Report of Stressor/Source Identification Studies in Dry Creek and Grayson Creek Part B

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Prepared for

Contra Costa Clean Water Program

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Introduction / Regulatory Background

This report documents Part B of the phased efforts of Contra Costa Clean Water Program (CCCWP) to fulfill Municipal Stormwater Permit requirements[1] for implementation of stressor/ source identification (SSID) studies per Permit Provision C.8.d.i, based on creek status monitoring performed in compliance with Permit Provision C.8.c. The SSID studies also complement the work being undertaken by CCCWP to fulfill requirements under Permit Provision C.9 (Pesticides Toxicity Control). Armand Ruby Consulting (ARC), under subcontract to ADH Environmental, was contracted to support CCCWP in fulfilling the Permit requirements for SSID studies.

Together with other Bay Area Stormwater Management Agencies Association (BASMAA) members, CCCWP entered into a regional collaborative known as the Regional Monitoring Coalition (RMC) to plan and conduct Creek Status Monitoring as required by provision C.8.c of the Municipal Regional Permit (MRP), evaluate the monitoring results, and perform related follow-up studies. The Creek Status Monitoring conducted by CCCWP includes monitoring in both Region 2 and Region 5 Water Quality Control Board jurisdictions.

When creek status monitoring conducted per Permit Provision C.8.c produces results that exceed the triggers defined in Permit Table 8.1, Permit Provision C.8.d.i requires follow-up monitoring, which may include SSID Studies. MRP Attachment H and Central Valley Permit Attachment D also require Permittees to “Identify cause(s) of impacts and spatial extent” when sediment toxicity, chemistry, and bioassessment results meet certain thresholds. Per MRP Provision C.8.d.i, when the creek status monitoring is performed under a regional collaborative (such as the RMC), a maximum of ten SSID studies must be initiated during the permit term; two of those studies must be related to toxicity. By agreement within the RMC, Contra Costa County Permittees are responsible for initiating two SSID Studies during the permit term. The Central

[1] The Contra Costa Clean Water Program (CCCWP) is responsible for complying with two National Pollutant Discharge Elimination System (NPDES) permits for urban runoff discharges, jointly referred to in this report as “Permit”:

- Order No. R2-2009-0074, the Municipal Regional Permit (MRP), issued by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), Region 2
- Order No. R5-2010-0102 (Central Valley Permit), issued by the Central Valley Regional Water Quality Control Board (CVRWQCB), Region 5

To promote a coordinated countywide program of water quality management, the two permits have nearly identical provisions. Requirements for implementation of stressor/source identification (SSID) studies (termed “stormwater monitoring projects”) are included in both the Region 2 and Region 5 permits per Provision C.8.d.i : Stressor/Source Identification.

Valley Permit also caps the SSID studies required of East County Permittees to one study during the permit term.

Both of the SSID studies being conducted by CCCWP involve toxicity to aquatic organisms. The current CCCWP SSID studies therefore fulfill the obligations of the Contra Costa County Permittees for conducting SSID projects under both the Region 2 and Region 5 permits, and also fulfill the RMC's obligations to conduct two SSID studies related to toxicity regionally under the MRP.

This report contains the results of data analysis and interpretation in support of CCCWP's SSID Studies, Part B. The scope of work for this report reflects discussions held during early 2015 between SF Bay Regional Water Quality Control Board staff and CCCWP staff regarding the recommended approach to conducting the two CCCWP SSID studies, and relevant guidance provided by Water Board staff.

Creek Status Monitoring, SSID Project Selection and Status

CCCWP's Creek Status Monitoring triggered exceedances under NPDES permit Provision C.8.c, Table 8.1 and Attachment H/D, for water and sediment toxicity parameters in both Water Year (WY) 2012 and WY 2013. Both Grayson Creek (site 207R00011; Region 2) and Dry Creek (site 544R00025; Region 5) exhibited water column toxicity to *Hyalella azteca* (*H. azteca*) in creek samples collected during wet weather in WY 2012. Retests confirmed water toxicity to *H. azteca* in wet weather samples collected from both creeks in WY 2013. Other test species were not adversely affected in the water column toxicity testing. In July 2012, sediment toxicity testing also revealed toxicity to *H. azteca* in sediment samples from both creeks.

In addition to the toxicity testing results, sediment chemistry testing of the dry weather samples in WY 2012 indicated elevated levels of sediment contaminants, including pyrethroid pesticides, in both creeks. Bioassessment monitoring of Grayson Creek and Dry Creek in spring, 2012 also yielded benthic macroinvertebrate index of biological integrity (IBI) scores in the "Very Low" range for both creeks. Taken together, the WY 2012 sediment toxicity, chemistry, and bioassessment results triggered follow-up actions required in NPDES permit Attachment H/D for Dry Creek and Grayson Creek.

Based on the WY 2012 and 2013 monitoring results, the Grayson Creek and Dry Creek locations were selected for the two SSID studies to be conducted by CCCWP. The creek status monitoring results and rationales that led to the selection of the two subject SSID projects are summarized, along with current project status, in Table 1. Both projects are related to urban creek toxicity.

As detailed in the *Draft Stressor/Source ID Study Concept Plan*, CCCWP has developed a four-part, phased approach to SSID project implementation[2]. Part A of the two selected SSID studies was performed by CCCWP during WY 2014. The SSID Part A study area is shown in Figure 1.

As indicated in Table 1, the results of the two SSID Part A studies, performed during 2014 in the Grayson Creek (Region 2) and Dry Creek (Region 5) watersheds, confirmed that current-use pesticides (particularly pyrethroids) appear to be the principal causes of the toxicity observed in the two study watersheds. Those pesticides therefore constitute the stressors being investigated in the CCCWP SSID studies (per study results as reported in the SSID Part A Report). In the Part B studies, the magnitudes and patterns of pesticide applications are further investigated, to more explicitly identify the sources of the identified stressors.

[2] This report refers to the Draft Contra Costa Clean Water Program Draft Stressor/Source ID Study Concept Plan ("Concept Plan", prepared for CCCWP by AMEC and ARC, May, 2013), and the Report of Stressor/Source Identification Studies in Dry Creek and Grayson Creek, Part A ("SSID Part A Report", prepared for CCCWP by ADH and ARC, December 3, 2014).

The results of the Part B studies as presented in this report will provide a basis for identifying the pesticide source controls to be selected and implemented as described in the SSID Study Concept Plan, Part C (to be conducted during FY 2015-16).

This report provides evidence of continuing progress in implementation of SSID Study requirements as required by the Permit and as outlined in CCCWP's SSID Study Concept Plan.

Table 1. CCCWP SSID Projects: Creek Status Monitoring Results, Rationales, Project Status

Creek Name Site Code	Summary of Creek Status Monitoring Results	Rationale for Selecting SSID Project Per MRP Prov. C.8.d.	Status of Project
Grayson Creek 207R00011	32% survival of *Hyalella azteca* in water during spring of 2012; 43.8% survival of *Hyalella azteca* in sediment during summer 2012; relatively high bifenthrin in sediment; IBI Score = 13 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of CA. Investigation of sources and solutions could be widely beneficial.	SSID Project Part A completed, WY 2014, including testing of water and sediments from sites upstream and downstream of original Grayson Creek site. Only water samples were toxic to *Hyalella*. Water TIE and concurrent chemistry point to pyrethroid pesticides as likely causes of toxicity in waters of Grayson Creek.
Dry Creek 544R00025	0% survival of *Hyalella azteca* in water during spring of 2012; 60% survival of *Hyalella azteca* in sediment during summer 2012; relatively high bifenthrin in sediment; IBI Score = 3 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of CA. Investigation of sources and solutions could be widely beneficial.	SSID Project Part A completed, WY 2014, including testing of water and sediments from sites upstream and downstream of original Dry Creek site. All samples were toxic to *Hyalella*. Water and sediment TIEs and concurrent chemistry point to pyrethroid pesticides as likely causes of toxicity in water and sediments of Dry Creek.

Figure 1. SSID Study Areas

Overview of Approach

The Concept Plan includes the following description of the activities planned for Part B of the SSID studies:

> "After confirming the stressors, sources need to be identified. Presuming that pesticide applications are determined to be the source(s) for the pesticides identified as stressors in Part A, the assessment would attempt to characterize the relative magnitudes of sources attributable to the following: Contra Costa County professional Pest Control Operators vs. homeowners, spatial and temporal characteristics of pesticide applications, the role of impervious surfaces, and any potential contribution from different land uses such as agriculture or golf courses. These activities are anticipated for FY 2014 - 2015."

Available information on urban sources of the subject current-use pesticides (focusing on pyrethroids, as per the results of the SSID Part A testing) is summarized as applicable to the two SSID studies being performed in Contra Costa County. The purpose of this summary is to characterize or estimate the sources of those pesticides, including the relative magnitudes of sources attributable to Contra Costa County Professional Pest Control Operators vs. homeowners, spatial and temporal characteristics of pesticide applications, the role of impervious surfaces, and any potential contribution from non-urban land uses such as agriculture or golf courses, as indicated in the Concept Plan, Part B, to the extent feasible, based on the following information sources:

- Prior monitoring data and analysis documenting the nature and extent of pesticides contamination and effects in urban areas of California (e.g., per Ruby, 2013[3] and Moran and TenBrook, 2011[4]); this prior work indicates that contamination of urban surface waters with current-use pesticides is common throughout California, and generally results from "structural" applications (around buildings) – as opposed to landscape/garden pesticide applications – and especially applications to impervious surfaces.

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[3] Ruby, A. 2013. "Review of Pyrethroid, Fipronil and Toxicity Monitoring Data from California Urban Watersheds". Prepared for the California Stormwater Quality Association (CASQA). Prepared by Armand Ruby, Armand Ruby Consulting. July 10.

[4] Moran, K. D., and P. L. TenBrook. 2011. "Sources of Pyrethroid Insecticides in California's Urban Watersheds: A Conceptual Model." In: *Pesticide Mitigation Strategies for Surface Water Quality*; Goh, K.S., B. Bret, T. Potter, J. Gan. Eds.; ACS Symposium Series Vol. 1075, ACS Washington, D.C., 2011.

- Monitoring data, pesticide use information, and analytical approaches recently and currently being developed by the CA Department of Pesticide Regulation (DPR)[5] and its contractors[6], including UC Irvine and UC Davis, as well as work previously published by the Urban Pesticide Pollution Prevention (UP3) Project[7].
- Ongoing collaborative efforts by DPR and the Water Boards to develop a coordinated approach to pesticide monitoring and management in California's urban areas.

Pesticide use reporting and sales data were obtained from the California Department of Pesticide Regulations databases. The most recent data available reflect pesticide sales and use in 2013[8].

Pesticides Selected for Analysis

The SSID Part A Studies report identified pyrethroid pesticides as being principally responsible for the observed water and sediment toxicity to *Hyalella azteca* during the 2014 testing. Based on the chemical testing, six pyrethroids were found to have detectable concentrations in waters and/or sediments of Grayson Creek and/or Dry Creek during the 2014 monitoring. The detected pyrethroids are summarized in Table 2; other pyrethroids were not detected in the 2014 monitoring of water or sediment samples.

[5] California Department of Pesticide Regulation (DPR) (2013). Prevention of Surface Water Contamination by Pesticides - DPR Regulation No. 11-004. California Code of Regulations Division 6. Pesticides And Pest Control Operations. Sections 6000, 6970, and 6972.

[6] Jiang, W., et al. 2012. "Runoff of pyrethroid insecticides from concrete surfaces following simulated and natural rainfalls." Water Research 46(3): 645-652;

Jorgenson, B. C., et al. 2012. "Factors Contributing to the Off-Target Transport of Pyrethroid Insecticides from Urban Surfaces." Journal of Agricultural and Food Chemistry 60(30): 7333-7340;

Jiang, W., J. Gan and M. Rust. 2014. Runoff of Phenylpyrazole Insecticide Fipronil from Concrete Surfaces. In: *Describing the Behavior and Effects of Pesticides in Urban and Agricultural Settings*, American Chemical Society Symposium Series, Vol. 1168, Ch. 1 pp. 1-12.

[7] TDC Environmental. 2010. Pesticides in Urban Runoff, Wastewater, and Surface Water, Annual Urban Pesticide Use Data Report 2010. Prepared for the San Francisco Estuary Partnership. June 28.

[8] California Department of Pesticide Regulation (DPR). 2014. State of California, Pesticides Sold in California for Year: 2013. 6/12/15. Available at: http://www.cdpr.ca.gov/docs/mill/pdsd2013.pdf

Ibid. 2015. Summary of Pesticide Use Report Data 2013 Indexed by Chemical. May, 2015. Available at: http://www.cdpr.ca.gov/docs/pur/pur13rep/chmrpt13.pdf

Table 2. Detected Pyrethroid Pesticides, 2014 Creek Monitoring (SSID Part A Studies)

Pesticide	# Detects / # Water Samples*	# Detects / # Sediment Samples*
Bifenthrin	8 of 8	4 of 4
Cyfluthrin	7 of 8	4 of 4
Cypermethrin	1 of 8	4 of 4
Deltamethrin	1 of 8	0 of 4
Lambda-Cyhalothrin	3 of 8	2 of 4
Permethrin	1 of 8	4 of 4

*Grayson Creek and Dry Creek studies combined

Based on the analysis of pyrethroid concentrations and relative toxicity of the various pyrethroids, bifenthrin was determined to be the leading cause of toxicity, followed by cyfluthrin, for both water and sediment samples, with lesser contributions from the other four detected pyrethroids. For the purposes of this report, all six detected pyrethroids listed in Table 2 are included in the analysis.

Pesticide Use Reporting Data

In California, only professional pest control operators (PCOs) are required to report amounts of pesticide used. The PCOs report amounts of pesticide applied, application site type, and other information by county to the County Agricultural Commissioners, who in turn report the data to DPR. DPR summarizes the use information annually by product and active ingredient (e.g., the commonly-used pyrethroid, bifenthrin), for each county and statewide. DPR's records include summaries of use by application site type (e.g., "Landscape Maintenance" and "Structural Pest Control"), and DPR's Pesticide Information Portal (PIP) provides reporting of pesticide use data by county categorically for agricultural uses, non-agricultural uses, or both (all reported uses).

The pesticide use reporting data do not include pesticides sold "over the counter" (OTC) and applied by non-professional applicators. Total urban uses therefore include both the amounts reported as applied by PCOs in non-agricultural uses, plus unreported amounts applied by non-professionals as a result of OTC sales.

Statewide Pesticide Sales Data

DPR also compiles data on pesticide sales by product and active ingredient, but on a statewide basis only. The pesticide sales records document the first sale of the product within California, including wholesale purchases by retail outlets, so the sales data include both pesticides purchased by professionals (PCOs) and amounts purchased by non-professionals (e.g., residents and businesses). The difference between pesticide sales data and reported use data (by PCOs) then represents an estimate of sales to non-professionals.

Computational Methods

For this report, unreported use amounts (assumed to be primarily attributable to residential uses) are estimated for Contra Costa County from statewide sales and use data. Unreported uses for each pyrethroid are assumed to be approximately equal to total sales amounts minus total amounts reported as used by professional applicators. The ratio of statewide sales to statewide reported uses is calculated for each pyrethroid, and that ratio is then multiplied by reported uses of pyrethroids for Contra Costa County to estimate the sales for each pyrethroid in Contra Costa County.

This analysis includes the most recent five years for which pesticide sales and use data are available from DPR data sources (2009-2013). Pesticide sales data were obtained from DPR's annual sales reports, available from the DPR web site[9]. Pesticide use data were obtained from DPR's CalPIP web site[10]. The calculations are summarized as follows (performed individually for each pesticide of concern):

To Estimate Urban Pesticide Use for Contra Costa County:

Urban Use (est.) = Reported Non-Agricultural (Urban) Use + OTC Sales

where: OTC Sales (est.) = Total Sales - All Reported Use

[Reported Non-Ag (Urban) Use and All Reported Use are known for CC County for each pesticide active ingredient from DPR Use Data]

To Estimate Total Sales for Contra Costa County:

Total Sales, CC County (est.) = S:U Ratio * All Reported Use (CC County)

where: S:U Ratio = Statewide Sales/Statewide Reported Use

[Statewide Sales and Statewide Reported Use are known for each pesticide active ingredient from DPR Sales and Use Data]

Analytical Assumptions

The analysis makes the following assumptions:

- that essentially all pesticides sold in a given year are used in that year,
- that essentially all unreported pesticide uses result from over the counter (OTC) sales, and that the resulting applications occur principally at residences and businesses in urban areas,

[9] Reports of Pesticides Sold In California: http://www.cdpr.ca.gov/docs/mill/nopdsold.htm
[10] California Pesticide Information Portal (CalPIP): http://calpip.cdpr.ca.gov/main.cfm

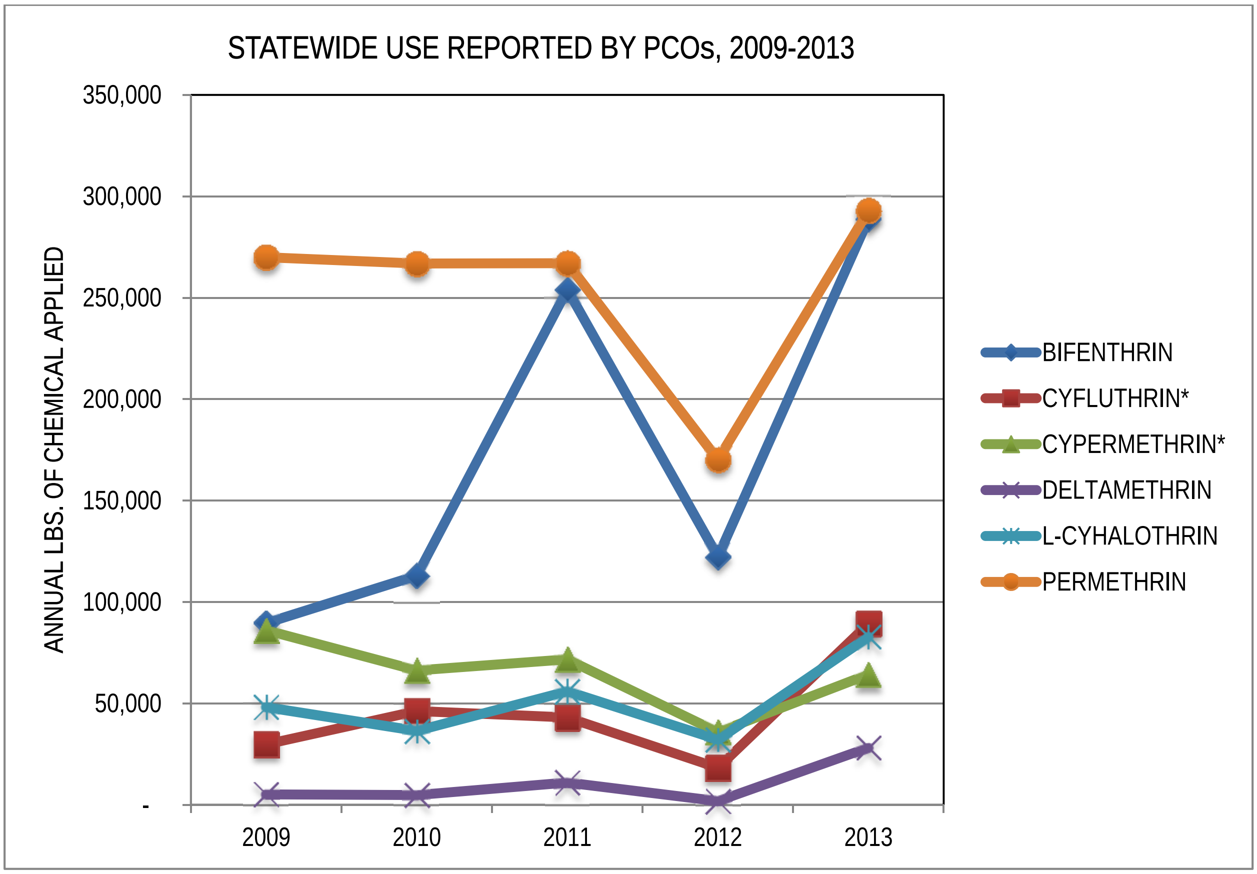
- that indoor uses of the subject pyrethroids comprise a relatively small fraction of their total use, and
- that the statewide ratio of pesticides sold to pesticides reported as used by professional operators is representative of Contra Costa County and can be applied to estimate pyrethroid sales in Contra Costa County.

The first assumption is mitigated in this analysis by the use of five-year averages covering the most recent five years of available data (2009-2013).

Results: Pesticide Sales and Reported Use Amounts; Annual Trends

The DPR pesticide data sources listed above were used to compile pyrethroid sales and use data for the urban pyrethroids of concern over a five year period. Figure 2 illustrates the pesticide use amounts reported by PCOs statewide (from Table 3B) for the period 2009-2013. Table 3 includes the statewide pesticide sales amounts and reported chemical use amounts by PCOs for all types of sites, as well as the reported PCO chemical use as a percentage of statewide sales for the same period.

Figure 2. Statewide Pesticide Use as Reported by PCOs, 2009 - 2013



*Includes multiple isomers

Table 3. Statewide Pesticide Sales and Reported Chemical Use (All Sites), 2009-2013

3A. Chemical Sales, Statewide (Lbs)							
Chemical	2009	2010	2011	2012	2013	5-Year Totals	Annual Average Sales
Bifenthrin	109,323	417,898	294,563	389,179	376,649	1,587,612	317,522
Cyfluthrin*	41,505	34,711	40,035	37,982	30,813	185,046	37,009
Cypermethrin*	90,583	78,355	79,010	86,476	90,079	424,503	84,901
Deltamethrin	3,935	2,897	3,007	4,838	3,922	18,599	3,720
Lambda-Cyhalothrin	55,422	54,266	67,457	79,922	75,711	332,778	66,556
Permethrin	430,776	489,974	356,083	333,886	371,261	1,981,980	396,396
ANNUAL TOTALS	731,544	1,078,101	840,155	932,284	948,435		
3B. Reported PCO Chemical Use, Statewide (Lbs)							
Chemical	2009	2010	2011	2012	2013	5-Year Totals	Annual Average Sales
Bifenthrin	89,663	112,941	253,989	122,298	288,883	867,775	173,555
Cyfluthrin*	29,818	46,282	43,068	18,254	89,311	226,734	45,347
Cypermethrin*	86,067	66,320	71,707	35,835	64,322	324,251	64,850
Deltamethrin	5,181	4,831	11,019	1,838	28,224	51,092	10,218
Lambda-Cyhalothrin	48,183	36,442	55,973	32,152	82,891	255,641	51,128
Permethrin	269,954	266,819	266,999	170,199	292,845	1,266,815	253,363
ANNUAL TOTALS	528,867	533,635	702,755	380,575	846,476		
3C. Reported PCO Chemical Use as % of Sales, Statewide							
Chemical	2009	2010	2011	2012	2013	5-Year Averages	Ratio of Sales:Use
Bifenthrin	82%	27%	86%	31%	77%	55%	1.8
Cyfluthrin*	72%	133%	108%	48%	290%	123%	1.0
Cypermethrin*	95%	85%	91%	41%	71%	76%	1.3
Deltamethrin	132%	167%	366%	38%	720%	275%	1.0
Lambda-Cyhalothrin	87%	67%	83%	40%	109%	77%	1.3
Permethrin	63%	54%	75%	51%	79%	64%	1.6

*Includes multiple isomers
See following paragraph for explanation of **Bolded** values

Note that because the reported statewide use amounts for cyfluthrin and deltamethrin on average exceeded the sales amounts for those chemicals, the S:U Ratio (ratio of Sales to Use amounts) as limited to a value of 1.0 in Table 3C. This phenomenon is not uncommon due to uncertainties associated with the DPR sales and use data.[11]

The statewide sales and use data (Table 3, Figure 2) show a substantial degree of annual variability. Within the five-year period studied, uses of the two principal pyrethroids of concern (bifenthrin and cyfluthrin) by PCOs peaked in the last year of available data, 2013, after uses of all of the subject pyrethroids dipped substantially in 2012.

Contra Costa County Use Data

The reported total chemical use amounts (all uses) for Contra Costa County are shown in Table 4 for 2009-2013. The reported non-agricultural use amounts for 2009-2013 for the County are shown in Table 5 and illustrated in Figure 3. The principal site types included in the non-agricultural (urban) uses are structural pest control and landscape maintenance.

Table 4. Reported Chemical Use by PCOs (All Uses), Contra Costa County, 2009-2013 (Lbs.)

	2009	2010	2011	2012	2013	5-Year Totals	Annual Average Total Use
Bifenthrin	2,584	7,230	2,919	10,270	15,857	38,860	7,772
Cyfluthrin*	578	376	310	582	11,140	12,987	2,597
Cypermethrin*	2,380	1,563	674	525	1,469	6,611	1,322
Deltamethrin	71	110	77	98	5,557	5,912	1,182
Lambda-Cyhalothrin	39	90	54	180	789	1,153	231
Permethrin	1,157	923	997	864	1,027	4,968	994
ANNUAL TOTALS	6,809	10,292	5,031	12,519	35,838		

*Includes multiple isomers

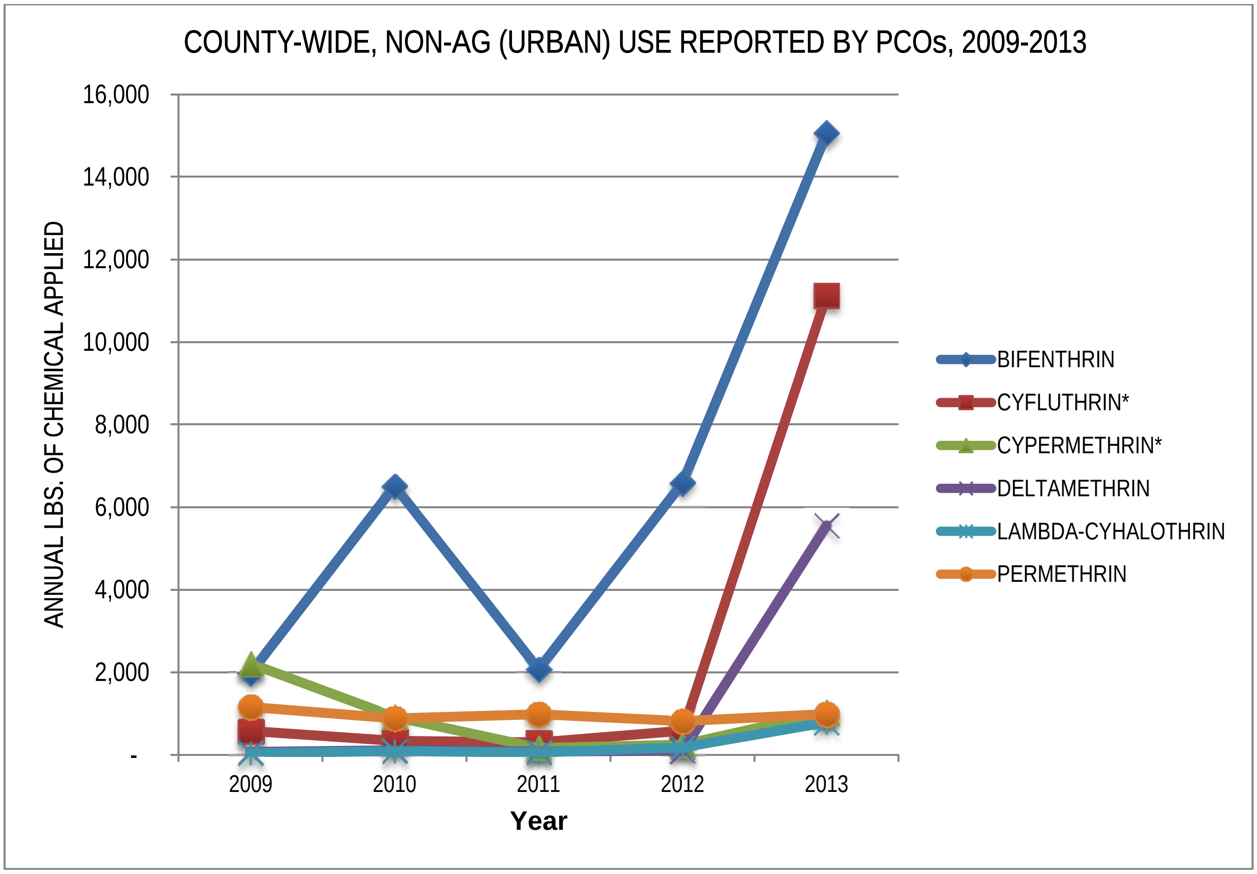
[11] For a detailed explanation of DPR data uncertainties, see: TDC Environmental. 2008. Pesticides in Urban Runoff, Wastewater, and Surface Water, Annual Urban Pesticide Use Data Report 2008. Prepared for the San Francisco Estuary Partnership. July 30. Available at: http://www.up3project.org/up3_documents.shtml

Table 5. Reported Chemical Use by PCOs (Non-Ag. (Urban) Uses Only), Contra Costa County, 2009-2013 (Lbs.)

	2009	2010	2011	2012	2013	5-Year Totals	Annual Average Non-Ag Use	Non-Ag % of Reported Use**
Bifenthrin	1,985	6,510	2,067	6,593	15,062	32,217	6,443	83%
Cyfluthrin*	572	337	297	582	11,139	12,927	2,585	100%
Cypermethrin*	2,206	914	163	246	1,029	4,558	912	69%
Deltamethrin	71	110	77	98	5,557	5,912	1,182	100%
Lambda-Cyhalothrin	39	90	54	180	789	1,153	231	100%
Permethrin	1,157	882	982	813	984	4,819	964	97%
ANNUAL TOTALS	6,029	8,843	3,641	8,513	34,560			

* Includes multiple isomers
** Calculated as Annual Average Non-Ag. Use from Table 5 divided by Annual Average Total Use from Table 4

Figure 3. Pesticide Use in Contra Costa County, Non-Agricultural (Urban) Areas Only, As Reported by PCOs, 2009 - 2013



*Includes multiple isomers

Within Contra Costa County, both bifenthrin and cyfluthrin show steep peaks in use reported by PCOs in 2013, echoing the trends displayed in Figure 2 for statewide uses.

Application Site Types and Amounts (PCOs)

As shown in Table 5, the majority of reported pyrethroid uses by professional applicators in Contra Costa County over the past five years have been in non-agricultural (urban) settings.

In addition to the CalPIP on-line database, DPR also presents statewide annual usage data by chemical in an annual Pesticide Use Report (PUR). The PUR data include a breakdown of the amount of each pesticide applied by “commodity” (site type). For the most recent year available (2013[12]), the major categories of non-agricultural site applications as reported by PCOs (structural pest control, landscape maintenance) are also summarized for the statewide data for the pyrethroids of interest in Table 6.

For most of the pyrethroids studied, the non-agricultural (urban) percentage of reported use is higher in Contra Costa County (per Table 5) than it is statewide (Table 6). Table 6 is focused on the non-agricultural (urban) uses; the non-urban uses are predominantly agricultural applications. So for bifenthrin, with an estimated statewide urban use amount equal to 42 percent of the total statewide usage (per Table 7), approximately 58 percent of the statewide usage by PCOs would be estimated to be applied in agricultural settings. The differences between the statewide and Contra Costa County percentages may lie in the higher proportion of agricultural land uses in a number of other counties.

[12] California DPR. 2015. Summary of Pesticide Use Report Data 2013 Indexed by Chemical. May, 2015. Available at: http://www.cdpr.ca.gov/docs/pur/pur13rep/chmrpt13.pdf

Table 6. Urban Chemical Use Reported by PCOs, Statewide, 2013 (DPR, PUR)				
Chemical	Landscape Maintenance Reported Use (Lbs)	Structural Pest Control Reported Use (Lbs)	2013 Total Statewide Reported Use (Lbs)	Estimated Urban % of 2013 Reported Use
Bifenthrin	2,104	120,735	290,027	42%
Cyfluthrin*	238	76,378	89,891	85%
Cypermethrin*	4,183	31,328	63,652	56%
Deltamethrin	23	45,460	45,547	99.9%
Lambda-Cyhalothrin	128	19,747	82,392	24%
Permethrin	32,396	141,108	292,072	59%

* Includes multiple isomers
** For Deltamethrin, the PUR datum for total reported use in 2013 differs from the amount derived from the 2013 CalPIP pesticide use data; for the other pyrethroids, the PUR and CalPIP amounts are in close agreement.

Results: Computation of Estimated Urban Uses, Contra Costa County

The computational methods described above were used to compute the estimated annual urban use of the selected pyrethroid pesticides (Table 7) county-wide. These calculations make use of the five-year averages of sales and use data provided by DPR for the period 2009-2013. The reported annual use figures used in the calculations are for applications by PCOs only. The sales figures include sales of pesticides both for uses reported by PCOs and unreported uses (private parties, assumed to be mainly urban/residential); the unreported uses are assumed to represent the OTC sales component (sales to non-PCOs). The sum of the OTC sales and reported non-agricultural (urban) uses are assumed to represent an estimate of total urban uses for the county.

It is important to note that the Estimated Annual Urban Use amounts calculated for Contra Costa County in Table 7 are based on five-year averages. As shown above (c.f., Figures 2 and 3), variations in annual usage amounts can be substantial. For example, the 2013 non-agricultural (urban) use reported by PCOs for Contra Costa County in 2013 for bifenthrin exceeds the annual average estimate shown in Table 7, even without consideration of the OTC sales component. As discussed further below, some of the annual variations in reported uses may be related to errors in pesticide use reporting.

Table 7. Calculated Urban Chemical Use, Contra Costa County (Lbs, Based on 5 Year Averages)

Chemical	Reported Total Annual Use (5-Year Average)	Ratio of Sales:Use**	Estimated Total Sales (County)	Estimated OTC Sales (County)	Reported Annual Non-Ag Use (5-Year Average)	Estimated Annual Urban Use (County)
Bifenthrin	7,772	1.8	14,219	6,447	6,443	12,890
Cyfluthrin*	2,597	1.0***	2,597	-	2,585	2,585
Cypermethrin*	1,322	1.3	1,731	409	912	1,320
Deltamethrin	1,182	1.0***	1,182	-	1,182	1,182
Lambda-Cyhalothrin	231	1.3	300	70	231	300
Permethrin	994	1.6	1,554	561	964	1,525

* Includes multiple isomers
** Calculated from statewide sales and use data; see Table 3C.
*** Due to uncertainties in the DPR sales and/or use data, these ratios were set equal to the minimum value (1.), which represents 100 percent of sales resulting in reported uses by PCOs (i.e., no OTC sales to non-professional applicators)

Results: Seasonal (Monthly) Trends

Individual non-agricultural (urban) use applications as reported by PCOs were plotted on a monthly basis for calendar year 2013 for the two pyrethroids of greatest concern, using data provided by CalPIP. Bifenthrin use applications are shown in Figure 4; cyfluthrin use applications are shown in Figure 5.

The scatter plots in Figures 4 and 5 are for individual applications of the specified pesticide. As such they are useful for identifying unusually large individual pesticide applications. For bifenthrin (Figure 4), four reported applications stand out well above the rest; for cyfluthrin, three applications stand out well above the rest. As shown in Table 8, those top four bifenthrin applications account for 81 percent of the annual reported non-agricultural (urban) uses, while the top three cyfluthrin applications account for 61 percent of the reported non-agricultural (urban) uses.

These relatively high, apparently out-of-range application amounts may represent data entry or computational errors by PCOs or DPR, so a first step should be to check/verify those data points. If the reporting data are valid, these results provide a potential direction for future investigation of specific pesticide sources and application patterns, and potential opportunities for source control. The specific site or PCO information is not provided in the DPR data set, but it seems likely that the information could be available, possibly through the County Agricultural Commissioner, who collects the use reports from the PCOs and submits them for the County to DPR after the end of the year.

Figure 4. Non-Agricultural (Urban) Applications of Bifenthrin in Contra Costa County, as Reported by PCOs During 2013

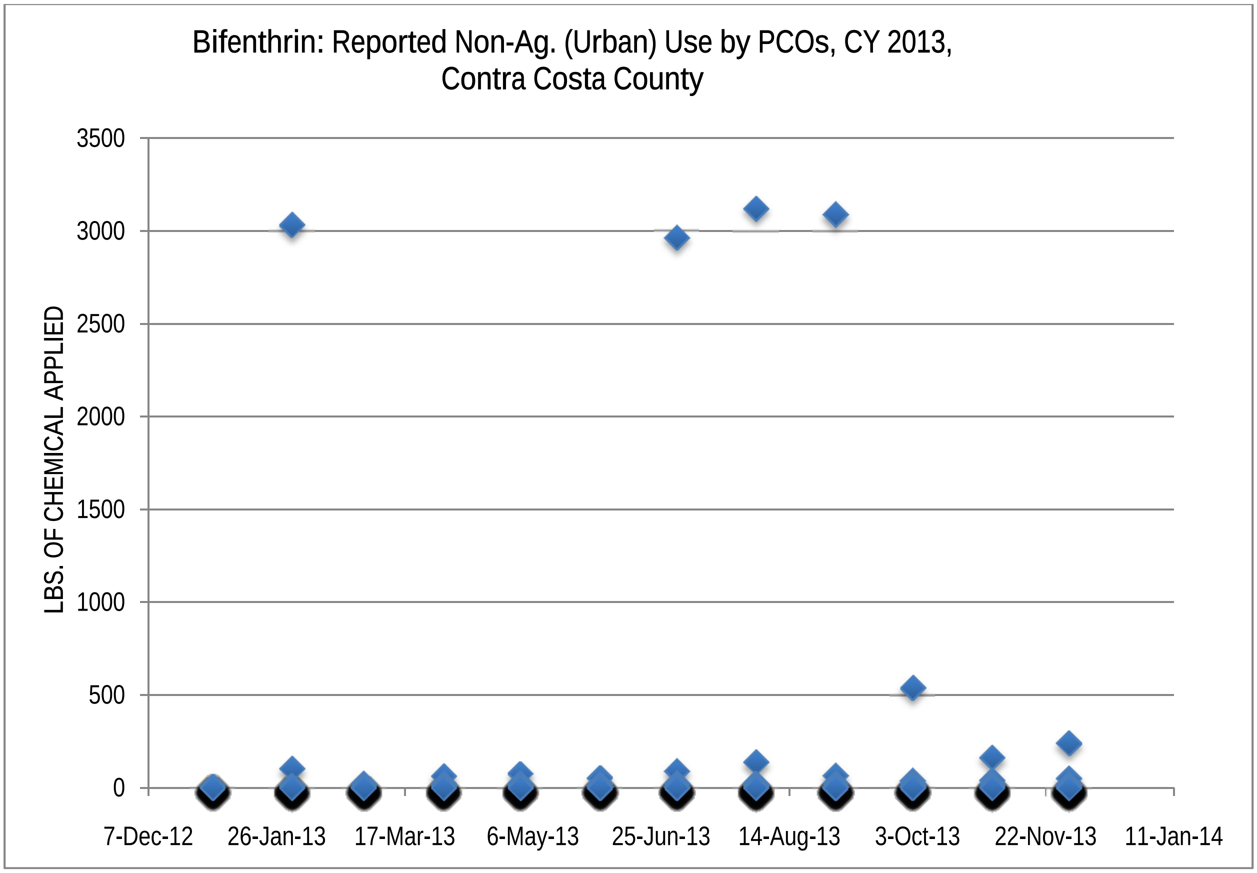
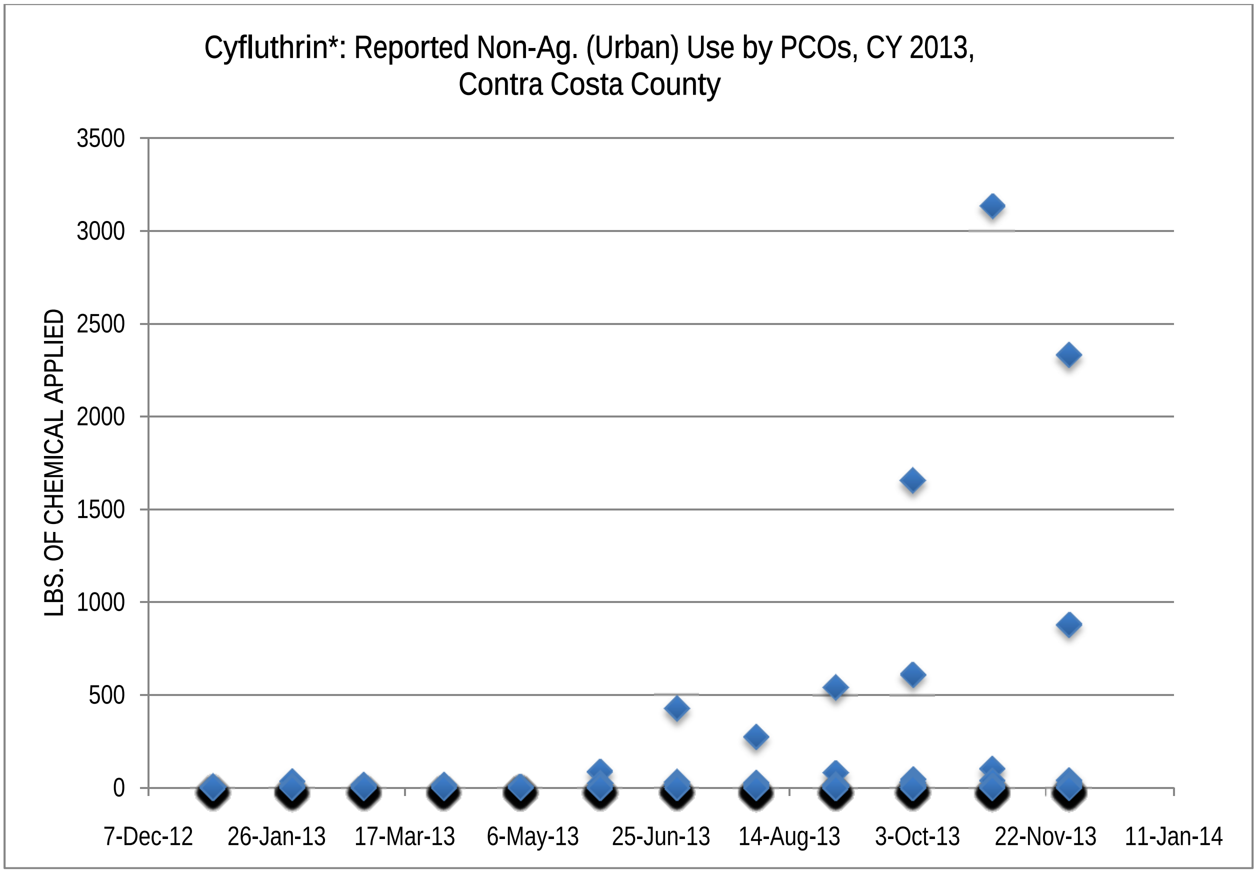


Figure 5. Non-Agricultural (Urban) Applications of Cyfluthrin* in Contra Costa County, as Reported by PCOs During 2013



* Includes multiple isomers

Table 8. Sum of Top 2013 Chemical Use Amounts Compared to Annual Urban Chemical Use During 2013 in Contra Costa County for Bifenthrin and Cyfluthrin

Chemical	2013 Reported Non-Ag Use County (Lbs)	Sum of Top Uses, 2013 County (Lbs) [See Notes >]	Top Uses % of Total 2013	Notes
Bifenthrin	15,062	12,211	81%	Top 4 of 1067 applications reported in CC County in 2013
Cycluthrin*	11,139	7,127	64%	Top 3 of 702 applications reported in CC County in 2013

* Includes multiple isomers
** Calculated based on 5 year average, 2009-2013

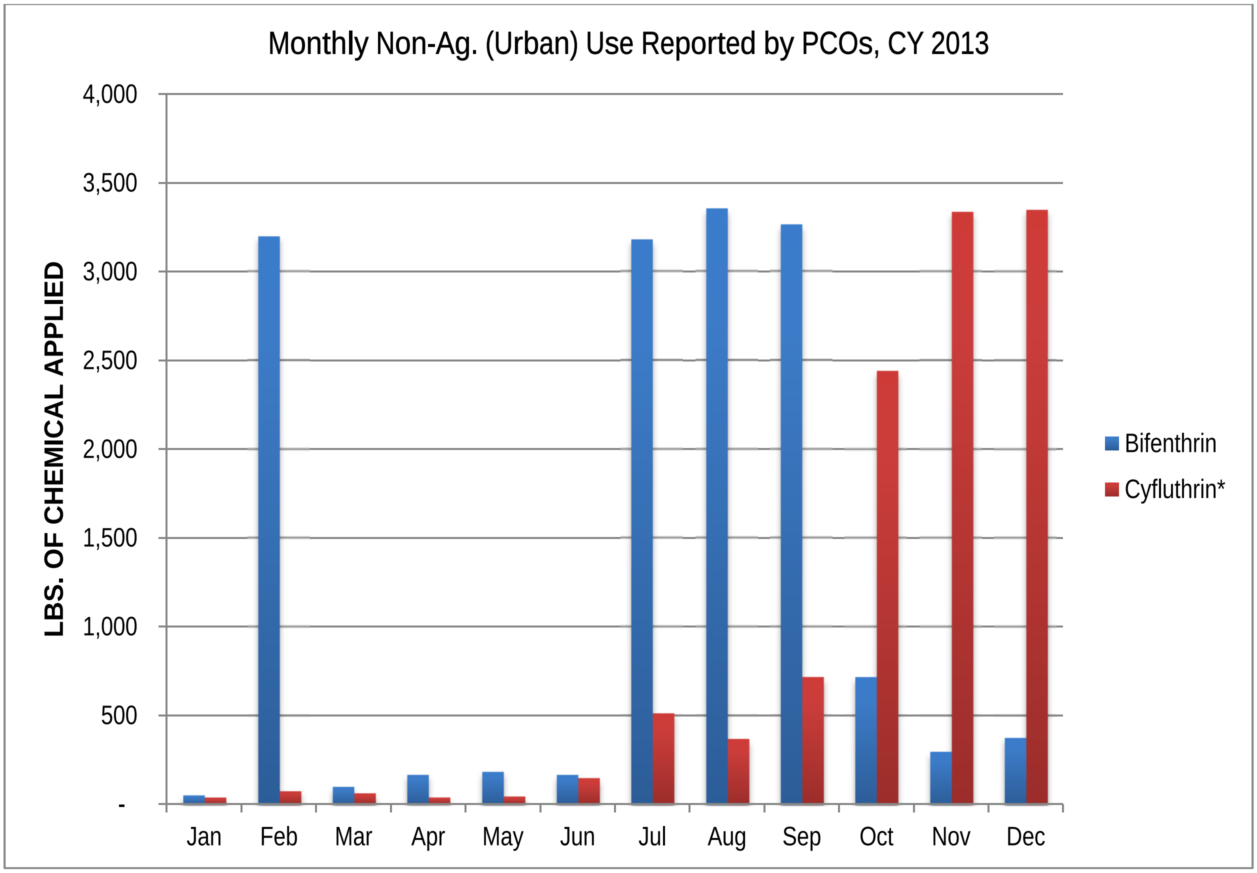
Looking at the monthly professional use totals for reported non-agricultural applications in 2013, the effects of the four high bifenthrin data points and the three high cyfluthrin data points are clearly evident; see Table 9 and Figure 6. Again, the reporting data should be carefully reviewed to determine whether reporting or calculation errors may have produced these excessively high values.

Table 9. 2013 Monthly Non-Agricultural (Urban) Use for Bifenthrin and Cyfluthrin, Contra Costa County

	Bifenthrin (Lbs)	Cyfluthrin* (Lbs)
January	51	38
February	3,203	76
March	98	62
April	167	39
May	186	43
June	163	144
July	3,181	516
August	3,356	369
September	3,266	718
October	716	2,441
November	298	3,340
December	378	3,351
2013 Totals	15,062	11,139

* Includes multiple isomers

Figure 6. Monthly Non-Agricultural (Urban) Applications of Bifenthrin and Cyfluthrin* in Contra Costa County, as Reported by PCOs, Calendar Year 2013



* Includes multiple isomers

Role of Impervious Surfaces

In urban environments, the principal pathway for aquatic impacts from pesticides is via rainfall / runoff, which can transport pesticides rapidly from urban land uses through the municipal stormwater conveyance system and directly into surface waters. What most prominently differentiates the urban environment from agricultural land uses is the extensive presence in urban areas of impervious surfaces such as streets, driveways, parking lots, and buildings.

Impervious surfaces cause increases in both total runoff volume and pollutant quantity washed into surface waters, compared to runoff from agricultural soils or other pervious surfaces (e.g., vegetated landscaped surfaces)[13]. When pesticides are applied directly to impervious surfaces, and runoff is transported via constructed urban storm drainage systems, pesticides can be washed off and transported quickly and efficiently away from application sites and into surface waters. Consequently, applications to impervious surfaces are considered to be a primary controlling factor in urban runoff contributions to pesticide-caused receiving water toxicity in urban areas[14].

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[13] Integrated Risk Assessment Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. 2009. The Impacts of Imperviousness on Aquatic Ecosystems: An annotated bibliography on the effects of a key stressor of urbanization on the aquatic ecosystem. March. Available at: http://www.oehha.ca.gov/ecotox/pdf/ICbiblio0309.pdf

[14] Moran, K. D., and P. L. TenBrook. 2011. "Sources of Pyrethroid Insecticides in California's Urban Watersheds: A Conceptual Model." In: Pesticide Mitigation Strategies for Surface Water Quality ; Goh, K.S., B. Bret, T. Potter, J. Gan. Eds.; ACS Symposium Series 1075, ACS Washington, D.C., 2011.

Implications for Source Identification and Controls; Next Steps

Based on the compiled data from 2009-2013, as presented above, it appears that use of the most toxic and impactful pyrethroids (bifenthrin and cyfluthrin) has increased in urban areas in Contra Costa County in recent years. This is surprising, given the restrictions placed on bifenthrin uses by DPR in its recently adopted Surface Water Quality Regulations[15]. The reported uses should be further investigated via DPR and the County Agricultural Commissioner's office to verify whether the reported use and sales figures are correct, and if so, whether PCOs are implementing the various mitigation measures included within DPR's regulation.

Similarly, the highest reported individual applications of bifenthrin and cyfluthrin in 2013, as described above, should be further investigated via DPR and the County Agricultural Commissioner's office to determine whether the figures are accurate, and if so, whether steps could be taken to reduce the volumes of pesticides applied in those instances, especially to impervious surfaces during the rainy season.

The monthly non-agriculture (urban) use patterns for bifenthrin and cyfluthrin during 2013 in Contra Costa County are apparently dominated by the several high values discussed above. If the high values prove to be legitimate data points, the monthly/seasonal patterns that coincide with those values could be useful in determining associated mitigation measures.

All efforts to effectively control water quality impacts from urban pesticide applications must account for the heightened water quality impacts that are attributable to applications to impervious surfaces. Additional work should be done in the two study watersheds to identify impervious surfaces, especially those that are directly coupled to constructed storm drain systems, and determine whether pesticides are typically applied to those impervious surfaces. Lessons learned from this additional research then can be used to support public education and outreach efforts aimed at business owners, residents, and PCOs that will be designed to minimize pesticide runoff from urban areas.

[15] California Department of Pesticide Regulation (DPR) (2013). Prevention of Surface Water Contamination by Pesticides - DPR Regulation No. 11-004. California Code of Regulations Division 6. Pesticides And Pest Control Operations. Sections 6000, 6970, and 6972.