminger, 2008). Now, the Surface Water Prioritization Model (SWMP) is used to identify priority areas for monitoring (Luo et al., 2017). SWMP incorporates pesticide use, aquatic toxicity, and population density data at the HUC12 watershed level (hydrological unit code; USGS, 2018a) to rank areas for monitoring by aggregating HUC12s into larger HUC8 watersheds.

SWMP limits personal bias although the numbers of pesticides to consider and HUC8 watersheds to incorporate into the model are still determined by the user. For this study, HUC12s were considered if they met the following criteria:

1) Contained in the nine Northern California HUC4s as defined in Luo et al. (2017);
2) Ranked in the top eight HUC8s by SWMP (based on final pesticide priority score of > 15 for urban pesticide use [structural pest control and landscape maintenance], see section 4.2);
3) Ranked in the top three mainstem or tributary type watersheds at the HUC12 level.

Using a ranking of > 15 allows for monitoring areas that have a higher potential for adverse risk to more sensitive aquatic organisms. Final HUC12 selection was then based on historical monitoring, fulfilling study objectives, site access and safety, budget constraints, exclusion of agricultural inputs, and distribution between top ranked HUC12s selected by the model. With the 2017 PUR data incorporated into the SWMP model, the top monitoring priority areas for FY 2019/2020 remain fairly constant from last year's protocol. The Sacramento and San Francisco Bay areas are the two main areas of Northern California where the highest levels of pesticide are expected in urban runoff. Of the top eight HUC8s, three are in the Sacramento area, four are in the San Francisco Bay area, and one in the San Joaquin Delta. High agricultural inputs into this HUC8 exclude it from urban monitoring (Appendix 1).

Surface water monitoring programs generally monitor at sites along creeks, rivers, lakes, or bays. In addition to these waterbodies, SWPP's urban monitoring program also monitors at storm drain outfalls. Because of lower dilution effects and proximity to the source of pesticide applications compared to waterbodies, storm drain outfalls tend to have higher pesticide detections and concentrations. Information from storm drain outfalls allows for a more direct measure of changes in residential neighborhoods (i.e., versus commercial, industrial, and other non-residential areas). Moreover, runoff samples tend to have less "non-detects," which facilitates more robust trend analyses.

4.1.1 Sacramento Area. The Sacramento area ranks higher than the San Francisco Bay area in the SWMP, with two top ranked HUC8s (Appendix 1), even given the much larger population in the San Francisco Bay area (California Department of Finance: Demographics, 2019). Monitoring will occur in these two top ranked HUC8s, in three HUC12 watersheds: Pleasant Grove Creek, Dry Creek, and Arcade Creek (Figure 1). Monitoring will occur at established mainstem creek sites in the Pleasant Grove Creek (PGC058) and Arcade Creek (ARC_ARC) watersheds (Appendix 2). The Arcade Creek site is near the USGS gage station 11447360, which will be used to calculate the percentage of the storm runoff sampled and to estimate mass loading. In the Dry Creek Watershed, the mainstem creek site will be moved approximately one mile downstream for FY 2019/2020. The move downstream will allow for more inputs from the city of Roseville storm drain system.

For FY 2019/2020, the Northern California Urban Monitoring Program will monitor three storm drain outfalls (27% of all sites), two in the Pleasant Grove Creek Watershed and one in the American River Watershed (Appendix 2; Figure 1). These sites have been monitored for at least eight years and are considered long-term monitoring sites, used for trend analysis. The American River Watershed (site FOL2) does not rank in the top three HUC12s for monitoring in SWMP as described in the criteria for HUC12 selection, but because of its sampling history, it will continue to be monitored.

4.1.2 San Francisco Bay Area. In the San Francisco Bay area, monitoring will continue at mainstem creek and rivers in three top ranked HUC8s (consisting of five HUC12 watersheds; Appendix 2, Figure 2). All these mainstem sites were monitored in FY 2018/2019, but two of these (Silver Creek and San Lorenzo HUC12s) have limited data due to issues as site access and autosampler failure. Major autosampler failures have been due to limited power of manufacturer's batteries, trash in waterways, and city changing gate locks. These issues have been resolved for FY 2019/2020. In the three other HUC12 watersheds (Walnut Creek, South San Ramon Creek, Guadalupe River), storm and dry season runoff samples were collected as planned in FY 2018/2019. The San Lorenzo and Guadalupe mainstem sites are at or near USGS gage stations, which will be used to calculate the percentage of the storm runoff sampled and to estimate mass loading.

4.1.3 Exploratory Sites. During FY 2019/2020, monitoring may include water samples from sites intended to establish future monitoring sites, broaden spatial distribution, investigate runoff from other sources, or collaborate with other monitoring studies. Monitoring will occur in top HUC12s (Figures 1, 2). Samples collected will be <10% of the total samples collected in FY 2019/2020.

4.2 Selection of Pesticides. For ambient monitoring, SWMP was used to assist in pesticide selection. SWMP is based on current use patterns (PUR 2015–2017), aquatic toxicity benchmarks, and physicochemical properties; the output is presented as a relative prioritization (final) score (Budd et al., 2013; Luo. 2015). The final score provides a guideline for monitoring. However, the decision to monitor a specific pesticide is influenced by other factors, including previous monitoring data, budgetary constraints, pesticide use patterns, and analytical capabilities.

For this study, pesticides that received a final score of nine or higher in SWMP for urban use (structural pest control and landscape maintenance) were considered for monitoring. Pesticides with lower scores have either low urban use and/or low potential toxicity and therefore were not considered high priority for monitoring. To increase the number of monitoring sites, the criteria used in previous monitoring were followed for final pesticide selection (Ensminger, 2018). Pesticides were selected based on the following criteria:

1) Reject any pesticides that receive a “false” recommendation in SWMP.
2) All pesticides with a final score > 18 will be monitored at all sites. This includes pyrethroids (e.g., bifenthrin, cyfluthrin, cypermethrin, deltamethrin, lambda-cyhalothrin, and permethrin), fipronil, and imidacloprid.
3) Pesticides with final scores between 9 and 18 will have reduced temporal and spatial monitoring. Long-term monitoring sites will include these pesticides for trend analysis. Other sites may include these pesticides if they fall into the same analytical screen as higher ranked pesticides (from 2 above)
4) Pesticides with a score of less than 9 will not be monitored unless they fall into the same analytical screen as 3 above.
5) Historical monitoring data, current use trends, CDFA analytical methods, sampling logistics, pesticide use patterns, and budget constraints were also used to decide a final monitoring list.

For Northern California, SWMP was used for two distinct geographical areas, Sacramento and San Francisco Bay. In Sacramento, SWMP selected 25 pesticides for monitoring with a final score $\geq$ 9. CDFA has analytical methods for 21 of these pesticides (Appendix 3). In the San Francisco Bay area, SWMP selected 29 pesticides; CDFA has methods for 23 of the pesticides (Appendix 4). SWPP will monitor all the selected pesticides with a CDFA analytical method except bromacil, chlorfenapyr, and tebuthiuron (see Appendix 5 excluded chemicals).

4.3 Water Sampling. Water samples will be collected from non-exploratory sites four times a year: two dry-season events and two rain events (Table 1). Dry season events will take place in August 2019 and in June 2020; rain events will occur in September–December (the first flush rainstorm of the 2019–2020 water year, if possible) and in the winter months (January–March). Water samples from exploratory sites may be monitored during a third storm during the rainy season. During dry-season monitoring, water samples will be collected as grab samples directly into 1-L amber bottles (Bennett, 1997). 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. During storm events, samples will be collected with Teledyne ISCO automatic 6700 series samplers. Aliquots of the entire storm sample will be collected as a composite sample (Jones, 2000). Samples will be transported on wet ice and then refrigerated at 4°C until analyzed.

4.4 Sediment Sampling. Sediments will be collected twice a year at sampling sites in Roseville and Folsom during the dry season (Table 1). Sediments will be collected using passive sampling techniques where practical but substituting 1-quart Mason glass jars with 1-quart stainless steel AirScape® (http://planetarydesign.com) containers (Budd et al., 2009). Otherwise, sediments will be collected with stainless steel scoops from the top bed layer (Mamola, 2005). Sediments will be sifted through a 2-mm sieve to remove gravel and plant material. Sediments will be analyzed for pyrethroids and total organic carbon.

4.5 Toxicity. Water samples will be collected from a subset of the sampling sites and sent to the University of California, Davis, Aquatic Health Program to be tested for toxicity to *H. azteca* and *C. dilutus*. Roseville long-term monitoring sites are the focus for toxicity testing because of historical testing at these sites.

4.6 Field Measurements. Water physicochemical properties (dissolved oxygen, electrical conductivity, pH, and temperature) will be measured *in situ* during all sampling events with a calibrated YSI EXO 1 multiparameter water quality sonde (https://www.ysi.com/productsdetail.php?EXO1-Water-Quality-Sonde-89). Flow data at or near sites at USGS gaging stations (Arcade Creek, Guadalupe River, and San Lorenzo Creek) will be utilized to estimate total loading of target pesticides (USGS, 2018b).

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 Modifications for FY 2019/2020. The current sampling plan is an extension of urban monitoring in Northern California (for details of previous sampling protocols, see http://www.cdpr.ca.gov/docs/emon/pubs/protocol.htm for Studies 269 and 299). The sampling and analysis schedule are similar to previous years. There are two main differences from FY 2018/2019:

1) Moving the Dry Creek monitoring site approximately one mile downstream to collect additional runoff from the city of Roseville; and
2) Setting up to six exploratory sites in ranked HUC12 watersheds to cultivate potentially new monitoring sites and to expand the knowledge of urban runoff in the Sacramento and San Francisco Bay areas.

5.0 LABORATORY ANALYSES

5.1. Chemical Analysis. CDFA will conduct pesticide analysis for water and sediment samples. CDFA will analyze up to 61 different pesticides and degradates in five different analytical screens (Appendixes 6 and 7). All 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.

5.2 Organic Carbon and Suspended Sediment Analysis. SWPP staff will analyze water samples for total organic carbon (TOC) and dissolved organic carbon (DOC) using a TOC-V CSH/CNS analyzer (Shimadzu Corporation, Kyoto, Japan) (Goh, 2011; Ensminger, 2013a). Water samples will also be analyzed for suspended sediment (Goh, 2010; Ensminger, 2013b). Sediment samples will be analyzed for TOC (Goodell, 2016).

6.0 DATA ANALYSIS

All data generated by this project will be entered to a Microsoft® Office Access database that holds site information, field measurements, and laboratory data since the project was initiated in 2008. All ambient monitoring analytical data will also be uploaded into the publicly-available CDPR Surface Water Database (SURF) (CDPR, 2018c). Toxicity data and water quality data are not accessible via SURF; however, they are available upon request. An annual report will be written to summarize detections, exceedances of aquatic life toxicity benchmarks (USEPA, 2018), and potential sediment toxicity. In the annual report, recommendations will be made for any follow-up, detailed data analysis for pesticides that consistently exceeded benchmarks.

7.0 TIMETABLE

Field Sampling:	August 2019–June 2020
Chemical Analysis:	August 2019–October 2020
Summary Report:	February 2021
SURF Data Upload:	June 2021

8.0 LABORATORY BUDGET

The estimated cost (for planning purposes) for the CDFA chemical analyses of water and sediment samples for ambient monitoring is $162,660 (Table 1).

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Table 1. Water and sediment monitoring for FY 2019/2020. For monitoring site information, see Appendix 2. For chemical screen information, see Appendixes 6 and 7.

Site	Analytical Screen	First Dry	Second Dry	First Storm	Second Storm	Other Storm**	Total	Cost/Sample	Budget
Water Samples									
PGC010 PGC022 PGC058 FOL2 ARC_ARC SRC_JD WAL_CA	DN	7	7	7	7	0	28	$840	$23,520
	LC*	7	7	7	7	0	28	$1,700	$47,600
	SA	7	7	7	7	0	28	$600	$16,800
	PY6	7	7	7	7	0	28	$600	$16,800
GUA_TRM SLV_KNG SLC_LA DRY_DW	LC*	4	4	4	4	0	16	$1,700	$27,200
	PY6	4	4	4	4	0	16	$600	$9,600
Exploratory Sites**	LC	0	0	0	0	6	6	$1,700	$10,200
	PY6	0	0	0	0	6	6	$600	$3,600
QC	DN	1				0	1	$840	$840
	LC	1				0	1	$1,700	$1,700
	SA	1				0	1	$600	$600
	PY6	1				0	1	$600	$600
Sediment Samples									
PGC010 PGC019 FOL2	PY6	3	3	0	0	0	6	$600	$3,600
Total									$162,660

*The budget is calculated on the LC “short” screen. The LC full screen may be used in up to 25% of the LC samples, which would add $7700 to the budget.

**Other storm, monitoring may occur during the first or second storm, or during third storm event. Exploratory sites will be monitored in collaborative research or by CDPR at new sites in the Sacramento and San Francisco Bay areas that could not be sampled in other storms due to sampling logistics.

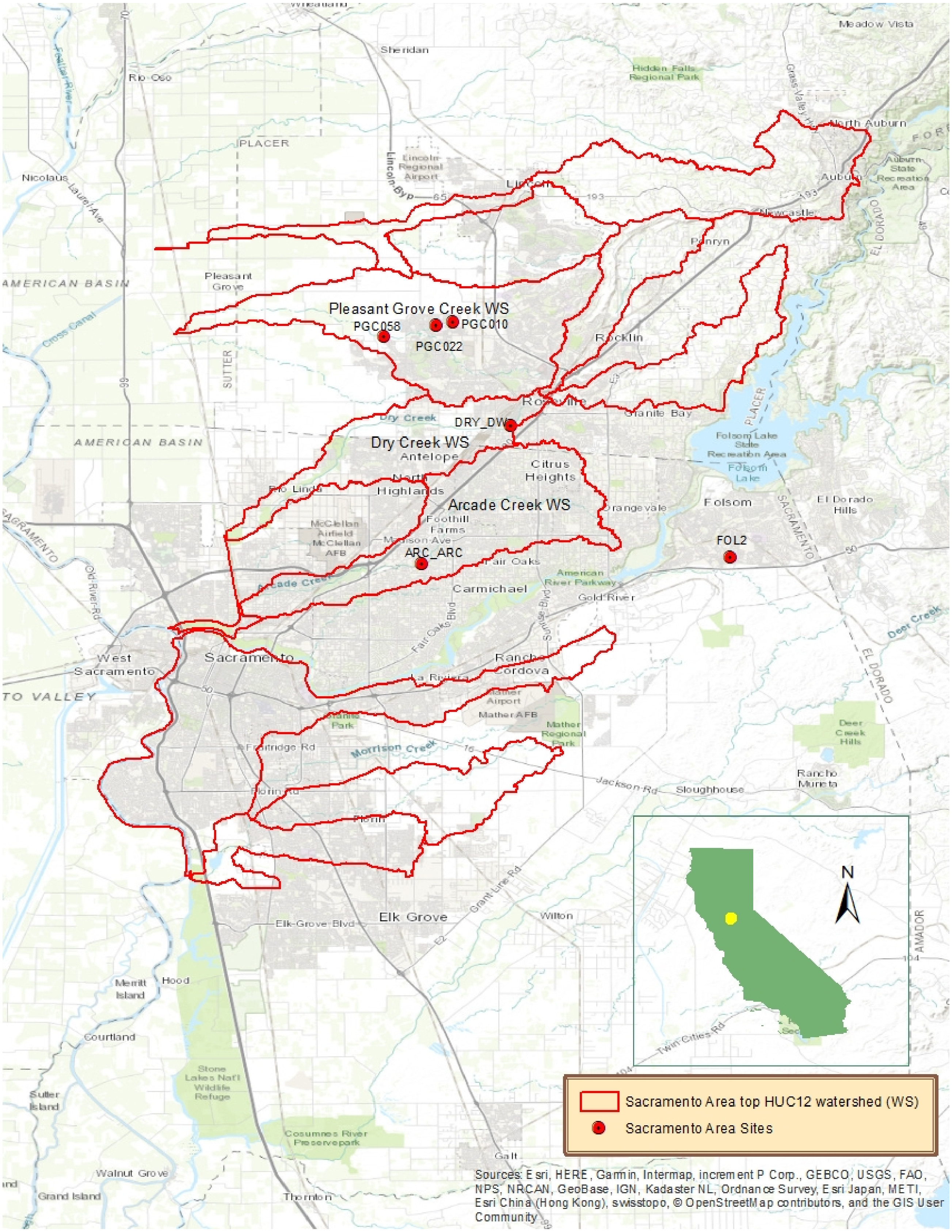

Figure 1. Sacramento area monitoring sites and top HUC12 watersheds for FY 2019/2020.

Figure 2. San Francisco Bay area monitoring sites and top HUC12 watersheds for FY 2019/2020.

Appendix 1. HUC12 selection for Northern California. Monitored HUC12 watersheds are highlighted.

HUC4	HUC8	HUC 8 Rank	HUC12*	HUC12 name	Type	Area**	CDPR Site Code***	Exclude pesticide due to agricultural inputs
1802	18020111	1	180201110102	Miners Ravine	Mainstem	SAC		
1802	18020111	1	180201110105	Gibson Lake-Dry Creek	Mainstem	SAC	DRY_DW	malathion
1802	18020111	1	180201110303	Lower Steelhead Creek	Mainstem	SAC		malathion, pendimethalin
1802	18020111	1	180201110103	Antelope Creek	Tributary	SAC		
1802	18020111	1	180201110302	Arcade Creek	Tributary	SAC	ARC_ARC	
1802	18020111	1	180201110105	Gibson Lake-Dry Creek	Tributary	SAC		
1802	18020161	2	180201610102	Dutch Ravine-Auburn Ravine	Mainstem	SAC		lambda-cyhalothrin, pendimethalin
1802	18020161	2	180201610302	Pleasant Grove Creek	Tributary	SAC	PGC010 PGC020 PGC058	
1802	18020161	2	180201610101	Orchard Creek	Tributary	SAC		
1802	18020161	2	180201610102	Dutch Ravine-Auburn Ravine	Tributary	SAC		
1805	18050003	3	180500030304	Guadalupe River	Mainstem	SFB	GUA_TRM	
1805	18050003	3	180500030202	Metcalfe Canyon-Coyote Creek	Mainstem	SFB		bifenthrin, cyfluthrin, lambda-cyhalothrin, malathion, pendimethalin
1805	18050003	3	180500030201	Silver Creek	Tributary	SFB	SLV_KNG	
1805	18050003	3	180500030302	Canoas Creek	Tributary	SFB		
1805	18050003	3	180500030304	Guadalupe River	Tributary	SFB		
1802	18020163	4	180201630404	Lower Morrison Creek	Mainstem	SAC		malathion, pendimethalin
1802	18020163	4	180201630404	Lower Morrison Creek	Tributary	SAC		
1802	18020163	4	180201630401	Elder Creek	Tributary	SAC		
1802	18020163	4	180201630701	Lake Greenhaven-Sacramento River	Tributary	SAC		
1805	18050004	5	180500040502	South San Ramon Creek	Mainstem	SFB	SRC_JD	
1805	18050004	5	180500040802	San Lorenzo Creek	Mainstem	SFB	SLC_LA	
1805	18050004	5	180500040203	Lower Arroyo Las Positas	Mainstem	SFB		diuron, imidacloprid, pendimethalin
1805	18050004	5	180500040903	Colma Creek-Frontal San Francisco Bay Estuaries	Tributary	SFB		
1805	18050004	5	180500040805	Sausal Creek-Frontal San Francisco Bay Estuaries	Tributary	SFB	Possible exploratory site	
1805	18050004	5	180500040501	Alamo Creek	Tributary	SFB		
1805	18050001	6	180500010204	Walnut Creek-Frontal Suisun Bay Estuaries	Mainstem	SFB	WAL_CA	
1805	18050001	6	180500010108	Laurel Creek-Frontal Suisun Bay	Tributary	SFB		
1805	18050001	6	180500010203	Pine Creek	Tributary	SFB	Possible exploratory site	

HUC4	HUC8	HUC 8 Rank	HUC12*	HUC12 name	Type	Area**	CDPR Site Code***	Exclude pesticide due to agricultural inputs
1805	18050001	6	180500010204	Walnut Creek-Frontal Suisun Bay Estuaries	Tributary	SFB		
1804	18040003	7	180400030303	McLeod Lake-Mormon Slough	Mainstem	SJD		bifenthrin, diuron, imidacloprid, lambda-cyhalothrin, malathion, pendimethalin, permethrin
1804	18040003	7	180400030702	Lower Marsh Creek	Mainstem	SJD		diuron, imidacloprid, pendimethalin
1804	18040003	7	180400030803	Dutch Slough-Big Break	Mainstem	SJD		bifenthrin, cypermethrin, diuron, imidacloprid, lambda-cyhalothrin, malathion, pendimethalin, permethrin
1804	18040003	7	180400030504	Fivemile Creek-San Joaquin River	Tributary	SJD		
1804	18040003	7	180400030403	Mosher Creek	Tributary	SJD		
1804	18040003	7	180400030902	Telephone Cut-Bishop Cut	Tributary	SJD		
1805	18050002	8	180500021001	Angel Island-San Francisco Bay Estuaries	Mainstem	SFB		
1805	18050002	8	180500020303	Lower Sonoma Creek	Mainstem	SFB		imidacloprid, malathion, pendimethalin
1805	18050002	8	180500020205	Lower Napa River	Mainstem	SFB		imidacloprid, malathion, pendimethalin
1805	18050002	8	180500020401	American Canyon Creek-Frontal San Pablo Bay Estuaries	Tributary	SFB		
1805	18050002	8	180500020702	Pinole Creek-Frontal San Pablo Bay Estuaries	Tributary	SFB		
1805	18050002	8	180500020904	Cerrito Creek-Frontal San Francisco Bay Estuaries	Tributary	SFB	Possible exploratory site	

*HUC12 watersheds are not ranked in SWMP; they are listed numerically here for each HUC8. HUC8 watersheds are ranked in SWMP.

**SAC, Sacramento area; SFB, San Francisco Bay area; SJD, San Joaquin Delta

***CDPR site codes, see Appendix 2

Appendix 2. Sampling site details for FY 2019/2020.

Site Id	Site Type*	Sample Type	Description	City	HUC12/Name	Site GPS Coordinates (NAD83)	
						Latitude	Longitude
PGC010	SD	Water Sediment	Outfall at Diamond Woods Circle,	Roseville	180201610302 Pleasant Grove Creek	38.80477	-121.32733
PGC022**	SD	Water Sediment	Outfall at Opal and Northpark Drive			38.802599	-121.338787
PGC058***	MS	Water	near Hayden Pkwy and Blue Oaks Blvd			38.79477	-121.37251
ARC_ARC	MS	Water	Arcade Creek at American River College	Sacramento	180201110302 Arcade Creek	38.645293	-121.347359
FOL2	SD	Water Sediment	Outfall at Brock Circle	Folsom	180201110202 Lower American	38.6503	-121.14494
DRY_DW	MS	Water	at Darling Way	Roseville	180201110105 Gibson Lake-Dry Creek	38.736134	-121.289163
WAL_CA	MS	Water	Walnut Creek near Concord Avenue	Concord	180500010204 Walnut Creek	37.980630	-122.0516
SLC_LA	MS	Water	San Lorenzo Creek at Lorenzo Avenue	San Leandro	180500040502 San Lorenzo	37.684572	-122.139337
SRC_JD	MS	Water	South San Ramon Creek at Johnson Drive	Pleasanton	180500040502 South San Ramon Creek	37.700976	-121.919837
GUA_TRM	MS	Water	Guadalupe River at Trimble Road	San Jose	180500030304 Guadalupe River	37.38062	-121.93802
SLV_KNG	MS	Water	Silver Creek at McKee Road and King Road	San Jose	180500030201 Silver Creek	37.35815	-121.861192

*SD, storm drain outfall; MS, mainstem on creek or river

**PGC022 sediment sampling will be downstream of the union of PGC021 and PGC022 (reported as PGC019)

***If there is no measurable runoff at PGC058, water will be collected at PGC040 (38.79857, -121.34802) to be consistent with previous years

Appendix 3. Priority pesticides for the Sacramento area based on the lowest toxicity value. Listed, pesticides with priorities greater or equal to the priority score of 9, with a “TRUE” monitoring recommendation from SWMP (based on acute toxicity). Priority model does not include homeowner pesticide use.

Pesticides with available analytical methods (CDFA)						
Pesticide	CDFA Screen*	2015-2017 Average Use (lb ai)	Use Score	Benchmark (µg/L)	Tox Score	Final Score
Bifenthrin	PY	10552	5	0.07	6	30
Permethrin	PY	13421	5	0.01	6	30
Deltamethrin	PY	5763	4	0.05	6	24
Lambda-Cyhalothrin	PY	1436	3	0.0035	7	21
Cypermethrin	PY	1839	4	0.19	5	20
Fipronil	LC	5957	4	0.11	5	20
Imidacloprid	LC	6495	4	0.38	5	20
Cyfluthrin	PY	1521	3	0.01	6	18
Pendimethalin	DN	4342	4	5.2	4	16
Prodiamine	DN	1628	4	6.5	4	16
Oryzalin	LC	12693	5	13	3	15
Chlorfenapyr**	CF	1252	3	2.91	4	12
Diuron	LC	1110	3	2.4	4	12
Isoxaben	LC	776	3	10	4	12
Trifluralin	DN	420	3	9.25	4	12
Esfenvalerate	PY	72	2	0.02	6	12
Carbaryl	LC	178	2	0.85	5	10
Oxyfluorfen	DN	121	2	0.29	5	10
Propiconazole	LC	640	3	21	3	9
Tebuthiuron**	PI	1076	3	50	3	9
Triclopyr	SA	1357	3	100	3	9
Pesticides with no analytical methods for surface water (CDFA) - these pesticides will not be monitored						
Dithiopyr		2702	4	20	3	12
Sulfometuron-methyl		239	2	0.45	5	10
Dichlobenil***		480	3	30	3	9
Mecoprop-P		619	3	14	3	9

*CF, chlorfenapyr; DN, dinitroaniline herbicides + oxyfluorfen; LC, LC multi-analyte screen; PI, photosynthetic inhibitor herbicide; PY, pyrethroid; SA, synthetic auxin herbicides. For method information, see http://cdpr.ca.gov/docs/emon/pubs/em_methd_main.htm

**Will not be monitored, see Appendix 5

***Dichlobenil product used in Sacramento area is only registered for sewer mains and drain lines (USEPA, 2018)

Appendix 4. Priority pesticides for San Francisco Bay area sampling sites. Listed, pesticides with priorities greater or equal to the priority score of 9, with a “TRUE” monitoring recommendation from SWMP (based on acute toxicity). Priority model does not include homeowner pesticide use.

Pesticide	CDFA Screen*	3 Yr Average Use (lb ai)	Use Score	Benchmark (µg/L)	Tox Score	Final Score
Pesticides with available analytical methods (CDFA)						
Permethrin	PY	22097	5	0.01	6	30
Bifenthrin	PY	5264	4	0.07	6	24
Cyfluthrin	PY	3214	4	0.01	6	24
Deltamethrin	PY	7780	4	0.05	6	24
Lambda-Cyhalothrin	PY	1185	3	0.0035	7	21
Fipronil	LC	13784	4	0.11	5	20
Imidacloprid	LC	6906	4	0.38	5	20
Diuron	LC	4131	4	2.4	4	16
Pendimethalin	DN	5400	4	5.2	4	16
Cypermethrin	PY	2497	3	0.19	5	15
Bromacil**	LC	1577	3	6.8	4	12
Chlorantraniliprole	LC	1131	3	4.9	4	12
Chlorfenapyr**	CF	1415	3	2.91	4	12
Esfenvalerate	PY	86	2	0.02	6	12
Isoxaben	LC	1289	3	10	4	12
Prodiamine	DN	1344	3	6.5	4	12
Triclopyr	SA	5377	4	100	3	12
Trifluralin	DN	782	3	9.25	4	12
Carbaryl	LC	182	2	0.85	5	10
Oxyfluorfen	DN	113	2	0.29	5	10
Pyriproxyfen	LC	231	2	0.18	5	10
Indoxacarb	LC	1365	3	84	3	9
Oryzalin	LC	2169	3	13	3	9
Pesticides with no analytical methods for surface water (CDFA) - these pesticides will not be monitored						
Chlorsulfuron		63	2	0.35	5	10
Fenamiphos***		59	2	0.95	5	10
Sulfometuron-methyl		178	2	0.45	5	10
Dithiopyr		1178	3	20	3	9
PCNB		2174	3	50	3	9
Spinosad		1334	3	90	3	9

*CF, chlorfenapyr; DN, dinitroaniline herbicides + oxyfluorfen; LC, multi-analyte screen; PY, pyrethroid; SA, synthetic auxin herbicides. See http://cdpr.ca.gov/docs/emon/pubs/em_methd_main.htm

**Will not be monitored, Appendix 5

*** No registered products in California

Appendix 5. SWMP selected pesticides excluded from monitoring in Northern California

BROMACIL in the San Francisco Bay Area

The PUR data used in the SWMP model shows that bromacil has limited use in the San Francisco Bay area. It was mainly used (99.8% of reported use in 2017) in Contra Costa County by one pesticide company for landscape applications (CDPR, 2018a). Bromacil products are not available for non-professional use (Budd and Peters, 2018; Osienski et al., 2010). In addition, bromacil has been monitored 584 times in 2008–2019 in SWPP's urban monitoring programs with only one detection (in Alameda County at a mixed urban/agricultural site). Bromacil will not be monitored until its urban use becomes more widespread.

CHLORFENAPYR in the San Francisco Bay and Sacramento Areas

The major chlorfenapyr product used in California (>99% PUR reported use) is a termiticide, applied with trenching, trenching and rodding, or inside buildings and crawl spaces, with limited exterior application to structures via crack and crevice or spot applications (CDPR, 2018a; CMDS, 2019). These application methods are not likely to end up in surface water, and chlorfenapyr is not available for non-professional use in California (Budd and Peters, 2018; Osienski et al., 2010). In 2014–2017, chlorfenapyr has been monitored for 68 times in urban areas without being detected (CDPR, 2018c). Recently, however, it was detected at one storm drain site in 15 water samples in Southern California (Budd, 2018). This pesticide will continued to be tracked in CDPR's Southern California Urban Monitoring Program.

TEBUTHIURON in the Sacramento Area

Tebuthiuron was selected by SWMP solely for its PUR reported use in Sacramento County. It is a herbicide used in non-crop areas as rangeland, airport runways, rights-off-ways, and under asphalt and concrete pavements. It is not registered for residential use, thus there are no non-professional use products in California (Budd and Peters, 2018; Osienski et al., 2010). In Sacramento County, 1996–2018, tebuthiuron has been monitored 815 times with 22 detections (3% detection frequency [DF]) (CDPR, 2018c). More specifically for this study, tebuthiuron has been monitored 203 times in Arcade Creek (the only Sacramento County site for Study 299), with 19 detections, most recently in 2004. In 2005-2018, it was not detected in Arcade Creek in 55 samples, even with an increasing trend in use (CDPR, 2018a). Tebuthiuron has never been detected in California at concentrations above its lowest USEPA benchmark (50 µg/L) (CDPR, 2018c). It is likely that tebuthiuron could be detected in future monitoring, albeit at low DFs. However, it will not be monitored unless it is incorporated into a CDFA multi-analyte analytical screen.

Appendix 6. Chemical analysis of pesticides in Northern California urban monitoring Study 299. CDFA will analyze all water samples. Specific methods can be found at http://www.cdpr.ca.gov/docs/emon/pubs/em_methd_main.htm.

Analyte Screen (Method ID)	Pesticide	Reporting Limit (µg L^{-1})	Method Detection Limit (µg L^{-1})
Dinitroaniline (DN) (EMON-SM-05-006)	oxyfluorfen	0.05	0.010
	pendimethalin	0.05	0.012
	prodiamine	0.05	0.012
	trifluralin	0.05	0.014
LC-multi screen (LC) (EMON-SM-05-037)	abamectin	0.02	0.004
	atrazine	0.02	0.004
	azoxystrobin	0.02	0.004
	bensulide	0.02	0.004
	bromacil	0.02	0.004
	carbaryl	0.02	0.004
	chlorantraniliprole	0.02	0.004
	chlorpyrifos	0.02	0.004
	cyprodinil	0.02	0.004
	desulfinyl fipronil	0.01	0.004
	desulfinyl fipronil amide	0.01	0.004
	diazinon	0.02	0.004
	diflubenzuron	0.02	0.004
	dimethoate	0.02	0.004
	diuron	0.02	0.004
	ethoprop	0.02	0.004
	etofenprox	0.02	0.004
	fipronil	0.01	0.004
	fipronil amide	0.01	0.004
	fipronil sulfide	0.01	0.004
	fipronil sulfone	0.01	0.004
	hexazinone	0.02	0.004
	imidacloprid	0.01	0.004
	indoxacarb	0.02	0.004
	isoxaben	0.02	0.004
	kresoxim-methyl	0.02	0.004
	malathion	0.02	0.004
	methidathion	0.02	0.004
	methomyl	0.02	0.004
	methoxyfenozide	0.02	0.004
	metribuzin	0.02	0.004
	norflurazon	0.02	0.004
	oryzalin	0.02	0.004
	oxadiazon	0.02	0.004
	prometon	0.02	0.004
	prometryn	0.02	0.004
	propanil	0.02	0.004
	propargite	0.02	0.004
	propiconazole	0.02	0.004
	pyraclostrobin	0.02	0.004
	pyriproxyfen	0.015	0.004
	quinoxyfen	0.02	0.004
	simazine	0.02	0.004
	s-metolachlor	0.02	0.004
	tebufenozide	0.02	0.004

Analyte Screen (Method ID)	Pesticide	Reporting Limit ($\mu g\ L^{-1}$)	Method Detection Limit ($\mu g\ L^{-1}$)
Pyrethroid (PY-6) (EMON-SM-05-022)	bifenthrin	0.001	0.00091
	cyfluthrin	0.002	0.00146
	cypermethrin	0.005	0.00154
	deltamethrin/tralomethrin	0.005	0.00177
	esfenvalerate/fenvalerate	0.005	0.00166
	lambda-cyhalothrin	0.002	0.00174
	permethrin cis	0.002	0.00105
	permethrin trans	0.005	0.00105
Synthetic Auxin Herbicides (SA) EMON-SM-05-012)	2,4-D	0.05	0.015
	dicamba	0.05	0.017
	MCPA	0.05	0.022
	triclopyr	0.05	0.020

Appendix 7. Chemical analysis of pyrethroids in Northern California urban monitoring Study 299. CDFA will analyze sediment samples (Method EMON-SM 52-9; https://www.cdpr.ca.gov/docs/emon/pubs/anl_methds/imeth_292.pdf).

Pesticide	Method Detection Limit (ng g^{-1} dry wt)	Reporting Limit (ng g^{-1} dry wt)
Bifenthrin	0.1083	1.0
Cyfluthrin	0.183	1.0
Cypermethrin	0.107	1.0
Deltamethrin/Tralomethrin	0.0661	1.0
Esfenvalerate/Fenvalerate	0.143	1.0
Lambda-cyhalothrin	0.1154	1.0
Permethrin cis	0.1159	1.0
Permethrin trans	0.1352	1.0