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STUDY 329: Surface Water Monitoring for Pesticides in Urban Areas of Northern California (FY 2020/2021)

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1.0 INTRODUCTION

Pesticides are commonly applied in urban areas. More than two and a half million pounds of pesticides per year are reported for structural and landscape applications in the California Department of Pesticide Regulation (CDPR) Pesticide Use Reporting Database (PUR) (CDPR, 2020a). 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 (Budd et al, 2020; 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, 2020b; UC ANR, 2019, USEPA, 2017a, b, c).

To determine 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, 2020; 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 329 is a continuation of CDPR's urban monitoring in Northern California from FY 2019/2020 (Ensminger, 2019). 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 changes: automated samplers were employed to capture runoff from an entire storm event rather than taking grab samples during expected high runoff peaks (Ensminger, 2018). This change was prompted by the CDPR's recent evaluation of its urban monitoring program (Ensminger et al., 2017). The FY 2020/2021 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 329 (FY 2020/2021), 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 concentration 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 Jennifer Teerlink, Environmental Program Manager I. Key personnel are listed below:

- Project Leader: Riley Smith
- Field Coordinator: Ameneh Tavakol, Ph.D.
- Reviewing Scientist: Michael Ensminger, Ph.D.
- Statistician: Dan Wang, Ph.D.
- Laboratory Liaison: Aniela Burant, Ph.D.
- Analytical Chemistry: Center for Analytical Chemistry, California Department of Food and Agriculture (CDFA)

Please direct questions regarding this study to Riley Smith, Environmental Scientist, at Riley.Smith@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 Monitoring 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 Hydrological Unit Code 12 (HUC;

USGS, 2020a) watershed level 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]);
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 updated PUR data incorporated into the SWMP model, the top monitoring priority areas for FY 2020/2021 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-ranked HUC8s, three are in the Sacramento area and three are in the San Francisco Bay area (Appendix 1).

Surface water monitoring programs generally monitor at urban creeks or rivers. 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, 2020). Monitoring will occur in these two top ranked HUC8s, in three HUC12 watersheds: Pleasant Grove Creek, Miner's Ravine, 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. Sampling sites at or near USGS gage stations allow for a QC check on storm runoff collection percentage and can be used to estimate mass loading. In the Miner's Ravine Watershed, the mainstem creek site will be moved upstream from Dry Creek for FY 2020/2021. The move upstream will allow for sampling closer to urban sources.

For FY 2020/2021, the Northern California Urban Monitoring Program will monitor three storm drain outfalls (27% of all regular [non-exploratory] 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 nine 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 creeks and rivers in three top ranked HUC8s (consisting of five HUC12 watersheds; Appendix 2, Figure 2). All these mainstem sites were monitored in the past few years, but three of these (Guadalupe River, Silver Creek and San Lorenzo Creek HUC12s) have limited storm runoff data collected by autosamplers due to issues with site access, autosampler failure, and staffing resource. In the two other HUC12 watersheds (Walnut Creek and South San Ramon Creek), autosampler collection has been successful and began to provide sufficient data to better understand the storm runoff profile. The San Lorenzo and Guadalupe sites are also important for quality control check of the autosampler collection. These sites are at or near USGS gage stations, which allows SWPP staff to calculate the percentage of the storm runoff sampled. Insufficient storm water sampling could mark the storm samples as of poor quality for a storm composite sample.

4.1.3 Exploratory Sites. During FY 2020/2021, monitoring may include water samples from sites intended to establish future monitoring sites in collaboration with the San Francisco Estuary Institute (SFEI), broaden spatial distribution, investigate runoff from other sources, or collaborate with other monitoring studies. Monitoring will occur in top ranked HUC12s (Figures 1, 2). Samples collected will be <15% of the total samples collected in FY 2020/2021.

4.2 Selection of Pesticides. For ambient monitoring, SWMP was used to assist in pesticide selection. SWMP is based on current use patterns, 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 unless: 1) they received a "false" recommendation in SWMP, based on the pesticides physiochemical properties, and are not likely to cause surface water toxicity; 2) there is no CDFA analytical method; 3) previous monitoring results had few detections, or 4) their use pattern is not likely to runoff into surface water. Pesticides with a score of less than 9 will not be monitored unless they fall into the same analytical screen as higher ranking pesticides. Other pesticides that received final scores less than 9 have either low urban use and/or low potential toxicity; therefore these were not considered high priority for monitoring.

The Sacramento and San Francisco Bay areas were modeled separately in SWMP as two distinct geographical areas. In Sacramento, SWMP selected 23 pesticides for monitoring with a final score ≥ 9. CDFA has analytical methods for 19 of these pesticides (Appendix 3). In the San Francisco Bay area, SWMP selected 30 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 and fenamiphos (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 2020 and in June 2021; rain events will occur in September–December (the first flush rainstorm of the 2020–2021 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 usually be collected with Teledyne ISCO automatic 6700 series samplers unless resource is lacking; in these cases, grab samples may be substituted. For ISCO samplers, time-weighted 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. In the Sacramento area, 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 by substituting 1-quart Mason glass jars with 1-quart stainless steel AirScape® (http://planetarydesign.com) containers (Budd et al., 2009). In the San Francisco Bay area, at two sites, sediments will be collected once in the Fall of 2020. Sediments will be collected with stainless steel scoops from the top bed layer (Mamola, 2005). Other sites in the San Francisco Bay area where sediments can be collected are currently monitored through the SPOT monitoring program (SWRCB, 2020). All sediments will be sifted through a 2-mm sieve to remove gravel and plant material and 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 monitoring sites and joint SPOT-CDPR sampling 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 storm percentage completion (USGS, 2020b).

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 2020/2021. 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 three main differences from FY 2019/2020:

1) Establishing a new monitoring site closer to urban sources in Roseville in the Miner's Ravine watershed to replace the previous Dry Creek site;
2) Collecting sediment samples at two sites in the San Francisco Bay area; and
3) Expanding exploratory sites in ranked HUC12 watersheds to cultivate potentially new monitoring sites through a collaboration with the San Francisco Estuary Institute (SFEI) which will expand the knowledge of urban runoff in the San Francisco Bay area. Exploratory sites in the Sacramento area may also be investigated to new areas or sources of urban runoff.

5.0 LABORATORY ANALYSES

5.1. Chemical Analysis. CDFA will conduct pesticide analysis for water and sediment samples. CDFA will analyze up to 74 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 (Peoples, 2019). 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 state-wide project was initiated in 2008. All ambient monitoring analytical, toxicity, and water quality data will also be uploaded into the publicly-available CDPR Surface Water Database (SURF) (CDPR, 2018c). Toxicity 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, 2020), and potential sediment toxicity; upon completion the report will be available at CDPR Environmental Monitoring's Study Report web page (https://www.cdpr.ca.gov/docs/emon/pubs/ehapreps.htm?filter=surfwater). In the annual report, recommendations will be made for any follow-up or detailed data analysis for pesticides that consistently exceeded benchmarks.

7.0 TIMETABLE

Field Sampling:	August 2020–June 2021
Chemical Analysis:	August 2020–October 2021
Summary Report:	February 2022
SURF Data Upload:	August 2022

8.0 LABORATORY BUDGET

SWPP requests that CDFA analyze 224 water samples and 11 sediment samples over four monitoring events for Study 329, FY2020/2011 (Table 1).

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Table 1. Water and sediment monitoring for FY 2020/2021. For monitoring site information, see Appendix 2. For chemical screen information, see Appendices 6 and 7.

Site	Analytical Screen	First Dry	Second Dry	First Storm	Second Storm	Other Storm	Total Samples
ARC_ARC	DN, LC, PYW, SA	4	4	4	4	0	16
FOL2	DN, LC, PYS, PYW, SA	5	5	4	4	0	18
MIN_MR	DN, LC, PYW, SA	4	4	0/4	0/4	0	8-16
PGC010	DN, LC, PYS, PYW, SA	5	5	4	4	0	18
PGC019/022	DN, LC, PYS, PYW, SA	5	5	4	4	0	18
PGC058	DN, LC, PYW, SA	4	4	4	4	0	16
GUA_TRM	DN, LC, PYW, SA	4	4	4	4	0	16
SLC_LA	DN, LC, PYW, SA	4	4	4	4	0	16
SLV_KNG	DN, LC, PYS, PYW, SA	5	5	4	4	0	18
SRC_JD	DN, LC, PYS, PYW, SA	5	5	4	4	0	18
WAL_CA	DN, LC, PYW, SA	4	4	4	4	0	16
Exploratory (up to 8 sites)	DN, LC, PYW, SA	0	0	0	0	32	32
QC	DN, LC, PYS, PYW, SA	5	4	4	4	0	17
Total		53	53	48	48	32	227-235

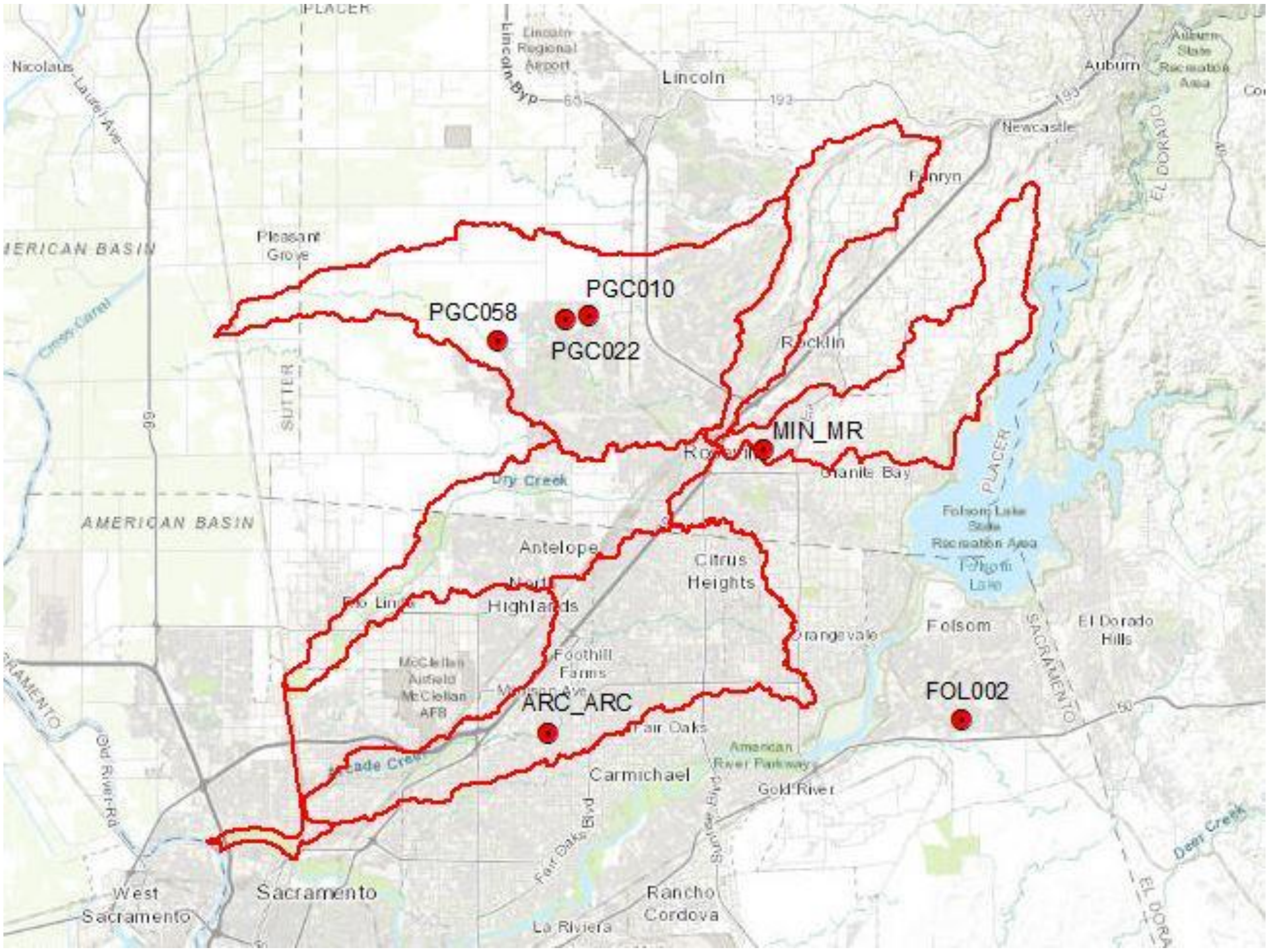

Figure 1. Sacramento area monitoring sites and top HUC12 watersheds for FY 2020/2021.

Figure 2. San Francisco Bay area monitoring sites and top HUC12 watersheds for FY 2020/2021.

Appendix 1. HUC12 selection for Northern California. Monitored HUC12 watersheds contain a double asterisk (**) next to the HUC12 name. See Appendix 2 for site codes and HUC12 information. For area, SAC = Sacramento and SFB = San Francisco Bay area.

HUC4	HUC8	HUC 8 Rank	HUC12	HUC12 name	Type	Area	CDPR Site Code	Exclude pesticide due to agricultural inputs
1802	18020111	1	180201110105	Gibson Lake-Dry Creek	Mainstem	SAC		
1802	18020111	1	180201110102	Miners Ravine**	Mainstem	SAC	MIN_MR	
1802	18020111	1	180201110303	Lower Steelhead Creek	Mainstem	SAC		
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	180500040501	Alamo Creek	Tributary	SFB		
1805	18050004	5	180500040502	South San Ramon Creek**	Tributary	SFB	SRC_JD	
1805	18050001	6	180500010204	Walnut Creek-Frontal Suisun Bay Estuaries**	Mainstem	SFB	WAL_CA	
1805	18050001	6	180500010203	Pine Creek	Tributary	SFB		
1805	18050001	6	180500010204	Walnut Creek-Frontal Suisun Bay Estuaries**	Tributary	SFB	WAL_CA	
1805	18050001	6	180500010301	Kirker Creek-Frontal Suisun Bay Estuaries	Tributary	SFB		
1805	18050002	7	180500021001	Angel Island-San Francisco Bay Estuaries	Mainstem	SFB		

HUC4	HUC8	HUC 8 Rank	HUC12	HUC12 name	Type	Area	CDPR Site Code	Exclude pesticide due to agricultural inputs
1805	18050002	7	180500020303	Lower Sonoma Creek	Mainstem	SFB		imidacloprid, malathion, pendimethalin
1805	18050002	7	180500020205	Lower Napa River	Mainstem	SFB		imidacloprid, malathion, pendimethalin
1805	18050002	7	180500020702	Pinole Creek-Frontal San Pablo Bay Estuaries	Tributary	SFB		
1805	18050002	7	180500020904	Cerrito Creek-Frontal San Francisco Bay Estuaries	Tributary	SFB		

Appendix 2. Sampling site details for FY 2020/2021. For site type, SD = storm drain outfall; MS = mainstem 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.

Site Code	Site Type	Sample Type	Description	City	HUC12/Name	Latitude GPS Coordinates (NAD83)	Longitude GPS Coordinates (NAD83)
PGC010	SD	Water Sediment	Outfall at Diamond Woods Circle	Roseville	180201610302 Pleasant Grove Creek	38.80477	-121.32733
PGC022	SD	Water	Outfall at Opal and Northpark Drive	Roseville	180201610302 Pleasant Grove Creek	38.802599	-121.338787
PGC019	SD	Sediment	Combination of outfalls at Opal and Northpark Drive (this site may also substitute for PGC022 if limited runoff)	Roseville	180201610302 Pleasant Grove Creek	38.80248	-121.3386
PGC058	MS	Water	near Hayden Pkwy and Blue Oaks Blvd	Roseville	180201610302 Pleasant Grove Creek	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
MIN_MR	MS	Water	Miner’s Ravine at Orvietto Drive (tentative Miner’s Ravine site)	Roseville	180201110102 Miner’s Ravine	38.752947	-121.241557
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

Appendix 3. Priority pesticides for the Sacramento area based on the acute 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. Screen codes: DN, dinitroaniline herbicides, oxyfluorfen, and chlorfenapyr; LC, LC multi-analyte; 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. For pesticides with an analytical method but not monitored, see Appendix 5.

Pesticide	CDFA Screen*	2016-2018 Average Use (lb ai)	Use Score	Benchmark (µg/L)	Tox Score	Final Score	Monitored?
Permethrin	PY	6308	5	0.01	6	30	Y
Deltamethrin	PY	5869	4	0.05	6	24	Y
Bifenthrin	PY	5601	4	0.07	6	24	Y
Lambda-cyhalothrin	PY	867	3	0.0035	7	21	Y
Chlorantraniliprole	LC	7850	5	4.9	4	20	Y
Imidacloprid	LC	4936	4	0.38	5	20	Y
Fipronil	LC	4297	4	0.11	5	20	Y
Cypermethrin	PY	1892	4	0.19	5	20	Y
Cyfluthrin	PY	1587	3	0.01	6	18	Y
Pendimethalin	DN	4071	4	5.2	4	16	Y
Prodiamine	DN	1673	4	6.5	4	16	Y
Oryzalin	LC	9176	5	13	3	15	Y
Dithiopyr	None	2702	4	20	3	12	N
Diuron	LC	929	3	2.4	4	12	Y
Chlorfenapyr	DN	725	3	2.91	4	12	Y
Isoxaben	LC	698	3	10	4	12	Y
Esfenvalerate	PY	107	2	0.02	6	12	Y
Oxyfluorfen	DN	148	2	0.29	5	10	Y
Sulfometuron-methyl	None	239	2	0.45	5	10	N
Dichlobenil	None	480	3	30	3	9	N
Mecoprop-P	None	619	3	14	3	9	N
Triclopyr	SA	1406	3	100	3	9	Y
Propiconazole	LC	785	3	21	3	9	Y

Appendix 4. Priority pesticides for San Francisco Bay area sampling sites based on the acute 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. Screen codes: DN, dinitroaniline herbicides, oxyfluorfen, and chlorfenapyr; LC, LC multi-analyte; OP, organophosphate, 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. For pesticides with an analytical method but not monitored, see Appendix 5.

Pesticide	CDFA Screen*	2016-2018 Average (lb ai)	Use Score	Benchmark (µg/L)	Tox Score	Final Score	Monitored?
Permethrin	PY	9530	5	0.01	6	30	Y
Bifenthrin	PY	5366	4	0.07	6	24	Y
Lambda-Cyhalothrin	PY	1525	3	0.0035	7	21	Y
Fipronil	LC	9111	4	0.11	5	20	Y
Imidacloprid	LC	4838	4	0.38	5	20	Y
Cyfluthrin	PY	2100	3	0.01	6	18	Y
Deltamethrin	PY	2094	3	0.05	6	18	Y
Pendimethalin	DN	4657	4	5.2	4	16	Y
Diuron	LC	2830	4	2.4	4	16	Y
Cypermethrin	PY	1371	3	0.19	5	15	Y
Triclopyr	SA	5158	4	100	3	12	Y
Oryzalin	LC	2312	4	13	3	12	Y
Prodiamine	DN	1452	3	6.5	4	12	Y
Chlorfenapyr	DN	1441	3	2.91	4	12	Y
Bromacil	LC	1255	3	6.8	4	12	N
Isoxaben	LC	1060	3	10	4	12	Y
Oxadiazon	LC	494	3	5.2	4	12	Y
Trifluralin	DN	464	3	9.25	4	12	Y
Esfenvalerate	PY	94	2	0.02	6	12	Y
Chlorsulfuron	None	63	2	0.35	5	10	N
Fenamiphos	OP	59	2	0.95	5	10	N
Sulfometuron-methyl	None	178	2	0.45	5	10	N
Carbaryl	LC	236	2	0.85	5	10	Y
Oxyfluorfen	DN	99	2	0.29	5	10	Y
Pyriproxyfen	LC	73	2	0.18	5	10	Y
Dithiopyr	None	1178	3	20	3	9	N
PCNB	None	2174	3	50	3	9	N
Spinosad	None	1334	3	90	3	9	N
Indoxacarb	LC	1036	3	84	3	9	Y
Propiconazole	LC	914	3	21	3	9	Y

Appendix 5. SWMP selected pesticides with a CDFA analytical method 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 (94% of reported use) in Contra Costa County by one pesticide company for landscape applications (CDPR, 2020a). Bromacil products are not available for non-professional use (Budd and Peters, 2018; Osienski et al., 2010). Bromacil has been monitored in over 700 samples in 2008–2019 in SWPP's urban monitoring program with only four detections (one detection in the San Francisco Bay area at a mixed urban/agricultural site). Bromacil will not be monitored until its urban use becomes more widespread.

FENAMIPHOS in the San Francisco Bay Area

Fenamiphos has no registered products in California. Nonetheless, it was reported twice in landscape applications in San Manteo County in 2016-2017 (CDPR, 2020a). These two limitations preclude it from sampling.

Appendix 6. Chemical analysis of pesticides in Northern California urban monitoring Study 329. 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 (ng L^{-1})	Method Detection Limit (ng L^{-1})
Dinitroaniline (DN) (EMON-SM-05-006)	chlorfenapyr	100	33.3
	oxyfluorfen	50	10
	pendimethalin	50	12
	prodiamine	50	12
	trifluralin	50	14
LC-multi screen (LC) (EMON-SM-05-037)	abamectin	20	4
	acetamiprid	20	4
	atrazine	20	4
	azoxystrobin	20	4
	bensulide	20	4
	boscalid	20	4
	bromacil	20	4
	carbaryl	20	4
	chlorantraniliprole	20	4
	chlorpyrifos	20	4
	clothianidin	20	4
	cyprodinil	20	4
	desulfinyl fipronil	10	4
	desulfinyl fipronil amide	10	4
	diazinon	20	4
	diflubenzuron	20	4
	dimethoate	20	4
	diuron	20	4
	ethoprop	20	4
	etofenprox	20	4
	fenamidone	20	4
	fenhexamid	20	4
	fipronil	10	4
	fipronil amide	10	4
	fipronil sulfide	10	4
	fipronil sulfone	10	4
	fludioxonil	20	4
	hexazinone	20	4
	imidacloprid	10	4
	indoxacarb	20	4
	isoxaben	20	4
	kresoxim-methyl	20	4
	malathion	20	4
	methidathion	20	4
	methomyl	20	4
	methoxyfenozide	20	4
	metribuzin	20	4
	norflurazon	20	4
	oryzalin	20	4
	oxadiazon	20	4
	prometon	20	4
	prometryn	20	4
	propanil	20	4

Analyte Screen (Method ID)	Pesticide	Reporting Limit (ng L^{-1})	Method Detection Limit (ng L^{-1})
	propargite	20	4
	propiconazole	20	4
	pyraclostrobin	20	4
	pyriproxyfen	15	4
	quinoxyfen	20	4
	simazine	20	4
	s-metolachlor	20	4
	tebuconazole	20	4
	tebufenozide	20	4
	tebuthiuron	20	4
	thiabendazole	20	4
	thiacloprid	20	4
	thiamethoxam	20	4
	trifloxystrobin	20	4
Pyrethroid (PYW) (EMON-SM-05-022)	bifenthrin	1	0.91
	cyfluthrin	2	1.46
	cypermethrin	5	1.54
	deltamethrin/tralomethrin	5	1.77
	esfenvalerate/fenvalerate	5	1.66
	lambda-cyhalothrin	2	1.74
	permethrin cis	2	1.05
	permethrin trans	5	1.05
Synthetic Auxin Herbicides (SA) EMON-SM-05-012)	2,4-D	50	15
	dicamba	50	17
	MCPA	50	22
	triclopyr	50	20

Appendix 7. Chemical analysis of pyrethroids in Northern California urban monitoring Study 329. CDFA will analyze sediment samples (Method EMON-SM 52-9 [PYS]; 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