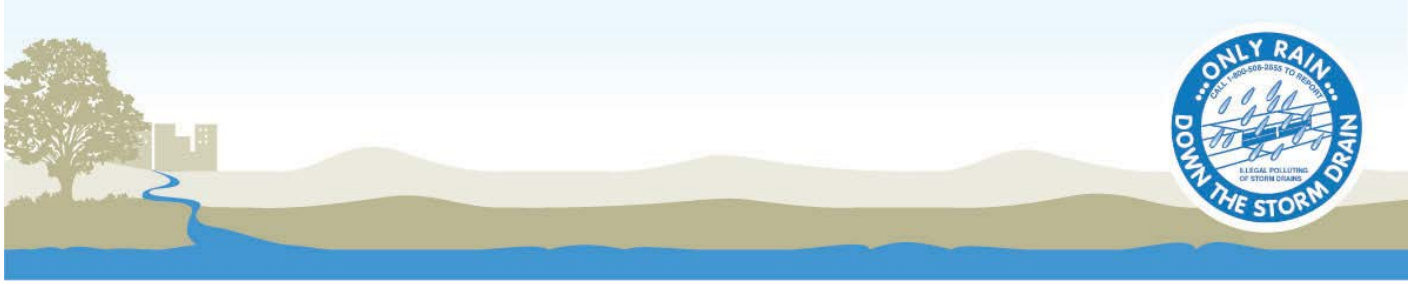


UPPER SANTA MARGARITA RIVER WATERSHED WATER QUALITY WORKPLAN

for the Santa Margarita Region of Riverside County

Date: June 30, 2012

UPPER SANTA MARGARITA RIVER WATERSHED WATER QUALITY WORKPLAN

FOR THE SANTA MARGARITA REGION OF RIVERSIDE COUNTY

In compliance with Order No. R9-2010-0016, this Upper Santa Margarita River Watershed Water Quality Workplan has been developed and will be implemented by the following Copermittees in the Santa Margarita Region no later than September 28, 2012 (within 90 days of submittal) unless otherwise directed by the San Diego Regional Water Quality Control Board:

Riverside County Flood Control and Water Conservation District http://www.rcflood.org

County of Riverside http://www.countyofriverside.us/

City of Murrieta http://www.murrieta.org/

City of Temecula http://www.cityoftemecula.org/

City of Wildomar http://www.cityofwildomar.org/

Table of Contents

1 INTRODUCTION TO THE UPPER SANTA MARGARITA RIVER WATERSHED WORKPLAN 1

1.1 Purpose of the Watershed Water Quality Workplan for the Upper Santa Margarita River 1

1.2 Watershed Workplan Development 1

1.3 Governance and Public Participation 2

1.4 Watershed Workplan Updates 2

2 DESCRIPTION OF THE UPPER SANTA MARGARITA RIVER WATERSHED 5

2.1 Physiography and Geology 5

2.2 Climate 7

2.3 Watershed Characteristics 7

2.4 Stream Flow Characteristics 9

3 CHARACTERIZATION OF RECEIVING WATER QUALITY 10

3.1 Sources of Information 10

3.2 Characterization of Receiving Water Quality 17

3.3 Prioritization of Receiving Water Quality Issues 26

4 UPPER SANTA MARGARITA RIVER WATERSHED BMP IMPLEMENTATION STRATEGY 30

4.1 BMP Selection and Implementation 30

4.2 BMP Assessment 35

5 MONITORING STRATEGY 37

6 ACRONYMS AND GLOSSARY 38

6.1 Acronyms 38

6.2 Glossary 39

List of Appendices

A Surface Water Ambient Monitoring Program (SWAMP) Report on the Santa Margarita Hydrologic Unit (July 2007)

B Toxicity Reduction Evaluation (TRE) for Pyrethroid Pesticides

C Effectiveness Assessments for the Watershed Workplan

1 Introduction to the Upper Santa Margarita River Watershed Workplan

1.1 Purpose of the Watershed Water Quality Workplan for the Upper Santa Margarita River

This Watershed Water Quality Workplan ("Watershed Workplan") has been developed in compliance with Directive G of the San Diego Regional Water Quality Control Board's (Regional Board) Order No. R9-2010-0016. Order No. R9-2010-0016 was adopted on November 10, 2010 and provides the Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) for the County of Riverside, the City of Temecula, the City of Murrieta, the City of Wildomar, and the Riverside County Flood Control and Water Conservation District (District), referred to simply as the "2010 MS4 Permit" in the remainder of this document. The purpose for developing this Watershed Workplan, as paraphrased from the 2010 MS4 Permit is to:

1. Characterize the Receiving Water quality in the Upper Santa Margarita River Watershed.
2. Identify and prioritize water quality problem(s) in terms of constituents by location in the Upper Santa Margarita River Watershed's Receiving Waters.
3. Identify the likely sources of the highest priority water quality problem(s) within the Upper Santa Margarita River Watershed.
4. Develop a watershed Best Management Practice (BMP) implementation strategy to attain Receiving Water Quality Objectives for the highest priority water quality problem(s).
5. Develop a strategy to monitor improvements in Receiving Water quality directly resulting from implementation of the BMP implementation strategy described in this Watershed Workplan.
6. Establish a schedule for development and implementation of the BMP and monitoring strategies outlined in this Watershed Workplan.

The primary goal of the Watershed Workplan is to promote the evaluation of water quality issues and the development of solutions on a comprehensive watershed basis rather than political jurisdictions or regulatory program authorities.

1.2 Watershed Workplan Development

According to the California State Water Resources Control Board[1], the mission of the Regional Board is to develop and enforce water quality objectives and implementation plans that will best protect the beneficial uses of the State's waters. To help meet their mission statement, the Regional Board has required the Copermittees to develop this Watershed Workplan. As the Copermittees are not the only dischargers in the watershed, nor do they have jurisdiction over all potential sources of pollutants, this watershed workplan focuses on identifying BMP strategies for those controllable sources that are within the jurisdiction and authority of the Copermittees.

[1] http://waterboards.ca.gov/about_us/water_boards_structure/

1.2.1 Public Participation

During the initial development of this document, two public notices were issued:

On January 17th, 2012, a public notice was posted in the *Press Enterprise*. In addition, on behalf of the Copermittees, the District posted the same notice on the "Public Notices" portion of the District's webpage (www.rcflood.org). This initial public notice (available on file at the District) provided a 30-day comment period requesting "*early input and comment from the public regarding any issues or concerns that should be considered during the development of these documents*." No comments or input was received from the public in response to this public notice.

On May 18, 2012 a second public notice was posted in the *Californian*. This public notice (available on file at the District) provided a link to the District's website where a draft of this document was posted for a 30-day public comment period.

1.3 Governance and Public Participation

There are five Copermittees named on the 2010 MS4 Permit that will implement this Watershed Workplan:

- Riverside County Flood Control and Water Conservation District (District)
- County of Riverside
- City of Murrieta
- City of Temecula
- City of Wildomar

The Copermittees hold periodic public meetings during which they review and discuss the status of the Watershed Workplan, BMP implementation, monitoring, special studies, reporting, and other issues related to the implementation of the requirements of their MS4 Permit. As the Principal Copermittee, the District coordinated the development of the Watershed Workplan, provided public notice to engage public participation, and will facilitate the annual watershed review meetings, and collaborate with the Copermittees in updating the Watershed Workplan.

1.4 Watershed Workplan Updates

The Watershed Workplan will be updated annually to reflect knowledge gained during the preceding reporting period (July 1, 2011 through June 30, 2012). Updating the Watershed Workplan is critically dependent upon:

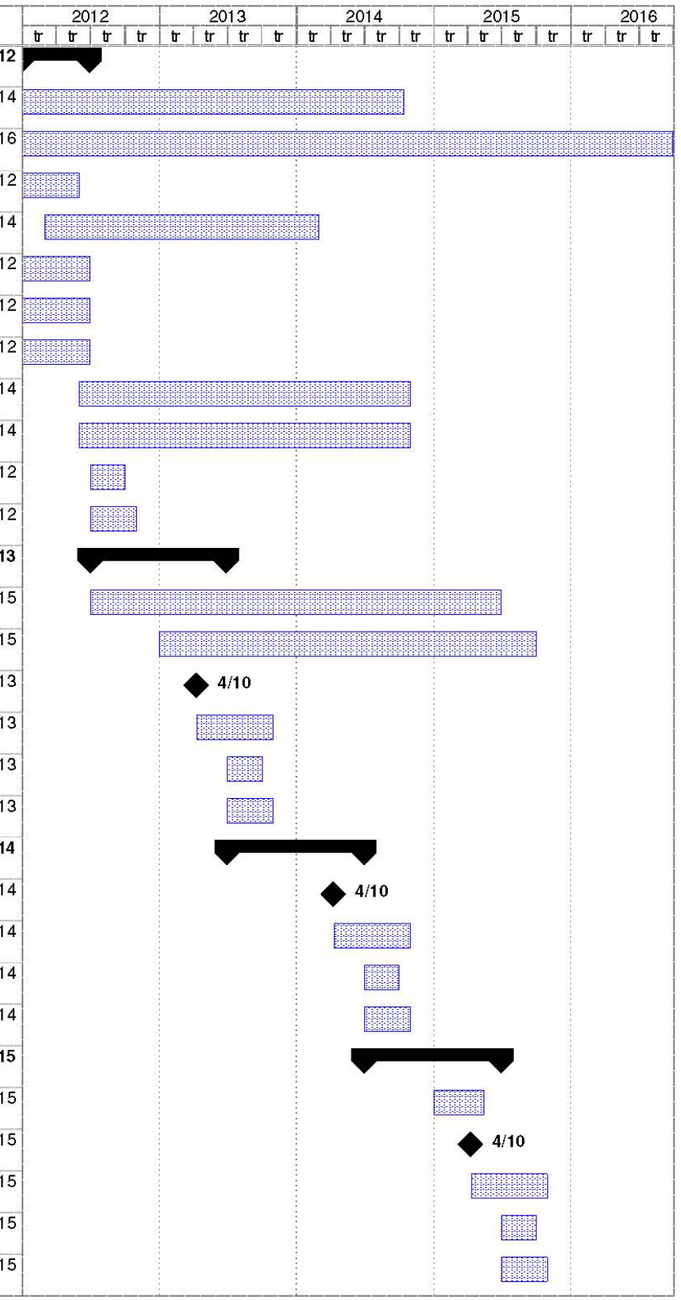
- The Jurisdictional Runoff Management Plan (JRMP) Annual Reports for the Santa Margarita River Monitoring Plan that are completed by October 1st of each year; and
- The annual Program Effectiveness Assessments associated with the Permittee JRMPs, which are completed by October 31st of each year.

An updated draft of the Watershed Workplan will be made available for public review in March 2013 (and annually thereafter) with an Annual Watershed Review Meeting to be conducted in April of each

year. The Annual Watershed Review Meeting will be open to the public during which the components of the updated Watershed Workplan will be described and public dialogue will be encouraged. The Watershed Workplan Annual Update will be completed to address public comment, as appropriate. The Copermittees will then reflect the Watershed Workplan Annual Update in their JRMPs, as may be necessary. The Watershed Workplan Annual Update and the Copermittee's JRMP Annual Reports will be submitted to the Executive Officer of the Regional Board by October 31st of each year. A graphical schedule of the various components of the Watershed Workplan through the term of the 2010 MS4 Permit is shown in Figure 1.

Figure 1. Schedule – Upper Santa Margarita River Watershed Workplan

ID	MS4 PERMIT COMPLIANCE ITEM	Start	Finish
1	**FY 2011/2012 Implementation/Reporting Period**	**Mon 1/2/12**	**Fri 6/29/12**
2	Sediment Toxicity Study	Mon 1/2/12	Tue 10/14/14
3	MS4 & Receiving Water Maintenance Study	Mon 1/2/12	Fri 9/30/16
4	Update Monitoring Program	Mon 1/2/12	Fri 6/1/12
5	Develop Hydromodification Management Plan (HMP)	Thu 3/1/12	Fri 2/28/14
6	Update Water Quality Management Plan	Mon 1/2/12	Fri 6/29/12
7	Update Jurisdictional Runoff Management Plans	Mon 1/2/12	Fri 6/29/12
8	Update Watershed Workplan	Mon 1/2/12	Fri 6/29/12
9	Trash & Litter Investigation Study	Fri 6/1/12	Thu 10/30/14
10	Agriculture, Federal, and Tribal Lands Input Study	Fri 6/1/12	Thu 10/30/14
11	Prepare 2011/2012 Annual Monitoring Report	Mon 7/2/12	Mon 10/1/12
12	Prepare 2011/2012 SWMPs Annual Report	Mon 7/2/12	Wed 10/31/12
13	**FY 2012/2013 Implementation/Reporting Period**	**Mon 7/2/12**	**Fri 6/28/13**
14	Pryethroid TRE Activities	Mon 7/2/12	Tue 6/30/15
15	Intermediate & Ephemeral Stream Perennial Conversion Study	Tue 1/1/13	Thu 10/1/15
16	2013 Annual Watershed Review Meeting	Wed 4/10/13	Wed 4/10/13
17	2012/2013 Watershed Workplan Update & Annual Report	Thu 4/11/13	Thu 10/31/13
18	Prepare 2012/2013 Monitoring Annual Report	Mon 7/1/13	Tue 10/1/13
19	2012/2013 JRMPs Annual Report	Mon 7/1/13	Thu 10/31/13
20	**FY 2013/2014 Implementation/Reporting Period**	**Mon 7/1/13**	**Mon 6/30/14**
21	2014 Annual Watershed Review Meeting	Thu 4/10/14	Thu 4/10/14
22	2013/2014 Watershed Workplan Update & Annual Report	Fri 4/11/14	Fri 10/31/14
23	Prepare 2013/2014 Monitoring Annual Report	Tue 7/1/14	Wed 10/1/14
24	2013/2014 JRMPs Annual Report	Tue 7/1/14	Fri 10/31/14
25	**FY 2014/2015 Implementation/Reporting Period**	**Tue 7/1/14**	**Tue 6/30/15**
26	Prepare Report of Waste Discharge	Thu 1/1/15	Fri 5/15/15
27	2015 Annual Watershed Review Meeting	Fri 4/10/15	Fri 4/10/15
28	2014/2015 Watershed Workplan Update & Annual Report	Mon 4/13/15	Fri 10/30/15
29	Prepare 2014/2015 Monitoring Annual Report	Wed 7/1/15	Thu 10/1/15
30	2014/2015 JRMPs Annual Report	Wed 7/1/15	Fri 10/30/15



2 Description of the Upper Santa Margarita River Watershed

2.1 Physiography and Geology

The Upper Santa Margarita River Watershed includes areas in Riverside and San Diego Counties, is the portion of the Santa Margarita River watershed above the confluence of Murrieta and Temecula Creeks, and encompasses approximately 588 square miles. Temecula and Murrieta Creeks join along the Elsinore fault zone at the head of Temecula Canyon to form the Santa Margarita River. Temecula Canyon is approximately five miles long, and is a steep, narrow, and rocky canyon from which the Santa Margarita River then traverses about 30 miles to the Pacific Ocean.[2]

The portion of Riverside County that is part of the Upper Santa Margarita River Watershed contains broad, relatively flat valleys which are structurally of block fault origin (i.e., graben and horst geologic structures). These valleys have deep alluvial deposits and generally rise to the southeast from an elevation of about 1,000 feet near the City of Temecula to the rolling plateaus of Glenoak, Lewis, and Reed Valleys that range from 3,000 to 3,500 feet in elevation. Surrounding mountains range in elevation from 4,000 to 7,500 feet including Red Mountain, Mount Olympus, and Palomar Mountain to the south (San Diego County), Thomas Mountain and Table Mountain to the east, Bachelor and Black Mountains to the north, and the Elsinore Mountains to the northwest (a sub-range of the Santa Ana Mountains).

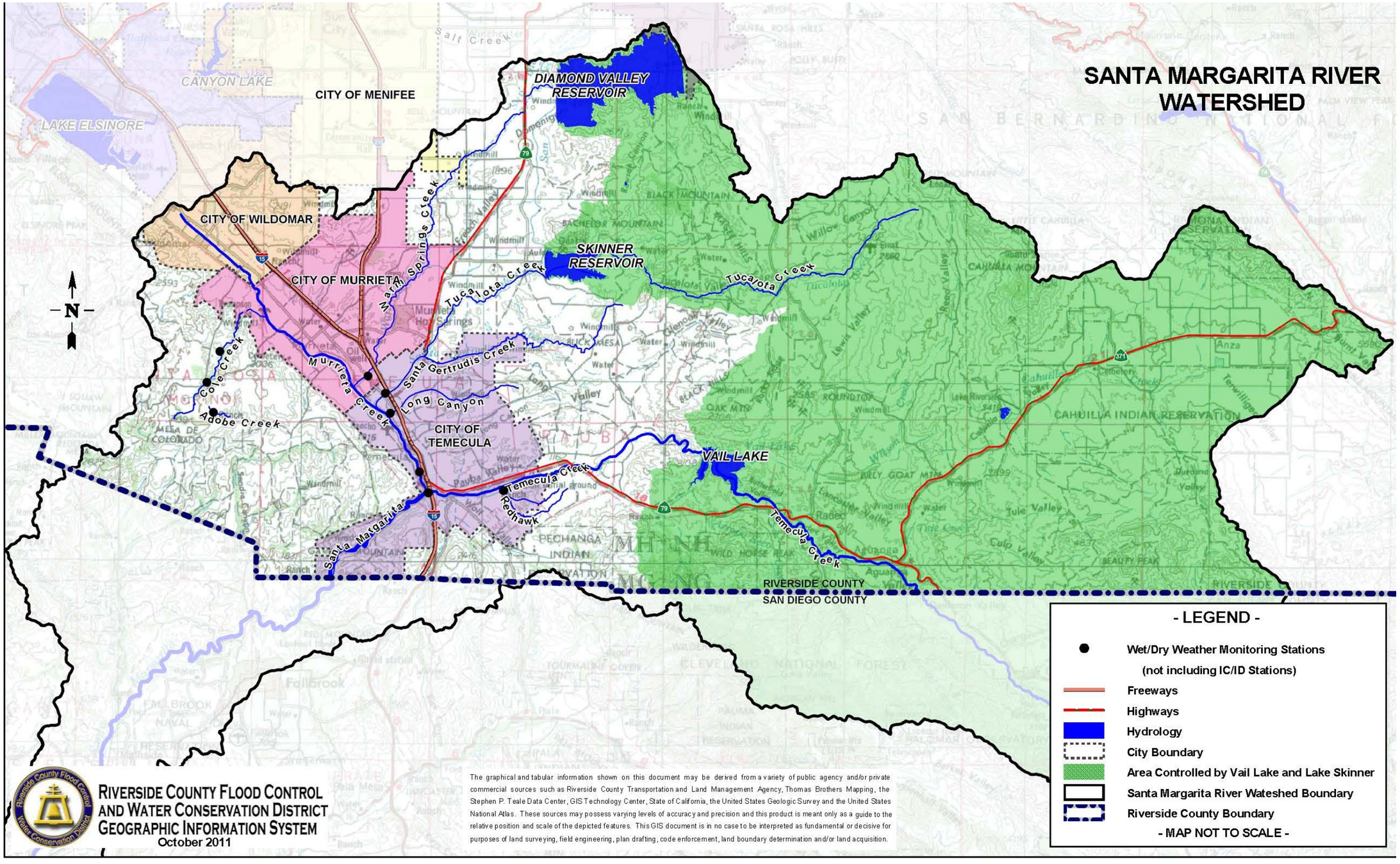
The headwaters of Temecula Creek originate on Aguanga Mountain (elevation about 4,200 feet) in the Cleveland National Forest within San Diego County. The creek flows northeast about one mile to Dodge Valley, where it continues northwest through Dodge Valley, Oak Grove Valley, Dameron Valley, Aguanga Valley, Radec Valley and Butterfield Valley to Vail Lake, after which it flows southwest through Pauba Valley to Temecula Valley where it joins Murrieta Creek to form the Santa Margarita River.

Murrieta Creek originates in the foothills of the Elsinore Mountains and flows southeasterly through Wildomar, Murrieta, and then Temecula.

Within the Upper Santa Margarita River Watershed are the City of Temecula and portions of the cities of Menifee, Murrieta, Wildomar, unincorporated county areas, portions of the Cleveland and San Bernardino National Forests, the Cahuilla, Ramona, Pauma, and Pechanga Tribal Lands, and properties under the jurisdiction of Caltrans and a number of special districts. In the eastern part of the Upper Santa Margarita River Watershed, Temecula Creek crosses the San Diego-Riverside County Line between Dameron Valley and Aguanga Valley. In the western part of the Upper Santa Margarita River Watershed, the Santa Margarita River (formed by the confluence of Temecula and Murrieta Creeks) crosses the San Diego-Riverside County Line in the valley formed by Gavilan Mountain (elevation 1,830 feet) to the north and Red Mountain (elevation 1,780 feet) to the south. A map of the Upper Santa Margarita River Watershed within Riverside County is provided as Figure 2.

[2] Phillips, Williams and Associates, Ltd., "Santa Margarita Watershed Study: Hydrologic and Watershed Processes", October 26, 1998, page 1.

Figure 2. Watershed Map of Upper Santa Margarita River



2.2 Climate

"The climate of the Santa Margarita River Watershed is typically Mediterranean, being characterized by warm dry summers and cool rainy winters. About 75 percent of the precipitation occurs during the four-month period from December through March. Mean annual depth of precipitation ranges from less than 10 inches near Vail Reservoir to over 40 inches west of Palomar Observatory, varying with elevation and topographic influences."[3] Precipitation increases with increases in elevation from the Pacific Ocean to the summit of the coastal mountain range while the shading effects of the coastal mountain range lead to a marked decrease of precipitation throughout the lower portions of the inland area. The significant and varied orographic features make rainfall prediction for a specific location particularly challenging in the urbanized portion of the watershed.

2.3 Watershed Characteristics

The Upper Santa Margarita River Watershed includes two major sub-basins, drained by Temecula and Murrieta Creeks. Temecula Creek and its tributaries have a drainage area of 366 square miles. The upper 316 square miles of that basin is controlled by Vail Lake (completed in 1949). Murrieta Creek and its tributaries (Empire Creek, Long Canyon Channel, Santa Gertrudis Channel, Warm Springs Creek, and Wildomar Channel) have a drainage area of 222 square miles, with over 50 square miles controlled by Lake Skinner (completed in 1974). The predominant surface water bodies of the Upper Santa Margarita River watershed and their Beneficial Uses are provided in Table 1.

Beneficial Uses are the foundation of water quality protection under the *Water Quality Control Plan for the San Diego Basin* (more commonly referred to as the *Basin Plan*). Beneficial Uses are broadly defined as the uses of water necessary for the survival or wellbeing of man, plants and wildlife.[4] The Regional Board adopted a *Basin Plan*[5] that recognizes the Beneficial Uses of the ground and surface waters in its region, natural variances in the water quality of different water resources, and local water quality conditions and Impairments. Given the designation of Beneficial Uses, Water Quality Objectives were established and programs implemented to maintain or enhance water quality that will be protective of Beneficial Uses.

[3] State of California Department of Public Works, Division of Water Resources, Bulletin No. 57, Santa Margarita River Investigation, Volume I, June 1956, p. 11.

[4] *Water Quality Control Plan for the San Diego Basin*. September 1994 (with amendments effective prior to August 25, 2007). California Regional Water Quality Control Board – San Diego Region. p.2-1. http://www.swrcb.ca.gov/rwqcb9/water_issues/programs/basin_plan/index.shtml

[5] http://www.swrcb.ca.gov/rwqcb9/water_issues/programs/basin_plan/index.shtml

Table 1. Beneficial Uses of Receiving Waters Upper Santa Margarita River Watershed

Beneficial Use	Santa Margarita River (2.21 & 2.22)	Murrieta Creek (2.31 & 2.32)	Cole Canyon (2.32)	Long Canyon (2.32)	Warm Springs Creek (2.33, 2.34, 2.35, & 2.36)	Diamond Valley Lake (2.35 & 2.36)	Santa Gertrudis Creek (2.42)	Tucalota Creek (2.41, 2.42, &2.43)	Lake Skinner (2.42)	Murrieta Creek (2.52)	Temecula Creek (2.51 & 2.52)	Temecula Creek (2.81, 2.83 & 2.84)	Vail Lake (2.81)	Temecula Creek (2.91, 2.92, & 2.93)	DeLuz Creek (2.21)
Municipal and Domestic Supply (MUN)	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Agricultural Supply (AGR)	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Industrial Service Supply (IND)	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Industrial Process Supply (PROC)		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Ground Water Recharge (GWR)						♦	◊	◊	◊	♦	♦	♦	♦	♦	
Contact Water Recreation (REC-1)	♦	◊	◊	◊	◊	♦	♦	♦	♦	◊	◊	♦	♦	◊	♦
Non-Contact Water Recreation (REC-2)	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Biological Habitats of Special Significance (BIOL)			♦												
Warm Freshwater Habitat (WARM)	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Cold Freshwater Habitat (COLD)	♦					♦					♦	♦			♦
Wildlife Habitat (WILD)	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Rare, Threatened or Endangered Species (RARE)	♦														♦
Spawn (SPWN)											♦	♦			♦
Hydropower Generation (POW)						♦									

Legend: ♦ Existing Beneficial Use; ◊ Potential Beneficial Use

Source: http://www.waterboards.ca.gov/sandiego/water_issues/programs/basin_plan/index.shtml

2.4 Stream Flow Characteristics

Murrieta and Temecula Creeks are considered perennial interrupted streams, as those creeks are comprised of reaches in which the flow is continuous and others where flow is ephemeral. The areas of perennial flow are located in mountain area tributaries outside of the urbanized areas serviced by the MS4s. The perennial flows disappear by seepage into the sands and gravels, and resurface upstream of the confluence of Murrieta and Temecula Creeks. The creeks in the urbanized areas of the Upper Santa Margarita River Watershed, located primarily in the valley, are ephemeral and flows are only observed during and immediately after significant storm events. During major storms, after initial wetting, periods of intense rainfall result in rapid increases in stream flow in steep foothill and mountain areas.[6] "Runoff in streams in the watershed is derived primarily from rainfall, and as a result, stream flows exhibit monthly and seasonal variations similar to those shown by the precipitation records. Absence of snow pack in the tributary watershed results in a rapid decrease in flow of streams at the conclusion of the winter precipitation season. Following severe storms, discharge in the larger streams often increases in a few hours' time from practically no flow to a rate of thousands of cubic feet per second. Stream flows vary greatly from month to month and from season to season."[7]

Rising groundwater is observed in Murrieta Creek below its confluence with the Santa Gertrudis Channel. Rising groundwater is also observed in Temecula Creek approximately one quarter mile upstream of the Interstate 15 Bridge over Temecula Creek. Additionally, until October 2002, the Rancho California Water District augmented the flow of the Santa Margarita River with reclaimed water at a point about five miles upstream from the Temecula gauging station. Since October 2002, the Rancho California Water District has instead discharged imported water at a location downstream of the confluence of Murrieta and Temecula Creeks in order to meet water supply obligations to Camp Pendleton.

[6] Riverside Flood Control and Water Conservation District, "Hydrologic Data for 1975-76 Season," March 1982, p. 49.

[7] State of California Department of Public Works, Division of Water Resources, Bulletin No. 57, Santa Margarita River Investigation, Volume I, June 1956, p. 48.

3 Characterization of Receiving Water Quality

Characterization of Receiving Water Quality in the Upper Santa Margarita Watershed is performed using various sources of information as described in this section.

3.1 Sources of Information

The Copermittees use the following sources of information to develop and update this Watershed Workplan.

3.1.1 Copermittee Water Quality Monitoring & Assessment

3.1.1.1 2004 MS4 Permit Monitoring

Prior to the adoption of the 2010 MS4 Permit, the Copermittees were subject to Order R9-2004-0001 (2004 MS4 Permit). The Monitoring and Reporting requirements under that Order were implemented through June 30, 2012. That program included the following major components:

- Receiving Water Triad Stations
  - Lower Murrieta Creek
  - Lower Temecula Creek
  - Adobe / Cole Creeks (Dry / Wet weather reference sites)
- Receiving Water Tributary Stations
  - Warm Springs Creek
  - Santa Gertrudis Creek
  - Long Canyon Creek
  - Redhawk Channel
- IC/ID Monitoring

For the initial characterizations of receiving water quality identified in this Watershed Workplan, the Copermittees relied heavily upon the data obtained under the 2004 MS4 Permit monitoring programs.

3.1.1.2 2010 MS4 Permit Monitoring

On June 1, 2012, the Copermittees submitted an updated monitoring plan that describes the monitoring that will be conducted in compliance with, and for the term of, the 2010 MS4 Permit. This updated plan will be implemented by the Copermittees beginning July 1, 2012. As stated in the 2010 MS4 Permit, the "Receiving Waters and MS4 Discharge Monitoring and Reporting Program"[8] is intended to meet the following goals:

1) Assess compliance with Order No. R9-2010-0016;
2) Measure and improve the effectiveness of the Copermittees' Runoff management programs;

[8] Attachment E, San Diego Regional Water Quality Control Board Order No. R9-2010-0016, p. 2

3) Assess the chemical, physical, and biological impacts to Receiving Waters resulting from MS4 discharges;
4) Characterize stormwater discharges;
5) Identify sources of specific Pollutants;
6) Prioritize drainage and sub-drainage areas that need management actions;
7) Detect and eliminate Illicit Connections and Illicit Discharges (IC/IDs) to the MS4;
8) Assess the overall health of Receiving Waters; and
9) Provide information to implement required BMP improvements.

Additionally, the "Receiving Waters and MS4 Discharge Monitoring and Reporting Program" is intended to collect and derive the information needed to answer these core watershed management questions[9]:

1) Are conditions in Receiving Waters protective, or likely to be protective, of Beneficial Uses?
2) What is the extent and magnitude of the current or potential Receiving Water problem(s)?
3) What is the relative MS4 discharge contribution to the Receiving Water problem(s)?
4) What are the sources of MS4 discharge that contribute to Receiving Water problem(s)?
5) Are conditions in Receiving Waters getting better or worse?

Other than special monitoring studies (described later), there are four major components to the "Santa Margarita Region Monitoring Plan" that is Volume III of the Consolidated Monitoring Program:

- Receiving Water monitoring, comprised of:
  - Dry and Wet Weather Mass Loading samples;
  - Stream assessment (Bioassessment, aquatic chemistry, and aqueous Toxicity); and
  - Follow-up Analysis and Actions (Triad approach[10]).
- Regional monitoring programs (where applicable)
- MS4 Outfall Monitoring
  - Wet Weather MS4 discharge monitoring: comprised of MS4 Outfall monitoring and source identification monitoring, and comparison of discharges to Stormwater Action Levels (SALs); and
  - Dry Weather MS4 discharge monitoring: comprised of MS4 Outfall monitoring, Illicit Discharge Detection and Elimination (IDDE), comparison of discharges to Non-Stormwater Action Levels (NALs), and Source Identification Monitoring.
- High Priority Inland Aquatic Habitat Monitoring, which includes both outfall and receiving water samples.

[9] Core management questions from "Model Monitoring Program for Municipal Separate Storm Sewer Systems in Southern California: A report from the Stormwater Monitoring Coalition's Model Monitoring Technical Committee." Technical Report No. 419. August 2004.

[10] Three lines of monitoring data/evidence are considered: water chemistry, water Toxicity, and Bioassessment.

The updated "Santa Margarita Region Monitoring Plan" can be viewed via website http://rcflood.org/NPDES/Monitoring.aspx.

The six Receiving Water stations from which samples are collected by the Copermittees are listed in Table 2 and are fully described in the "Santa Margarita Region Monitoring Plan".

Table 2. Receiving Water Sampling Stations

Station Name	Year Sampling Began	
	Dry Weather	Wet Weather
Adobe Creek	2004	Not applicable
Cole Creek	Not applicable	2001
Murrieta Creek	1994	1996
Temecula Creek	1994	2004
Upper Santa Margarita River∗	2013	Not applicable
Tocalota Creek parallel Borel Rd.	2013	Not applicable
Warm Springs d/s Murrieta Hot Springs	2013	Not applicable
∗ Sampling location at latitude 33.472006 and longitude -117.14518		

Monitoring at these Receiving Water stations consists of water chemistry analysis, Bioassessment, and Toxicity testing. During Wet Weather and Dry Weather sampling events, the water samples collected at these Receiving Water stations will be analyzed for the water chemistry parameters shown in Table 3.

Table 3. Water Chemistry Analytical Parameters[11]

Metals (total and dissolved)	Pesticides
Arsenic	Diazinon
Cadmium	Carbamates
Chromium★	Chlorpyrifos
Copper	Malathion
Iron	Pyrethroids
Lead	
Manganese	**Hydrocarbons**
Mercury	Oil and Grease
Nickel	Dissolved Organic Carbon
Selenium	Total Organic Carbon
Silver	
Thallium	**Conventional Parameters**
Zinc	pH
	Temperature
Nutrients	Hardness (total)
Ammonia (NH_3)	Dissolved Oxygen (DO)
Nitrate (NO_3)✦	Biological Oxygen Demand, 5-day (BOD_5)
Nitrite (NO_2)✦	Chemical Oxygen Demand (COD)
Total Kjeldahl Nitrogen (TKN)	Total Dissolved Solids
Dissolved Phosphorus	Total Suspended Solids
Total Phosphorus	Specific Conductance
	Sulfate
Bacteriological	Turbidity
E. coli	Methlyene Blue Active Substances (MBAS)
Enterococcus	
Fecal Coliform	

★ Hexavalent chromium (Cr^{+6}) laboratory analysis must occur only for mass loading stations for the first Wet Weather event and first Dry Weather event.
✦ Nitrate and nitrite may be combined and reported as nitrate + nitrite.

In characterizing the water quality chemistry for the Receiving Waters, both the *Basin Plan* Water Quality Objectives (WQOs) and the California Toxics Rule (CTR) Continuous Concentration Criterion are considered. The WQOs are provided in Chapter 3 of the *Basin Plan*. The *Basin Plan* WQOs are determined by the Beneficial Uses of individual reaches of a water body and are allocated based on respective sub-watersheds. CTR criteria are listed in 40 CFR 131.38. The *Basin Plan* and the CTR are the basis of the Receiving Water numeric WQOs shown in Table 4 for Pollutants that are commonly associated with Runoff.

[11] Table 1, Analytical Testing for Mass Loading and Stream Assessment in Attachment E, San Diego Regional Water Quality Control Board Order No. R9-2010-0016, p. 5.

Table 4: Numeric WQOs for Receiving Waters in Santa Margarita River Watershed

Constituent	Units	CTR Criterion		*Basin Plan* WQOs by Hydrologic Subarea		
		Acute *	Chronic	902.10, 902.30, 902.70, 902.80, 902.90	902.20, 902.40, 902.50, 902.60	902.21, 902.22, 902.52
Conventional Parameters, Nutrients, and Hydrocarbons						
TDS	mg/L	NA	NA	750	500	750
TSS	mg/L	NA	NA	NA	NA	NA
Turbidity	NTU	NA	NA	20	20	20
Total Hardness	mg/L	NA	NA	NA	NA	NA
pH	pH units	NA	NA	6.5-8.5	6.5-8.5	6.5-8.5
Specific Conductance	µmhos/cm	NA	NA	NA	NA	NA
Temperature	°Celsius	NA	NA	Normal + 5° C	Normal + 5° C	Normal + 5° C
Dissolved Oxygen	mg/L	NA	NA	5	5	5
Total Phosphorus	mg/L	NA	NA	0.1	0.1	0.1
Dissolved Phosphorus	mg/L	NA	NA	NA	NA	NA
Nitrate + Nitrite	mg/L	NA	NA	10	10	10
TKN	mg/L	NA	NA	NA	NA	NA
Ammonia	mg/L	NA	NA	0.025	0.025	0.025
BOD (5 day)	mg/L	NA	NA	NA	NA	NA
COD	mg/L	NA	NA	NA	NA	NA
TOC	mg/L	NA	NA	NA	NA	NA
DOC	mg/L	NA	NA	NA	NA	NA
MBAS	mg/L	NA	NA	0.5	0.5	0.5
Oil and Grease	mg/L	NA	NA	NA	NA	NA
Sulfate	mg/L	NA	NA	300	250	250
TPH	mg/L	NA	NA	NA	NA	NA
Total Residual Chlorine	mg/L	NA	NA	NA	NA	NA
Pesticides						
Diazinon	µg/L	NA	NA	NA	NA	NA
Chlorpyrifos	µg/L	NA	NA	NA	NA	NA
Malathion	µg/L	NA	NA	NA	NA	NA
Carbamates	µg/L	NA	NA	NA	NA	NA
Pyrethroids	mg/L	NA	NA	NA	NA	NA
Metals (Total and Dissolved)						
Arsenic	µg/L	340	150	50	50	50
Cadmium	µg/L	4.3	2.2	5	5	5
Chromium, Total	µg/L	NA	NA	50	50	50
Chromium, Hexavalent	µg/L	16	11	NA	NA	NA
Chromium, Trivalent	µg/L	550	180	NA	NA	NA
Copper	µg/L	13	9	1000	1000	1000
Lead	µg/L	65	2.5	2.5	2.5	2.5
Iron	µg/L	NA	NA	300	300	300
Manganese	µg/L	NA	NA	50	50	50

Constituent	Units	CTR Criterion		*Basin Plan* WQOs by Hydrologic Subarea		
		Acute *	Chronic	902.10, 902.30, 902.70, 902.80, 902.90	902.20, 902.40, 902.50, 902.60	902.21, 902.22, 902.52
Nickel	µg/L	470	52	100	100	100
Selenium	µg/L	NA	5	50	50	50
Zinc	µg/L	120	120	5000	5000	5000
Mercury	µg/L	NA	NA	2	2	2
Silver	µg/L	3.4	NA	100	100	100
Thallium	µg/L	NA	NA	2	2	2
Bacteriological						
Fecal Coliform	MPN/100mL	NA	NA	200	200	200
Enterococcus	MPN/100mL	NA	NA	33	33	33
E. Coli	MPN/100mL	NA	NA	126	126	126
* The California Toxics Rule (CTR) refers to acute criteria as Criterion Maximum Concentration (CMC), also referred to as the EPA 1-hour maximum concentration.						

3.1.2 NPDES MS4 Permit Special Studies

The 2010 MS4 Permit identified six (6) special studies to be conducted or supported by the Permittees in a collaborative effort to further characterize water quality in the Upper Santa Margarita River Watershed. Those six special studies are listed in Table 6.

Table 6. Monitoring Special Studies

Study Descriptive Name	Date Study Workplan due to Regional Board	Study Completed
Sediment Toxicity Study	April 1, 2012	October 1, 2014
MS4 and Receiving Water Maintenance Study	April 1, 2012	October 1, 2016
Trash and Litter Investigation	September 1, 2012	TBD
Agriculture, Federal, and Tribal Input Study	September 1, 2012	TBD
Intermittent & Ephemeral Stream Perennial Conversion Study	April 1, 2013	TBD
StormWater Monitoring Coalition Regional Monitoring of Southern California Coastal Watersheds	Not applicable	Ongoing

As these studies progress and are completed, information gained will be reflected in annual updates of the Watershed Workplan. The study workplans for the Sediment Toxicity Study, and the MS4 and Receiving Water Maintenance Study have been prepared and are included as attachments to the "Santa Margarita Region Monitoring Plan" that can be viewed via website http://rcflood.org/NPDES (after June 1, 2012).

3.1.3 303(d) Listed Water Bodies

As required by Section 303(d) of the CWA the State Water Resources Control Board is required, in conjunction with the Regional Boards, to develop a list of water quality limited segments. "Water quality limited segments" are Receiving Waters that do not meet WQOs necessary for designated

Beneficial Uses. Section 303(d) of the CWA also requires that priority rankings for the water quality limited segments be established and that TMDLs be established to improve water quality. Table 7 shows the Pollutants identified as causing the impairment for Receiving Waters in the Upper Santa Margarita River Watershed.

Table 7. Receiving Waters and Impairments in the Upper Santa Margarita River Watershed

Pollutant	Santa Margarita River (2.22)	Murrieta Creek (2.52)	Long Canyon Creek (2.32)	Santa Gertrudis Creek (2.42)	Redhawk Channel (2.51)	Temecula Creek (2.51)	Warm Springs Creek (2.33)	DeLuz Creek (2.21)
Pesticides								
Chlorpyrifos		♦	♦	♦	♦	♦	♦	
Diazinon					♦			
Pathogens (i.e., Indicator Bacteria)								
Fecal Coliform			♦	♦	♦		♦	
E. coli				♦	♦		♦	
Metals								
Copper		♦		♦	♦	♦		
Iron		♦	♦	♦	♦		♦	♦
Manganese		♦	♦	♦	♦		♦	♦
Nutrients								
Nitrogen		♦			♦			♦
Phosphorous	♦	♦		♦	♦	♦	♦	
Total Nitrogen as N							♦	
Other								
Sulfates								♦
Total Dissolved Solids					♦	♦		
Toxicity	♦	♦				♦		

Source: 2010 California 303(d) List of Water Quality Limited Segments; http://www.waterboards.ca.gov/water_issues/programs/#wqassessment

3.1.4 Other Receiving Water Quality Data

The Copermittees will consider water chemistry data, Bioassessment data, and aquatic Toxicity data of Receiving Waters that may have been collected by other entities, such as other dischargers, regulatory or resource agencies, and non-governmental organizations (NGOs)[12]. In March of each year beginning in 2013, when the draft Watershed Workplan Annual Update is posted for public comment, Receiving Water quality data collected by others will be solicited. In soliciting other Receiving Water quality data, entities will be requested to provide the sampling location latitude and longitude, name and address of the water quality analytical laboratory, the laboratory analytical reports, and the quality assurance/quality control (QA/QC) program for sampling and analysis. This other Receiving Water

[12] The term "NGO" may be applied to any non-profit organization that is typically formed around a common special interest and, in whole or in part, sustained on charitable donations and voluntary service. NGOs have been formed to address issues, such as environmental protection, children's welfare, health care, human rights, economic development, etc.

quality data, if deemed to have had appropriate QA/QC such that it can be considered comparable to the data collected by the Copermittees, will be considered in completing the Watershed Workplan Annual Update.

The most recent Surface Water Ambient Monitoring Program (SWAMP) report to focus on the Santa Margarita River Watershed was published in July 2007[13]. That report is based upon "water chemistry, toxicity, and fish tissues…assessed under SWAMP between 2002 and 2003" and "bioassessment samples…collected under other programs between 1998 and 2005." One of the findings of that report (copy included as Appendix A) was:

> "…the watershed is in moderate to good health, although many impacts were evident, particularly in the lower portions of the mainstem. Multiple lines of evidence support this conclusion. For example, several water chemistry constituents exceeded aquatic life and human health thresholds at all sites. Toxicity was observed at every site, although never on every sampling date. Bioassessment samples suggested that poor ecological conditions were widespread, although conditions were better at DeLuz and Roblar Creeks. Physical habitat was good throughout the watershed.
>
> Despite the strength of the evidence, limitations of this study affect the assessment. These limitations include difficulties integrating data from SWAMP and non-SWAMP sources, the non-randomization of sample sites, small sample size, and the lack of applicable thresholds for several indicators. Although these limitations require that results be interpreted with caution, it is unlikely that they would alter the conclusion that the Santa Margarita HU is in moderate to good ecological health."

3.2 Characterization of Receiving Water Quality

Receiving Water quality in the Upper Santa Margarita River Watershed is characterized by considering the listing of impaired water bodies as designated in an approved CWA Section 303(d) List, together with Mass Loading and Stream Assessment information from Receiving Waters monitoring and Special Studies described in the "Santa Margarita Region Monitoring Plan", and where appropriate, other Receiving Water monitoring data provided by third parties.

3.2.1 Priority Pollutants and Potential Sources

The following pollutants have been identified by the Regional Board as exceeding Water Quality Objectives and have been added to the 2010 303(d) List. It should be noted, however, that although this document has been prepared by the Copermittees, that discharges from Copermittee-owned MS4s are not the sole, nor in some cases the predominant source of such pollutants. Nor are the Copermittees solely responsible for attainment of Water Quality Objectives or Beneficial Uses in Receiving Waters. This Watershed Workplan is, however, an opportunity for the MS4 Copermittees to prioritize issues

[13] Southern California Coastal Water Research Project. July 2007. Technical Report 527_SantaMargarita: "Surface Water Ambient Monitoring Program (SWAMP) Report on the Santa Margarita Hydrologic Unit." Prepared for the California Regional Water Quality Control Board, San Diego Region.

within the watershed with respect to their discharges, and to identify the BMP strategy that the Copermittees will implement to address discharges of those pollutants from the MS4 consistent with the MEP standard.

Information about likely sources of the various pollutants is also described in each sub-section below. With future Watershed Workplan updates, any additional source information obtained through JRMP implementation and/or the MS4 Outfall Source Identification Monitoring will be incorporated.

3.2.1.1 Pesticides

Pyrethroid Pesticides

Pyrethroid pesticides are widely used in the Upper Santa Margarita River Watershed and throughout California, and were the subject of the Toxicity Reduction Evaluation (TRE) submitted to the San Diego Regional Board in January 2009. The *Basin Plan* provides a narrative WQO for pesticides[14] in general, which is applicable to pyrethroid pesticides.

Pyrethroid pesticides detected at the monitoring stations include bifenthrin, cyfluthrin, cypermethrin, danitol, deltamethrin, esfenfaverate, fenvalerate, fluvalinate, l-cyhalothrin, and permethrin (both cis and trans). More varied types of pyrethroid pesticides were present than during the 2009-2010 Monitoring Year. Pyrethroid pesticides have also been detected at the Cole Creek Reference Station during 2010-2011 and at the Cole Creek and Adobe Creek Reference Stations in the 2009-2010 Monitoring Year. The presence of pyrethroid pesticides at the Reference Stations may indicate that the source of at least some of the pyrethroid pesticides is not limited to urbanized areas. Furthermore, Toxicity to *Hyalella Azteca* was observed in only one sample collected during the 2010-2011 Monitoring Year indicating that persistent exceedances of the narrative WQO may no longer be of concern.

Chlorpyrifos, Diazinon, and Other Organophosphate Pesticides

The *Basin Plan* provides a narrative WQO for pesticides in general, which is applicable to organophosphate pesticides. No organophosphate pesticides, including chlorpyrifos and diazinon, were detected during the 2010-2011 Monitoring Year or the 2009-2010 Monitoring Year; nor was Toxicity to *Ceriodaphnia dubia* observed. Results from Toxicity Investigation Evaluations (TIEs) conducted from 2006 through 2008 did not find evidence that chlorpyrifos is the cause of Toxicity in freshwater organisms in Murrieta and Temecula Creeks. Toxicity to *Ceriodaphnia dubia*, a water flea that is sensitive to chlorpyrifos, was not detected at Temecula Creek or Murrieta Creek between Fall 2004 and Spring 2011. Chlorpyrifos concentrations have been decreasing steadily in samples since 2004, and this trend is likely to continue as a result of the USEPA restrictions. The Copermittees will continue to monitor for organophosphate pesticides, however, since organophosphate pesticides are associated with CWA Section 303(d) impairments for both Murrieta and Temecula Creeks.

[14] No individual pesticide or combination of pesticides shall be present in the water column, sediments or biota at concentration(s) that adversely affect Beneficial Uses. Pesticides shall not be present at levels which will bioaccumulate in aquatic organisms to levels which are harmful to human health, wildlife or aquatic organisms.

3.2.1.2 Metals

Metals that are observed in surface water quality samples collected in the Upper Santa Margarita River watershed include Copper, Iron and Manganese.

Copper

The following table shows those Downstream Receiving Waters that are on the 303(d) list for Copper, and correlates that listing with findings of other sources of data:

COPPER	Reference Sites		Downstream Receiving Waters						
	Adobe Creek	Cole Creek	Murrieta Creek		Redhawk Channel		Temecula Creek		Santa Gertrudis Creek
CWA Section 303(d) Listing			✓		✓		✓		✓
Copermittee Data FY 08/09 – FY 10/11	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet
WQO Exceedance / Total Samples	0 / 6	0 / 8	0 / 6	0 / 9	0 / 6	1 / 6	0 / 6	0 / 9	2 / 6
CTR Exceedance / Total Samples	0 / 6	2 / 8	0 / 6	0 / 9	0 / 6	0 / 6	0 / 6	0 / 9	0 / 6

Although the three downstream Receiving Waters are on the 303(d) List for copper, no exceedances of WQO have been detected in the last three years at any of these Receiving Waters. Only one in six Wet Weather samples taken at Redhawk Channel has exceeded CTR. The Cole Creek reference site had two of eight Wet Weather samples exceed CTR criterion. Per the *Basin Plan*, the WQO for total Copper is 1,000 µg/L. CTR criterion was utilized for the dissolved Copper WQO, using hardness-based calculations from 40 CFR 131.38.

Copper, particularly Copper salts, are not commonly found in natural surface waters. Elevated copper concentrations in Urban Runoff are frequently associated with brake pad wear (TDC Environmental, 2004). California State Bill 346 was passed in September 2010, requiring the reduction of copper and other toxic materials in brake pads sold in California. However, significant reductions in copper concentrations from the phase out of older-style brake pads will most likely not impact copper concentrations in surface waters in the short term. Additionally, the effects of large wildfires have been linked to elevated copper and other Pollutant concentrations in surface waters. For example, water samples collected from Ballona Creek in San Diego County showed indirect effects of fires with disproportionately high Copper and Zinc concentrations after the 2003 fires (SCCWRP, 2009). Also, soil samples from residential areas affected by the 2007 Harris fire in Southern California, have been found to contain elevated concentrations of Arsenic, Lead, Antimony, Copper, Zinc, and Chromium (USGS, 2007). Potential industrial sources of Copper may include corrosion of Copper and Brass tubing, Copper compounds used to control undesirable plankton organisms, alloy production, electrical wiring, pipes, roofing, and many purposes where its conductivity or corrosion resistance are important. Copper salts are also used in insecticides and fungicides and many industrial processes.

Iron

The following table shows those Downstream Receiving Waters that are on the 303(d) List for Iron, and correlates that listing with findings of other sources of data:

IRON	Reference Sites		Downstream Receiving Waters							
	Adobe Creek	Cole Creek	Long Canyon Channel		Murrieta Creek		Redhawk Channel		Santa Gertrudis Creek	Warm Springs Creek
CWA Section 303(d) Listing			✓		✓		✓		✓	✓
Copermittee Data FY 08/09 – FY 10/11	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Wet
WQO Exceedance / Total Samples	2 / 6	6 / 8	0 / 5	6 / 6	0 / 6	9 / 9	0 / 6	6 / 6	6 / 6	6 / 6
CTR Exceedance / Total Samples	0 / 6	0 / 8	0 / 5	0 / 6	0 / 6	0 / 9	0 / 6	0 / 6	0 / 6	0 / 6

Iron was routinely detected above WQO in all Wet Weather samples, including at the Reference station at Cole Creek. No Dry Weather samples exceeded WQO. The Iron WQO is 300 µg/L for all Triad and Tributary stations. However, background concentrations are also routinely detected above WQO as concentrations of Total Iron measured in samples collected at the Reference stations have ranged from 63 µg/L to 20,000 µg/L.

In the Upper Santa Margarita River Watershed, Iron is likely naturally sourced from the corrosion of Iron in soil, mineral deposits, and Iron-bearing groundwater. For example, concentrations of Iron have been historically observed at the Cole Creek Reference Station at 20,000 µg/L. Further, according to the Rancho California Water District (RCWD), Iron is found in groundwater within the Upper Santa Margarita River Watershed. The RCWD indicates leaching from natural deposits that exist in the Upper Santa Margarita River Watershed as the source (Bill Insert Summer 2008 Information Statement, Volume 63). Preliminary research into soils near and tributary to Murrieta Creek reveal geologic features that are basaltic in origin due to the proximity of the Elsinore Fault Zone to Murrieta and Temecula Creeks. Upstream reaches of Murrieta Creek also show geologic areas of pyrite (FeS_2) that may be contributing to higher concentrations measured in samples collected during storm event flows. The Copermittees will continue further research of natural and possible urban sources of Iron within the Upper Santa Margarita River Watershed. To aid in this research, analytical testing of Iron will be performed for samples collected at IC/ID stations for Monitoring Year 2011-2012. Results of continued monitoring will be used to guide any actions to address this Pollutant.

Manganese

The following table shows those Downstream Receiving Waters that are on the 303(d) List for Manganese, and correlates that listing with findings of other sources of data:

MANGANESE	Reference Sites		Downstream Receiving Waters							
	Adobe Creek	Cole Creek	Long Canyon Channel		Murrieta Creek		Redhawk Channel		Santa Gertrudis Creek	Warm Springs Creek
CWA Section 303(d) Listing			✓		✓		✓		✓	✓
Copermittee Data FY 08/09 – FY 10/11	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Wet
WQO Exceedance / Total Samples	0 / 6	2 / 8	0 / 5	5 / 6	4 / 6	9 / 9	1 / 6	6 / 6	3 / 6	4 / 6
CTR Exceedance / Total Samples	0 / 6	0 / 8	0 / 5	0 / 6	0 / 6	0 / 9	0 / 6	0 / 6	0 / 6	0 / 6

Manganese is geochemically similar to Iron and has similar natural origins and can occur naturally in Runoff from the corrosion of Manganese in soil and mineral deposits. According to the RCWD, Manganese has been found in the groundwater in the Upper Santa Margarita River Watershed at concentrations ranging from 0 to 290 µg/L; and the RCWD identified leaching from natural deposits as the source of contamination (Bill Insert Summer 2008 Information Statement, Volume 63). Per the *Basin Plan*, the WQO for Manganese is 50 µg/L, which is well below the concentrations observed in groundwater.

As such, concentrations of Manganese 20% or more above the WQO were measured in samples collected from all events at Murietta Creek and Temecula Creek. Manganese, therefore, appears to be a Pollutant of Concern at the Triad stations. Exceedances were also detected at Cole Creek, and all Tributary stations during one storm event. Manganese did not exceed the WQO in samples collected at Adobe Creek or the Tributary stations during Dry Weather. As discussed previously, dry weather flows in Temecula Creek and Murrieta Creek consist of rising groundwater, with no MS4 input observed by field crews during sampling activities.

Preliminary research into geologic features near and tributary to Murrieta and Temecula Creeks revealed soil and rock are basaltic in origin due to the proximity of the Elsinore Fault Zone to Murrieta and Temecula Creeks; this may be contributing to higher Manganese levels seen during storm event flows. Additionally, exceedances of the WQO for Manganese have been observed at the Cole Creek Reference Station as well as at stations in the valley. It is likely that leaching from natural sources is the cause of at least some WQO exceedances. The Copermittees will continue further research of natural and possible urban sources of Manganese within the Upper Santa Margarita River Watershed. To aid in this research, analytical testing of Manganese will be performed for samples collected at IC/ID stations for Monitoring Year 2011-2012. Results of continued monitoring will used to guide any actions to address this Pollutant.

3.2.1.3 Nutrients

Nitrogen

Nitrogen can be present in water as ammonia, organic nitrogen, nitrites, and nitrates. The total concentration of nitrogen is not as important as the form in which it exists. Organic nitrogen, amino acids, and ammonia may inhibit biological growth, whereas nitrates stimulate growth of algae. Nitrates are an essential fertilizer for plant life. Nitrogen-producing activities in a given watershed may include field or yard application of fertilizer, livestock and pet wastes, and irrigated agriculture. Nitrogen may also be present as a result of cesspool or septic tank leachate (USEPA, 2006).

Per the *Basin Plan*, the total nitrogen WQO is narrative, requiring concentrations that do not stimulate algal growth. In the absence of specific research on a particular water body, the WQO is described generally as a concentration of nitrogen ten times higher than the level of phosphorus (10:1 N-P ratio). The WQO for nitrogen was calculated by multiplying the phosphorous concentration of the sample by ten. The result of the calculation was compared to the nitrogen concentration of the same sample to determine whether the sample exceeded the WQO. The Copermittees, represented by the District, are

collaborating with stakeholders south of the County Boundary in developing a Numerical Nutrient Endpoint (NNE) for the Santa Margarita River.

The following table shows those Downstream Receiving Waters that are on the 303(d) List for Nitrogen, and correlates that listing with findings of other sources of data:

NITROGEN	Reference Sites		Downstream Receiving Waters				
	Adobe Creek	Cole Creek	Murrieta Creek		Redhawk Channel		Santa Gertrudis Creek
CWA Section 303(d) Listing			✓		✓		✓
Copermittee Data FY 08/09 – FY 10/11	Dry	Wet	Dry	Wet	Dry	Wet	Wet
WQO Exceedance / Total Samples	2 / 6	3 / 8	1 / 6	0 / 9	2 / 6	1 / 6	1 / 6

Nitrogen concentrations greater than the WQOs were observed in both Dry and Wet Weather samples collected from both the Downstream Receiving Waters and the Reference Stations. The number of WQO exceedances observed at the Reference Stations indicate that high nitrogen concentrations may be partially attributable to natural conditions in the Upper Santa Margarita River Watershed. There is no direct evidence that nitrogen levels have stimulated algal growth above naturally occurring conditions.

Phosphorus

Phosphorus, an essential nutrient for plant and animal growth, is found naturally in soil and rocks. However, excessive phosphorus concentrations may lead to overabundant algae growth. Other potential phosphorus sources include wastewater treatment plant effluent, agricultural runoff, residential fertilizer applications, failing septic systems, and disturbed land areas (EPA, 2006). Per the *Basin Plan*, the Total Phosphorus WQO is narrative, requiring concentrations that do not stimulate algal growth. In the absence of specific research on a particular water body, the *Basin Plan* provides a "desired goal" for Total Phosphorus of 0.1 mg/L. For consistency in reporting, the WQO utilized is 0.1 mg/L. The Copermittees, represented by the District, are collaborating with other stakeholders in developing NNE for the Santa Margarita River Watershed to ensure that appropriate targets are identified.

The following table shows those Downstream Receiving Waters that are on the 303(d) List for Phosphorus, and correlates that listing with findings of other sources of data:

PHOSPHORUS	Reference Sites		Downstream Receiving Waters							
	Adobe Creek	Cole Creek	Murrieta Creek		Redhawk Channel		Temecula Creek		Santa Gertrudis Creek	Warm Springs Creek
CWA Section 303(d) Listing			✓		✓		✓		✓	✓
Copermittee Data FY 08/09 – FY 10/11	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Wet
WQO Exceedance / Total Samples	0 / 6	4 / 8	1 / 6	9 / 9	6 / 6	6 / 6	4 / 6	9 / 9	6 / 6	6 / 6

All Wet Weather samples collected from all Downstream stations exceeded the WQO for Total Phosphorous. The Reference Sites exceeded in 50% of the samples collected. The historically

intermittent and varying presence of phosphorus at the two Reference stations may indicate that phosphorus concentrations are the result of a natural source. There is no direct evidence that phosphorus levels have stimulated algal growth above naturally occurring conditions.

3.2.1.4 Pathogens (Indicator Bacteria)

Escherichia coli (*E. coli*)

E. coli is a specific strain of fecal coliform bacteria that live in the intestines of animals and humans. It is of special concern to human health (USEPA, 2006). The San Diego Regional Board in Resolution No. R9-2008-0028, stated, "Exceedances of indicator bacteria Water Quality Objectives frequently occur at beaches or in creeks that receive runoff from predominately undeveloped watersheds. This demonstrates that natural sources cause exceedances of indicator bacteria WQO on their own, without contributions from anthropogenic sources."

Per the *Basin Plan*, the WQO for *E. coli* is applicable to water bodies with a contact recreation (REC-1) designated Beneficial Use. The WQO presented in this report is 126 MPN/100mL for the freshwater steady state (all areas).

The following table shows those Downstream Receiving Waters that are on the 303(d) List for E. coli, and correlates that listing with findings of other sources of data:

E. coli	Reference Sites		Downstream Receiving Waters			
	Adobe Creek	Cole Creek	Redhawk Channel		Santa Gertrudis Creek	Warm Springs Creek
CWA Section 303(d) Listing			✓		✓	✓
Copermittee Data FY 08/09 – FY 10/11	Dry	Wet	Dry	Wet	Wet	Wet
WQO Exceedance / Total Samples	3 / 6	6 / 8	3 / 6	6 / 6	6 / 6	6 / 6

The above data shows that E. coli exceedances are seen in at least 50% of both Dry and Wet weather samples from the reference sites. Although exceedances are more prevalent in the downstream receiving waters, the presence of exceedances at the reference sites indicates that there is likely a strong natural component to the presence of E. coli in Receiving Waters.

Fecal Coliform

Coliform organisms are intestinal bacteria that are excreted as waste by humans and animals. They are also found in non-fecal forms (USEPA, 2006). The urban areas within the Upper Santa Margarita River watershed are relatively new and have modern municipal waste water collection and treatment systems, so human waste from septic systems or leaking sanitary sewers is not a likely source of fecal coliform bacteria in Urban Runoff from this area. The San Diego Regional Board, in Resolution No. R9-2008-0028, stated, "Exceedances of indicator bacteria Water Quality Objectives frequently occur at beaches or in creeks that receive Runoff from predominately undeveloped watersheds. This

demonstrates that natural sources cause exceedances of indicator bacteria Water Quality Objectives on their own, without contributions from anthropogenic sources".

Per the *Basin Plan*, the WQO for fecal coliform bacteria is applicable to water bodies designated as the contact recreation (REC-1) Beneficial Use. All Triad and Tributary stations are listed in the *Basin Plan* as having either the existing or potential REC-1 Beneficial Use. The WQO presented in this report is 200 MPN/100mL for inland surface waters.

The following table shows those Downstream Receiving Waters that are on the 303(d) List for Fecal Coliform, and correlates that listing with findings of other sources of data:

FECAL COLIFORM	Reference Sites		Downstream Receiving Waters					
	Adobe Creek	Cole Creek	Long Canyon Channel		Redhawk Channel		Santa Gertrudis Creek	Warm Springs Creek
CWA Section 303(d) Listing			✓		✓		✓	✓
Copermittee Data FY 08/09 – FY 10/11	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Wet
WQO Exceedance / Total Samples	2 / 6	4 / 8	0 / 5	6 / 6	2 / 6	6 / 6	6 / 6	6 / 6

Fecal coliform bacteria were detected at levels above the WQO in all Wet Weather samples. Dry Weather samples, including those collected at the Adobe Creek Reference station only intermittently contained counts that exceeded the WQO.

3.2.1.5 Total Dissolved Solids (TDS)

In natural waters TDS consists mainly of carbonates, bicarbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium with traces of iron, manganese and other substances (RWQCB, 2007). High concentrations of TDS found in water often come from natural sources such as mineral springs and where water has flowed through a region with rocks that contain a high salt content. During hot or dry weather, which is typical of the Upper Santa Margarita River Watershed from May through September, evaporation may increase TDS concentrations in water bodies. In addition, agricultural and Urban Runoff may carry minerals into Receiving Waters, resulting in increased TDS concentrations. Industrial and wastewater sources regulated directly by the Regional Board may also cause increases in TDS concentrations in Receiving Waters (SDWF, 2009).

The following table shows those Downstream Receiving Waters that are on the 303(d) List for Total Dissolved Solids, and correlates that listing with findings of other sources of data:

TOTAL DISSOLVED SOLIDS	Reference Sites		Downstream Receiving Waters			
	Adobe Creek	Cole Creek	Redhawk Channel		Temecula Creek	
CWA Section 303(d) Listing			✓		✓	
Copermittee Data FY 08/09 – FY 10/11	Dry	Wet	Dry	Wet	Dry	Wet
WQO Exceedance / Total Samples	0 / 6	0 / 8	5 / 6	0 / 6	5 / 6	3 / 9

In the *Basin Plan*, the WQO for TDS is dependent on the hydrologic area, and/or hydrologic sub-area. The TDS WQO is 500 mg/L for Adobe Creek, Cole Creek, Temecula Creek, Redhawk Channel, and Santa Gertrudis. The TDS WQO is 750 mg/L for Murrieta Creek, Long Canyon Channel, and Warm Springs Channel.

3.2.2 Stream Assessment (Bioassessment)

The Pollutants identified in Section 3.2.1 provide an analysis of the presence of specific constituents within Receiving Waters in the Upper Santa Margarita River Watershed. Stream Assessments use that information, together with assessments of physical habitat and biological conditions to provide an overall assessment of the health of a natural stream. To date, Bioassessment monitoring has been conducted for three creeks (Adobe, Murrieta, and Temecula). Beginning in May 2013, Stream Assessments will be conducted at three additional sites that have yet to be determined.

With regard to the Stream Assessments of Adobe, Murrieta, and Temecula Creeks, each creek exhibits a distinctive pattern in regard to the respective Index of Biological Integrity (IBI) scores:

- Adobe Creek was stable across the summer of 2010, but then showed a sharp increase from November 2010 to May 2011.
- Lower Murrieta Creek remained relatively stable across all three sampling events.
- Lower Temecula Creek fell 18 points across the summer of 2010, but then rose 22 points the following spring.

Of the biological metrics considered to be negative stream characteristics (% collector individuals, % non-insect taxa, and % tolerant taxa), both Lower Temecula and Lower Murrieta Creeks exhibited low scores, relative to Adobe Creek. Of those biological metrics considered to be positive stream characteristics (# coleopteran taxa, # EPT taxa, # predator taxa, and % intolerant individuals), none of the three creeks exhibited a noteworthy trend. All were generally stable, alternating back and forth with no observable pattern between sites.

Diversity metrics provide valuable information about the number of taxa found and the evenness of the distribution of individuals among those taxa. In a pristine system with high diversity, the benthic macroinvertebrate community would be expected to contain many different taxa with a relatively even distribution of organisms between them. Across all sampling events, the number of taxa and the evenness of their distribution were considerably greater at Adobe Creek than either of the two lower watershed creeks.

Physical habitat quality scores for all three creeks remained relatively stable, with all sites remaining in the same qualitative category. Lower Murrieta Creek showed a slight decrease in score for the last sampling period in May 2011 that was primarily driven by metrics related to water volume (i.e., velocity to depth regime and channel flow status) and stream bank quality (i.e., channel alteration, bank stability, and vegetative protection). Lower Temecula Creek showed a small but steady increase in physical habitat scores, primarily driven by velocity to depth regime and an increase of in-stream emergent vegetation that provided habitat for macroinvertebrates. Lower Temecula Creek has a high percentage of bed load fines. Accumulation of fine sediments may be harmful to benthic macro-

invertebrate communities by covering and filling interstitial areas of boulder, gravel, and cobble that aquatic insects utilize. As a result, Lower Temecula Creek is characterized as having a "Poor" benthic biological community. Lower Murrieta Creek is also characterized as having a "Poor" benthic biological community due to the site streambed being primarily bare bedrock.

3.2.3 Toxicity

Stormwater toxicity testing has shown consistent and persistent Toxicity to *Hyalella* at Lower Murrieta Creek and Lower Temecula Creek. To date, Toxicity Identification Evaluations (TIEs) have consistently identified pyrethroid pesticides as the main driver of this stormwater Toxicity. Pyrethroid pesticides are designed to be Toxic to insects; however, a definitive connection between acute stormwater Toxicity and benthic community impacts has yet to be made in published studies.

3.3 Prioritization of Receiving Water Quality Issues

One of the purposes of this Watershed Workplan is to inform the component programs (e.g., public education, IDDE, development planning, etc.) implemented by the Copermittees in compliance with the 2010 MS4 Permit. Therefore, the prioritization of Receiving Water Quality issues is focused on several factors:

- Adopted TMDLs;
- 303(d) listings;
- Persistent exceedances of WQOs, Toxicity or other impacts to Beneficial Uses;
- Pollutants known or suspected to have contribution from controllable sources (i.e., anthropogenic) under the jurisdiction of the Copermittees; and
- Pollutants associated with persistent exceedances in dry weather discharges.

The Copermittees will prioritize the water quality issues of Receiving Waters using the criteria as shown in Table 8.

Table 8. Prioritization Hierarchy for Water Quality Issues

Priority	Receiving Water Characteristic or Issue				
	Adopted TMDL	CWA 303(d) Listed	Persistent exceedances of WQOs	Known or Suspected Anthropogenic Source	Persistent Dry Weather exceedances
1	✓				
2		✓	✓	✓	✓
3		✓	✓	✓	
4		✓	✓		
5		✓			

1 = Adopted TMDL
2 = CWA § 303(d) Listed, and persistent exceedances, and known or suspected anthropogenic source controllable by the Copermittees, and a persistent dry weather exceedance
3 = CWA § 303(d) Listed and persistent exceedances and known or suspected anthropogenic source controllable by the Copermittees
4 = CWA § 303(d) Listed and persistent exceedances
5 = CWA § 303(d) Listed

Using these prioritization criteria, Table 9 shows the priority assigned to water quality issues in various Receiving Waters in the Upper Santa Margarita River Watershed. Each year with the Watershed Workplan Annual Update, the prioritization of water quality issues will be revised to reflect the addition of the most current information.

Table 9. Receiving Waters and Priority of Water Quality Issues

Pollutant	Priority of Water Quality Issues				
	1	2	3	4	5
Metals					
Copper					Murrieta Creek Redhawk Channel Santa Gertrudis Creek Temecula Creek
Iron				Long Canyon Creek Murrieta Creek Redhawk Channel Santa Gertrudis Creek Warm Springs Creek	
Manganese				Long Canyon Creek Murrieta Creek Redhawk Channel Santa Gertrudis Creek Warm Springs Creek	
Nutrients					
Nitrogen					Murrieta Creek Redhawk Channel Warm Springs Creek
Phosphorous		Redhawk Channel Santa Gertrudis Creek Santa Margarita River Temecula Creek Warm Springs Creek	Murrieta Creek		
Other Inorganics					
Total Dissolved Solids				Redhawk Channel Temecula Creek	

Pathogens (i.e., Indicator Bacteria)					
Escherichia coli (E. coli)			Redhawk Channel Santa Gertrudis Creek Warm Springs Creek		
Fecal Coliform			Long Canyon Creek Redhawk Channel Santa Gertrudis Creek Warm Springs Creek		
Pesticides					
Chlorpyrifos					Long Canyon Creek Murrieta Creek Redhawk Channel Santa Gertrudis Creek Temecula Creek Warm Springs Creek
Diazinon					Redhawk Channel
Toxicity			Murrieta Creek* Santa Margarita River Temecula Creek*		

1 = Adopted TMDL
2 = CWA § 303(d) Listed, and persistent exceedances, and known or suspected anthropogenic source controllable by the Copermittees, and a predominantly dry weather occurrence
3 = CWA § 303(d) Listed and persistent exceedances and known or suspected anthropogenic source controllable by the Copermittees
4 = CWA § 303(d) Listed and persistent exceedances
5 = CWA § 303(d) Listed
* Toxicity at these locations has been determined through the TIE/TRE process to be from Pyrethroid pesticides. Although this source is suspected to be anthropogenic, the Copermittees have limited ability to control sources of pesticides as they are federally authorized.

4 Upper Santa Margarita River Watershed BMP Implementation Strategy

As defined in federal regulations[15], Best Management Practices (BMPs) are schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent, reduce, or eliminate the Pollution of Receiving Waters. BMPs also include treatment requirements, operating procedures and practices to control site runoff, spillage or leaks, sludge or waste disposal, or drainage from material storage areas. In the case of MS4 permits, BMPs are typically used in place of numeric effluent limits.

The Copermittees have been implementing BMPs since the development of the first Riverside County Drainage Area Management Plan (DAMP) in 1992. Through an iterative process of implementation, monitoring, and assessment over the last 20 years, the Riverside County DAMP has evolved into distinct Jurisdictional Runoff Management Plans (JRMPs) for each Copermittee. The result of this iterative process is that the Copermittees have modified and greatly expanded the BMPs that they implement for their own facilities and activities, and require of residents, industrial facilities, commercial enterprises, construction sites, and development projects.

Where structural BMPs are employed, maps of the locations of those BMPs will be included in future updates to this Watershed Workplan, otherwise, most of the BMPs implemented by the Copermittees are implemented throughout their jurisdiction.

4.1 BMP Selection and Implementation

The following table identifies the categories of Pollutants that are addressed by each compliance element implemented or supported by the Copermittees:

Program Component	Pollutant Category					
	Copper	Iron and Manganese	Nutrients	Pathogens (Indicator Bacteria)	Pesticides	Total Dissolved Solids
Development Planning	●	●	●	●	●	●
Construction	●	●	●			●
Municipal Facilities and Activities	●	●	●	●	●	●
Industrial / Commercial		●	●	●	●	●
Residential		●	●	●	●	●
Illicit Connection / Illegal Discharge Elimination		●	●	●	●	●
Public Education Program	●	●	●	●	●	●
Retrofitting Program		●	●	●	●	●
Pyrethroid Toxicity Reduction Program					●	
Numeric Nutrient Endpoints Study			●			
Brake Pad Legislation	●					

[15] See 40 CFR 122.2

4.1.1 Development Planning Program

The Copermittees' Development Planning Programs are designed to:

- Reduce Development Project discharges of Stormwater Pollutants from the MS4 to the Maximum Extent Practicable (MEP);
- Prevent Development Project discharges from the MS4 from causing or contributing to a violation of Water Quality Standards;
- Prevent Illicit Discharges into the MS4; and
- Manage increases in Runoff discharge rates and durations from Development Projects that are likely to cause increased erosion of streambeds and banks, silt Pollutant generation, or other impacts to Beneficial Uses and stream habitat due to increased erosive force.

The Development Planning program element links the Copermittee's General Plans, the environmental review processes, and the development approval and permitting processes to the later phases of detailed design, construction and operation. A General Plan specifies policies that guide development. The environmental review process examines potential impacts from proposed development with respect to the General Plan policies and many environmental issues, including water quality, and includes consideration of mitigation measures to reduce any identified significant impacts. The development approval and permitting processes carry forth project-specific requirements in the form of conditions of approval, design specifications, tracking, inspection, and enforcement actions.

4.1.2 Construction Program

The Copermittees' Construction Programs are designed to:

- Prevent Illicit Discharges into the MS4;
- Require implementation and maintenance of structural and non-structural BMPs to reduce Pollutants in stormwater Runoff from construction sites to the MS4;
- Reduce construction site discharges of stormwater Pollutants from the MS4 to the MEP; and
- Prevent construction site discharges from the MS4 from causing or contributing to a violation of WQOs.

This program is implemented primarily through requirements in building and grading permits and Construction Site inspections, and includes designation of minimum BMPs for construction sites, maintenance of an updated inventory of facilities, regular inspections, and enforcement where necessary.

4.1.3 Municipal Areas and Activities Program

The Copermittees implement as part of their JRMP, a variety of BMPs for their Municipal areas and activities. These BMPs address the Planning, Construction, and Operation and Maintenance of facilities, and includes annual inspections of applicable areas, including inspections and cleaning of each Copermittees' MS4 infrastructure to remove accumulated pollutants / debris, and to help detect and address illegal discharges and/or connections to the MS4. Each Copermittee also implements controls and measures to prevent and eliminate infiltration of seepage from sanitary sewers to MS4s through

routine preventive maintenance of the MS4. Inspection programs are implemented to verify implementation of these programs.

4.1.4 Industrial / Commercial Program

The Copermittees implement as part of their JRMP a variety of BMPs, including maintenance of an inventory of Industrial and Commercial facilities within their jurisdiction including mobile businesses, designation of minimum BMPs for each facility, regular inspections based on the priority of the facility, and enforcement where necessary.

4.1.5 Residential Program

Each Copermittee implements a residential program as part of their JRMP that is designed to:

- Prevent illicit discharges into the MS4;
- Reduce residential discharges of Stormwater Pollutants from the MS4 to the MEP; and
- Prevent residential discharges from the MS4 from causing or contributing to a violation of Water Quality Standards.

Each Copermittee has designated a set of minimum BMPs for high-threat-to-water-quality residential areas and activities within their jurisdiction to reduce the discharge of Pollutants to the MEP. The Copermittees require implementation of the minimum BMPs and any additional measures necessary to comply with the Prohibitions and Receiving Water Limitations and restrictions on Non-Stormwater discharges as specified in the 2010 MS4 Permit. Through public education and outreach the Copermittees notify the residents of the minimum BMPs and its Stormwater Ordinance.

Each Copermittee also implements programs to ensure that effective measures exist and are implemented or required to be implemented to ensure that Runoff within and from common interest developments, including areas managed by associations and mobile home parks, is properly managed.

4.1.6 Existing Development Retrofitting Program

The Copermittees, as part of their JRMP, have developed and will implement a retrofitting program with the goals of addressing the impacts of existing development through strategic retrofit projects that reduce impacts from Hydromodification, promoting the use of Low Impact Development (LID) BMPs, supporting riparian and aquatic habitat restoration, reducing the discharges of stormwater Pollutants from the MS4 to the MEP, and preventing discharges that cause or contribute to a violation of Water Quality Standards.

4.1.7 Illicit Connection /Illegal Discharge Elimination Program

Each Copermittee implements an IC/ID program to actively detect and eliminate Illicit Discharges and disposal into the MS4. Through their legal authorities, enforcement mechanisms, and various other programs, each Copermittee effectively prohibits all types of Non-Stormwater discharges into its MS4 facilities unless such discharge is authorized by a separate NPDES permit or specifically allowed under the 2010 MS4 Permit. The Copermittees also implement public education and waste management programs to prevent IC/IDs. In addition, the Copermittees control, consistent with the MEP standard,

Illegal Discharges (including the discharge of spills, leaks, or dumping of any materials other than stormwater and authorized Non-Stormwater) into the MS4.

4.1.8 Public Education Program

The Riverside County NPDES Permittees have established a county-wide public education and outreach program known as the "Only Rain Down the Storm Drain" program. The specific objectives of the public education program include:

- Fostering a broad public awareness of water pollution concerns;
- Increasing public acceptance of pollution prevention activities to curtail everyday human behaviors that contribute to water quality problems;
- Educating/informing the general public, regulators and key local government and state decision makers on urban runoff conditions in Riverside County; and
- Promoting stewardship of all local water resources.

The "Only Rain Down the Storm Drain" program implements the public awareness objectives by focusing on three areas of Pollutant reduction/prevention:

- Public Behavior
- Proper Management of Pollutants
- Business Specific Outreach

In addition, when attempting to make use of the finite resources available for the Public Education Program, the Permittees use these management goals to ensure that resources are used effectively:

- Focusing on pollutants of concern specific to each watershed region;
- Coordinating public education efforts with adjacent stormwater management programs and other related education programs to share resources, coordinate outreach efforts and avoid unnecessary duplication; and
- Adapt public education programs and objectives, based on effectiveness analysis, to address changing MS4 programs and goals.

4.1.9 Pyrethroid Toxicity Reduction Program

As part of this Watershed Workplan, the Copermittees will implement the Pyrethroid Toxicity Reduction Program dated January 2009[16], included as Appendix B. The adaptive management approach of the program is comprised of the following broad elements:

- Pursue State and Federal regulatory change through the California Stormwater Quality Association (CASQA).
- Implement a set of source controls targeted specifically at urban pesticide use.

[16] Prepared for the Copermittees by MACTEC (San Diego, California).

- Through the JRMP Annual Reporting process, monitor the implementation of those controls, assess effectiveness, and identify sources or areas where additional effort is needed.
- Evaluate whether additional controls, including treatment controls, may be needed to further reduce Pyrethroid Pollution.
- Implement additional controls as needed.
- Continue to monitor implementation, as well as conditions within the target Receiving Waters, assess effectiveness, and re-evaluate control program.

4.1.10 Numeric Nutrient Endpoints Study

The Copermittees are collaborating, through the Upper Santa Margarita IRWM with stakeholders in the lower Santa Margarita Watershed to develop the technical work that the Regional Board will potentially use to support adoption of nutrient site-specific objectives and potentially a TMDL for the Santa Margarita Watershed. This work is expected to include the use of a Numeric Nutrient Endpoint methodology to identify the site-specific objective.

4.1.11 Brake Pad Legislation

California State Bill 346 was passed in September 2010, requiring the reduction of Copper and other toxic materials in brake pads sold in California.

4.2 BMP Assessment

Beginning with the Annual Report due in 2013, each Copermittee will annually assess and report on the effectiveness of its JRMP and Watershed Workplan implementation to:

1) reduce the discharge of Stormwater Pollutants from the MS4 to the MEP;
2) prohibit Non-Stormwater discharges; and
3) prevent Runoff discharges from the MS4 from causing or contributing to a violation of Water Quality Standards.

The findings of the assessment will be communicated to the Upper Santa Margarita River watershed stakeholders in an annual workshop to review the progress achieved through implementation of this Watershed Workplan and to review the Watershed Workplan for the subsequent fiscal year.

The evaluation of BMP effectiveness will incorporate an assessment of the data collected as part of the "Santa Margarita Region Monitoring Plan", an assessment of the actions and outcomes associated with the implementation of the Copermittees' JRMPs, and an assessment of the actions and outcomes associated with implementation of this Watershed Workplan. The Copermittees will utilize the California Stormwater Quality Association's (CASQA) approach to assess effectiveness. The Copermittees will frame their effectiveness assessment in terms of:

- Outcome Level 1 - Outcomes directly related to the implementation of specific activities.
- Outcome Level 2 - Outcomes reflected through increases in knowledge and awareness.
- Outcome Level 3 - Outcomes reflected as behavioral change and BMP implementation.
- Outcome Level 4 - Outcomes estimated/measured load reductions associated with better controlling specific sources through BMP implementation.
- Outcome Level 5 - Outcomes estimated/measured in runoff discharge quality.
- Outcome Level 6 - Outcomes estimated/measured in Receiving Water quality.

For each metric, an 'assessment interval' and an 'outcome timeframe' have been established. Each metric will be evaluated to determine the applicable CASQA Outcome Levels at each 'Assessment Interval'.. If a desired outcome is not attained within the associated timeframe, the Copermittee(s) will re-assess the BMP to identify adjustments that may be needed to improve their ability to detect and attain the outcome. Based on the findings of this evaluation, Copermittee-specific (JRMP) and/or modifications of this Watershed Workplan may be made to improve the effectiveness of the implemented BMP.

As shown in the table below, many of the BMPs described in Section 4.1 are implemented individually by each Copermittee, and any associated effectiveness metrics are reported in each Copermittees' JRMP Annual Report. The remaining BMPs will be assessed as part of the "Santa Margarita Region Monitoring Plan" and/or this Watershed Workplan.

Program Component	Annual Monitoring Report	Watershed Workplan Annual Update	JRMP Annual Reports
Development Planning			✓
Construction			✓
Municipal Facilities and Activities			✓
Industrial / Commercial			✓
Residential			✓
Retrofitting Program			✓
Illicit Connection / Illegal Discharge Elimination	✓		✓
Public Education Program			✓
Watershed Workplan Implementation		✓	
Pyrethroid Toxicity Reduction Program	✓	✓	
Numeric Nutrient Endpoints Study	✓	✓	
Brake Pad Legislation		✓	

Effectiveness assessments that are to be conducted as part of the Watershed Workplan Annual Update are identified in Appendix C.

The continued implementation of the BMPs required in the 2010 MS4 Permit are anticipated to result in incremental improvement in the metrics, that may or may not be discernible within the Permit Term. However, the implementation of the JRMPs and this Watershed Workplan is intended to be an iterative process that will bridge more than one MS4 Permit term and will ensure that improvements are made consistent with the MEP standard.

5 Monitoring Strategy

The Santa Margarita Monitoring Plan, further discussed in Section 3.1.1.2, describes the program that the Copermittees will implement in compliance with the 2010 MS4 Permit. This Monitoring Plan will monitor improvements in receiving water quality directly resulting from implementation of the BMPs described in the Watershed Workplan. The annual Watershed Workplan updates will incorporate review and consideration of the necessary data to report on the measured pollutant reduction that has resulted from proper BMP implementation.

6 Acronyms and Glossary

6.1 Acronyms

BMP	Best Management Practice
Basin Plan	Water Quality Control Plan for the San Diego Basin
CASQA	California Stormwater Quality Association
CFR	Code of Federal Regulations
CWA	Clean Water Act
IBI	Index of Biological Integrity
IDDE	Illicit Discharge Detection and Elimination
JRMP	Jurisdictional Runoff Management Plan
LID	Low Impact Development
MBAS	Methylene Blue Active Substances
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
NAL	Non-Stormwater Dry Weather Action Levels
NGO	Non-Governmental Organization
NPDES	National Pollutant Discharge Elimination System
QA/QC	Quality Assurance/Quality Control
RCWD	Rancho California Water District
Regional Board	California Regional Water Quality Control Board, San Diego Region
SAL	Stormwater Action Level
SCCWRP	Southern California Coastal Water Research Project
SWAMP	Surface Water Ambient Monitoring Program
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluations
TMDL	Total Maximum Daily Load
TRE	Toxicity Reduction Evaluation
USEPA	United States Environmental Protection Agency

6.2 Glossary

Anthropogenic– Originating from human activities.

Indicator Bacteria – Indicator bacteria are types of bacteria that indicate the possible presence of disease causing (pathogenic) microorganisms.. Indicator bacteria are not themselves dangerous to the health but are used to indicate the presence of a health risk.

Basin Plan – Water Quality Control Plan, San Diego Basin, Region 9, and amendments, developed by the Regional Board.

Beneficial Uses – The uses of water necessary for the survival or well being of man, plants, and wildlife. These uses of water serve to promote tangible and intangible economic, social, and environmental goals. "Beneficial Uses" of the waters of the State that may be protected include, but are not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves. Existing Beneficial Uses are uses that were attained in the surface or groundwater on or after November 28, 1975; and potential Beneficial Uses are uses that would probably develop in future years through the implementation of various control measures. "Beneficial Uses" are equivalent to "Designated Uses" under federal law. [California Water Code Section 13050(f)].

Best Management Practices (BMPs) – Defined in 40 CFR 122.2 as schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the Pollution of Waters of the United States. BMPs also include treatment requirements, operating procedures and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. In the case of municipal stormwater permits, BMPs are typically used in place of numeric effluent limits.

Bioassessment – The use of biological community information to evaluate the biological integrity of a water body and its watershed. With respect to aquatic ecosystems, Bioassessment is the collection and analysis of samples of the benthic macroinvertebrate community together with physical/habitat quality measurements associated with the sampling site and the watershed to evaluate the biological condition (i.e., biological integrity) of a water body.

Biological Integrity – Defined in Karr J.R. and D.R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5:55-68 as: "A balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region." Also referred to as ecosystem health.

Dry Weather – Weather is considered 'dry' if the preceding 72 hours has been without precipitation.

Hydromodification – The change in the natural watershed hydrologic processes and runoff characteristics (i.e., interception, infiltration, overland flow, interflow and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, such as stream channelization, concrete lining, installation of dams and water impoundments, and excessive streambank and shoreline erosion are also considered hydromodification, due to their disruption of natural watershed hydrologic processes.

Index of Biological Integrity (IBI) – is a scientific tool used to identify and classify water pollution problems.

Jurisdictional Runoff Management Plan (JRMP) – A written description of the specific jurisdictional runoff management measures and programs that each Copermittee will implement to comply with this Order and ensure that stormwater Pollutant discharges in Runoff are reduced to the MEP and do not cause or contribute to a violation of Water Quality Standards.

Low Impact Development (LID) – A stormwater management and land development strategy that emphasizes conservation and the use of onsite natural features integrated with engineered, small-scale hydrologic controls to more closely reflect pre-development hydrologic functions.

Mass Loading – The mass of a Pollutant contained in a discharge to a Receiving Water. The Pollutant mass is calculated based on concentration of water quality samples collected from the discharge and the measured flow of the discharge.

Monitoring Year – The Monitoring Year includes a full Wet Season and Dry Season, beginning annually on October 1st and ending on September 30th.

Municipal Separate Storm Sewer System (MS4) – A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or designated and approved management agency under Section 208 of the CWA that discharges to Waters of the United States; (ii) Designated or used for collecting or conveying stormwater; (iii) Which is not a combined sewer; (iv) Which is not part of the Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.26.

National Pollutant Discharge Elimination System (NPDES) – The national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 318, 402, and 405 of the CWA.

NGO – The term "NGO" may be applied to any non-profit organization that is typically formed around a common special interest and, in whole or in part, sustained on charitable donations and voluntary service. NGOs have been formed to address issues, such as environmental protection, children's welfare, health care, human rights, economic development, etc.

Non-Stormwater – All discharges to and from a MS4 that do not originate from precipitation events (i.e., all discharges from a MS4 other than stormwater). Non-Stormwater includes Illicit Discharges, non-prohibited discharges, and NPDES permitted discharges.

Pollutant – Any agent that may cause or contribute to the degradation of water quality such that a condition of Pollution or contamination is created or aggravated.

Pollution – As defined in the Porter-Cologne Water Quality Control Act: "the alteration of the quality of the Waters of the State by waste, to a degree that unreasonably affects the either of the following: 1)

The waters for Beneficial Uses; or 2) Facilities that serve these Beneficial Uses." Pollution may include contamination.

Pollutants of Concern – Pollutants for which water bodies are listed as impaired under CWA Section 303(d), Pollutants associated with the land use type of a development, and/or Pollutants commonly associated with runoff. Pollutants commonly associated with runoff include total suspended solids; sediment; pathogens (e.g., bacteria, viruses, protozoa); heavy metals (e.g., copper, lead, zinc, and cadmium); petroleum products and polynuclear aromatic hydrocarbons; synthetic organics (e.g., pesticides, herbicides, and PCBs); nutrients (e.g., nitrogen and phosphorus fertilizers); oxygen-demanding substances (decaying vegetation, animal waste, and anthropogenic litter).

Pollution Prevention – Pollution prevention is defined as practices and processes that reduce or eliminate the generation of Pollutants, in contrast to source control BMPs, treatment control BMPs, or disposal.

Receiving Waters – Waters of the United States.

Runoff – All flows in a stormwater conveyance system that consists of the following components: (1) stormwater (Wet Weather flows) and (2) Non-Stormwater including Dry Weather flows.

Source Control BMP – Land use or site planning practices, or structural or nonstructural measures that aim to prevent runoff Pollution by reducing the potential for contamination at the source of Pollution. Source control BMPs minimize the contact between Pollutants and Runoff.

Stream Assessment – Assessment of the condition of biological communities in freshwater receiving waters to using multiple lines of evidence, including instream biological, chemical, and physical (including habitat) data. (Receiving Waters and MS4 Discharge Monitoring and Reporting Program No. R9-2010-0016, San Diego Regional Water Quality Control Board, November 10, 2010).

Surface Water Ambient Monitoring Program (SWAMP) – A water quality monitoring program conducted by the State Water Resources Control Board and the Regional Water Quality Control Boards to assess the conditions of surface waters throughout the state. The program includes monitoring directly and through collaborative partnerships on a statewide and/or a regional basis.

Total Maximum Daily Load (TMDL) – The maximum amount of a Pollutant that can be discharged into a water body from all sources (point and non-point) and still maintain Water Quality Standards. Under CWA section 303(d), TMDLs must be developed for all water bodies that do not meet Water Quality Standards after application of technology-based controls.

Toxicity – Adverse responses of organisms to chemicals or physical agents ranging from mortality to physiological responses such as impaired reproduction or growth anomalies. The Water Quality Objectives for Toxicity provided in the Water Quality Control Plan, San Diego Basin, Region 9, (*Basin Plan*), state in part…"All waters shall be free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life….The survival of aquatic life in surface waters subjected to a waste discharge or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge".

Treatment Controls – Any engineered system designed to remove Pollutants by simple gravity settling of particulate Pollutants, filtration, biological uptake, media absorption or any other physical, biological, or chemical process.

Triad – Three lines of monitoring data/evidence are considered: water chemistry, water Toxicity, and Bioassessment.

Water Quality Objective – Numerical or narrative limits on constituents or characteristics of water designated to protect designated Beneficial Uses of the water. [California Water Code Section 13050 (h)]. California's Water Quality Objectives are established by the State Water Resources Control Board and the Regional Water Quality Control Boards in the Water Quality Control Plans. Numeric or narrative limits for Pollutants or characteristics of water designed to protect the Beneficial Uses of the water. In other words, a Water Quality Objective is the maximum concentration of a Pollutant that can exist in a receiving water and still generally ensure that the Beneficial Uses of the receiving water remain protected (i.e., not impaired). Since Water Quality Objectives are designed specifically to protect the Beneficial Uses, when the objectives are violated the Beneficial Uses are, by definition, no longer protected and become impaired. This is a fundamental concept under the Porter Cologne Act. Equally fundamental is Porter Cologne's definition of Pollution. A condition of Pollution exists when the water quality needed to support designated Beneficial Uses has become unreasonably affected or impaired; in other words, when the Water Quality Objectives have been violated. These underlying definitions (regarding Beneficial Use protection) are the reasons why all waste discharge requirements implementing the Federal NPDES regulations require compliance with Water Quality Objectives. (Water Quality Objectives are also called water quality criteria in the CWA.)

Water Quality Standards – The Beneficial Uses (e.g., swimming, fishing, municipal drinking water supply, etc.) of water and the Water Quality Objectives necessary to protect those uses.

Waters of the United States – As defined in the 40 CFR 122.2, the Waters of the U.S. are defined as: "(a) All waters, which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; (b) All interstate waters, including interstate "wetlands"; (c) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, "wetlands", sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds the use, degradation or destruction of which would affect or could affect interstate or foreign commerce including any such waters: (1) Which are or could be used by interstate or foreign travelers for recreational or other purposes; (2) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or (3) Which are used or could be used for industrial purposes by industries in interstate commerce; (d) All impoundments of waters otherwise defined as waters of the United States under this definition: (e) Tributaries of waters identified in paragraphs (a) through (d) of this definition; (f) The territorial seas; and (g) "Wetlands" adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a) through (f) of this definition. Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other federal agency, for the purposes of the Clean Water Act, the final authority regarding Clean Water Act jurisdiction remains with the EPA."

Watershed – That geographical area which drains to a specified point on a watercourse, usually a confluence of streams or rivers (also known as drainage area, catchment, or river basin).

Appendix A
Surface Water Ambient Monitoring Program (SWAMP) Report on the Santa Margarita Hydrologic Unit (July 2007)

Final Technical Report	2007

Surface Water Ambient Monitoring Program (SWAMP) Report on the Santa Margarita Hydrologic Unit

July 2007

www.waterboards.ca.gov/swamp

SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP) REPORT ON THE SANTA MARGARITA HYDROLOGIC UNIT

Raphael D. Mazor
Ken Schiff

Southern California Coastal Water Research Project
3535 Harbor Blvd., Suite 110
Costa Mesa, CA 92626
www.sccwrp.org

Prepared for the California Regional Water Quality Control Board, San Diego Region (Region 9).

This project was funded by the Surface Water Ambient Monitoring Program.

Technical Report 527_SantaMargarita

TABLE OF CONTENTS

I. Abstract 1
2. Introduction 2
2.1 Geographic Setting 3
2.1.1 Climate 3
2.1.2 Hydrology 5
2.1.3 Land Use within the Watershed 5
2.1.4 Beneficial Uses and Known Impairments in the Watershed 6
3. Methods 7
3.1 Indicators 9
3.1.1 Water chemistry 9
3.1.2 Toxicity 9
3.1.3 Tissue 9
3.1.4 Bioassessment 10
3.1.5 Physical Habitat 10
3.2 Data Analysis 10
3.2.1 Thresholds 11
3.2.2 Quality Assurance and Quality Control (QA/QC) 15
4. Results 15
4.1 Water Chemistry 15
4.2 Toxicity 25
4.3 Tissue 26
4.4 Bioassessment 27
4.5 Physical Habitat 31
5. Discussion 32
6. Literature Cited 38
7. Appendices 40
APPENDIX I 1
APPENDIX II 1
APPENDIX III 1
APPENDIX IV 1

LIST OF FIGURES

Figure 1. Location of the Santa Margarita HU. 3
Figure 2. Rainfall and sampling events at three stations in the San Diego region 4
Figure 3. The Santa Margarita HU, including major waterways. 5
Figure 4. Land use within the Santa Margarita HU.....6
Figure 5. SWAMP and non-SWAMP sampling locations.....8
Figure 6. Aquatic life threshold exceedances for water chemistry.....23
Figure 7. Human health exceedances for water chemistry.....24
Figure 8. Frequency of toxicity at SWAMP sites 26
Figure 9. Fish tissue exceedances at SWAMP sites 27
Figure 10. IBI scores at sites in the Santa Margarita HU.....29
Figure 11. Mean IBI scores at each bioassessment site and each season....30
Figure 12. IBI values for each year and site 31
Figure 13. Assessment of physical habitat at SWAMP sites 32
Figure 14. Summary of the ecological health of SWAMP sites in the Santa Margarita HU.....33

LIST OF TABLES

Table 1. Watersheds monitored under the SWAMP program. 2
Table 2. Sources of data used in this report. 7
Table 3. SWAMP sampling site locations 7
Table 4. Non-SWAMP sampling site locations 8
Table 5. Threshold sources 12
Table 6. Water chemistry thresholds for aquatic life and human health standards 13
Table 7. Threshold concentrations for fish tissue contaminants 14
Table 8. Number of anthropogenic organic compounds detected at each site 15
Table 9. Frequency of detection of anthropogenic organic compounds 16
Table 10. Frequency of water chemistry threshold exceedances 20
Table 11. Frequency of SWAMP sites with aquatic life and human health threshold exceedances of each constituent 22
Table 12. Number of constituents exceeding thresholds at each SWAMP site. 23
Table 13. Frequency of toxicity detected for each endpoint and at each site .25
Table 14. Concentrations of contaminants in fish tissues 27
Table 15. Mean and standard deviation of IBI scores at sites within the Santa Margarita HU 28
Table 17. Summary of the ecological health for five SWAMP sites in Santa Margarita HU 34

I. ABSTRACT

In order to assess the ecological health of the Santa Margarita Hydrologic Unit (San Diego and Riverside Counties, CA), water chemistry, water and sediment toxicity, fish tissues, benthic macroinvertebrate communities, and physical habitat were assessed at multiple sites. Water chemistry, toxicity, and fish tissues were assessed under SWAMP between 2002 and 2003. Bioassessment samples were collected under other programs between 1998 and 2005. All indicators showed evidence of impact, although for most indicators the impacts were moderate at most sites. Water chemistry constituents at all sites exceeded aquatic life thresholds, ranging from 4 constituents at Deluz Creek and the upstream site on the Santa Margarita River to 9 constituents at the downstream site on the Santa Margarita River. Nutrients were impacted at most sites, except at Deluz and Sandia Creeks. Toxicity was moderate, although samples from all sites were toxic to the freshwater algae *Selenastrum capricornutum* on at least one sampling date. Fish tissues from the downstream Santa Margarita River site showed no evidence of impact. Bioassessment samples indicated that large areas of the watershed are in poor ecological condition, meaning that benthic macroinvertebrate communities at these sites were similar to communities at impaired sites. However, certain areas of the watershed, such as Deluz and Roblar Creeks are in fair or good condition. Physical habitat showed few signs of degradation at any site. Despite a number of limitations of this assessment (e.g., uncertain spatial and temporal variability, low levels of replication, non-probabilistic sampling, and lack of thresholds for several indicators), multiple lines of evidence support the conclusion that parts of the Santa Margarita HU are in moderate to good ecological condition.

2. INTRODUCTION

The Santa Margarita hydrologic unit (HU 902) is in Riverside and San Diego Counties. The hydrologic unit represents an important water resource in one of the most arid regions of the nation. Despite strong interest in the surface waters of the Santa Margarita HU, a comprehensive assessment of the ecological health of these waters has not been conducted at this time. The purpose of this report is to provide such an analysis using data collected in 2003 under the Surface Waters Ambient Monitoring Program (SWAMP), as well as additional sources, such as including data collected by National Pollution Discharge Elimination System (NPDES) permittees. SWAMP monitoring efforts rotated among sets of watersheds, ensuring that each HU is monitored once every 5 years (Table 1). These programs collected data to describe water chemistry, water and sediment toxicity, fish tissues, physical habitat, and macroinvertebrate community structure. By examining these data from multiple sources, this report provides a measure of the ecological integrity of the Santa Margarita HU.

Table 1. Watersheds monitored under the SWAMP program.

Year (Fiscal year)	Sample collection	Hydrologic unit	HUC
1 (2000-2001)	2002	Carlsbad	904
	2002	Peñasquitos	906
2 (2001-2002)	2002-2003	San Juan	901
	2003	Otay	910
3 (2002-2003)	2003	Santa Margarita	902
	2003	San Dieguito	905
4 (2003-2004)	2004-2005	San Diego	907
	2004-2005	San Luis Rey	903
5 (2004-2005)	2005-2006	Pueblo San Diego	908
	2005-2006	Sweetwater	909
	2005-2006	Tijuana	911

There are two objectives for this assessment: 1) To evaluate the condition of SWAMP sites; and 2) To evaluate the overall condition of the watershed. Evaluations were based on multiple indicators of ecological integrity, including water chemistry, water and sediment toxicity, fish tissue bioaccumulation, biological assessment of benthic macroinvertebrate communities, and physical habitat assessment.

This report is organized into four sections. The first section (Introduction) describes the geographic setting in terms of climate, hydrology, and land use within the watershed. The second section (Methods) describes the approach to data collection, assessment indicators, and data analysis. The third section (Results) contains the results of these analyses. The fourth section (Discussion) integrates evidence of impact from multiple indicators, describes the limitations of this assessment, and summarizes the overall health of the watershed.

2.1 Geographic Setting

The Santa Margarita River drains one of the largest unregulated rivers in southern California. The watershed covers 750 mi^2, of which 26.5% is in San Diego County, and 73.5% is in Riverside County. The watershed is bounded by several mountain ranges, including the Santa Ana and Santa Margarita mountains to the North and the Palomar Mountains to the South. Several tributaries originate on the Santa Rosa Plateau, a region known for its biological diversity and its abundant wetland resources (Figure 1).

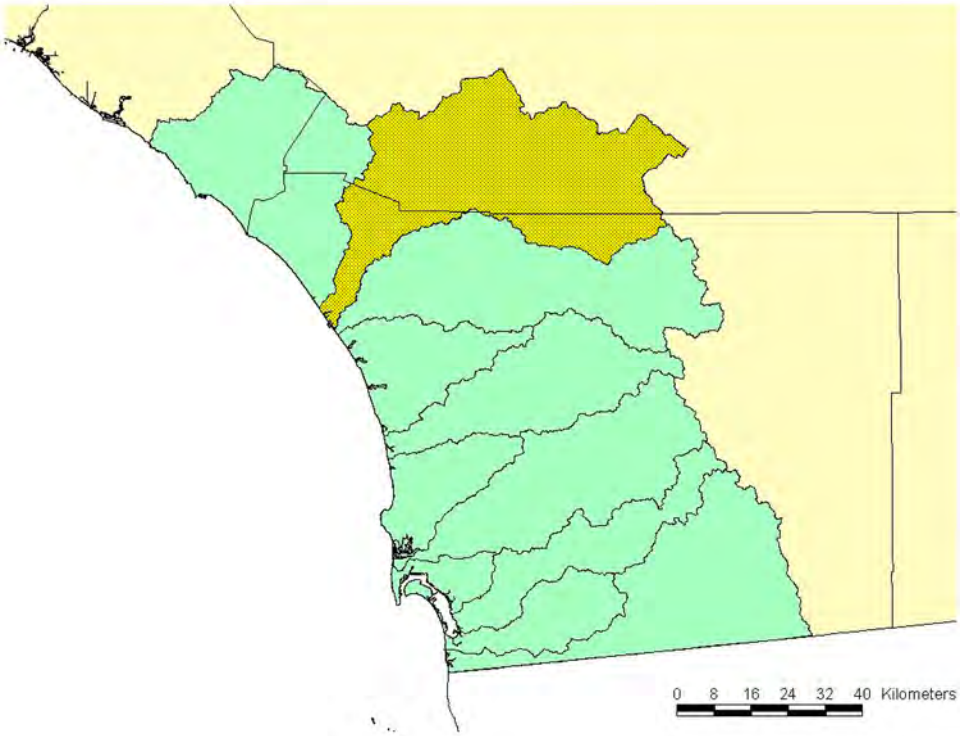


Figure 1. San Diego region (green) includes portions of San Diego, Riverside, and Orange counties. The Santa Margarita HU (yellow, shaded) is located within Orange, Riverside, and San Diego Counties.

2.1.1 Climate

The Santa Margarita HU, like the entire San Diego region, is characterized by a Mediterranean climate, with hot dry summers and cool wet winters. Average monthly rainfalls collected at the Lindberg Airport (SDG) in San Diego, California between 1905 and 2006 show that nearly all rain fell between the months of October and April, with hardly any falling between the months of May and September (California Department of Water Resources 2007). The wettest month was January, with an average rainfall of 2.05"). Average annual rainfall at this station was 10.37". Daily rainfall measured at Palomar Mountain (near the eastern end of the watershed), Temecula (in the northern part of the watershed), and at Fallbrook (near the lower mainstem, close to the coast) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007) (Figure 2).

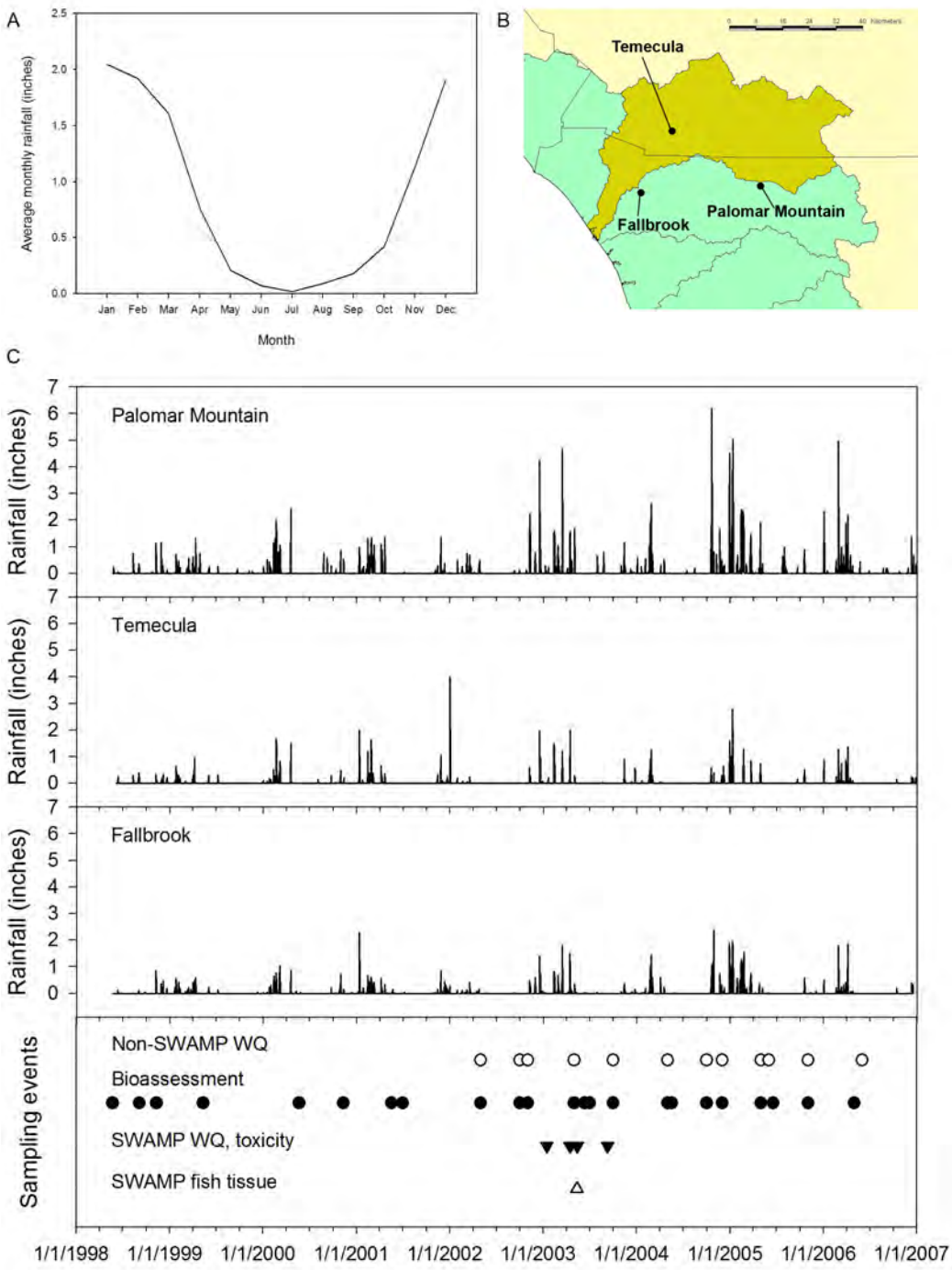


Figure 2. Rainfall and sampling events at three stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the Palomar Mountain, Temecula, and Fallbrook gauges. C. Storm events and sampling events in the Santa Margarita HU. The top three plots show daily precipitation between 1998 and 2007 at the three stations. The bottom plot shows the timing of sampling events. SWAMP water chemistry and toxicity samples are shown as black downward triangles. SWAMP fish tissue samples are shown as white upward triangles. Non-SWAMP water chemistry samples are shown as white circles. Bioassessment samples are shown as black circles.

2.1.2 Hydrology

The Santa Margarita HU consists of a single major drainage—the Santa Margarita River—which is comprised of several smaller tributaries. The mainstem begins at the confluence of Murrieta and Temecula Creeks. South-flowing tributaries include Roblar, Deluz, and Sandia Creeks. Tributaries that flow north into the mainstem include Pechanga and Rainbow Creeks. The mainstem enters the Santa Margarita estuary, which is connected to the Pacific Ocean (Figure 3).

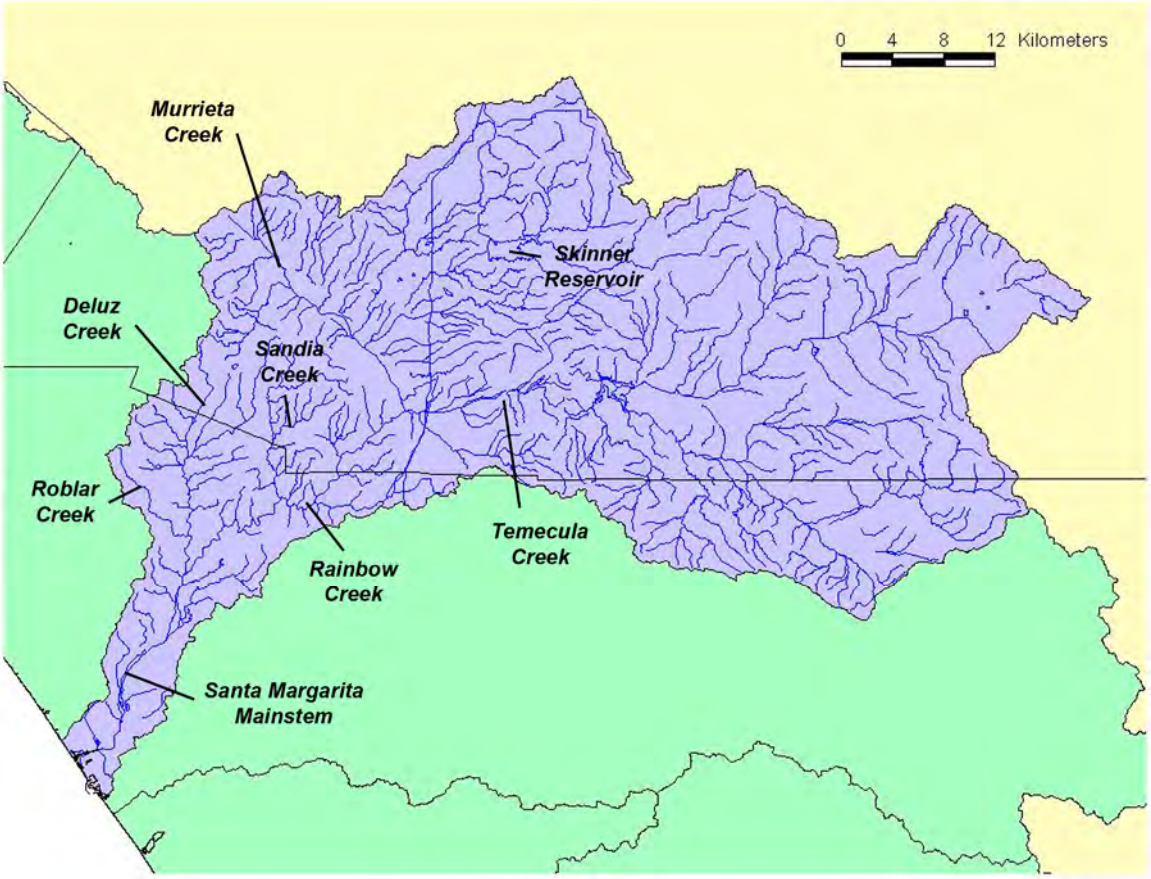


Figure 3. The Santa Margarita HU, including major waterways.

2.1.3 Land Use within the Watershed

Two counties and several municipalities have jurisdiction over portions of the watershed. Riverside County includes the majority (73.5%) of the Santa Margarita HU. This region includes the towns of Murrieta and Temecula. The San Diego County portion of the watershed (26.5%) contains the Camp Pendleton Marine Corps Base, as well as the community of Fallbrook. The Santa Margarita River drains one of the least developed watersheds in southern California. Open

space and vacant land occurs in 81% of the watershed. Agricultural land use occupies only 6%, and developed land use occurs in 13% (Figure 4). The United States Military is one of the largest land owners in the region, as is Caltrans, which has jurisdiction over the major freeways in the watershed. The Cleveland National Forest contains large areas of open space in the watershed, as does the Santa Rosa Ecological Preserve, managed by Riverside County Regional Park and Open Space District. (SANDAG 1998, SCAG 2000)

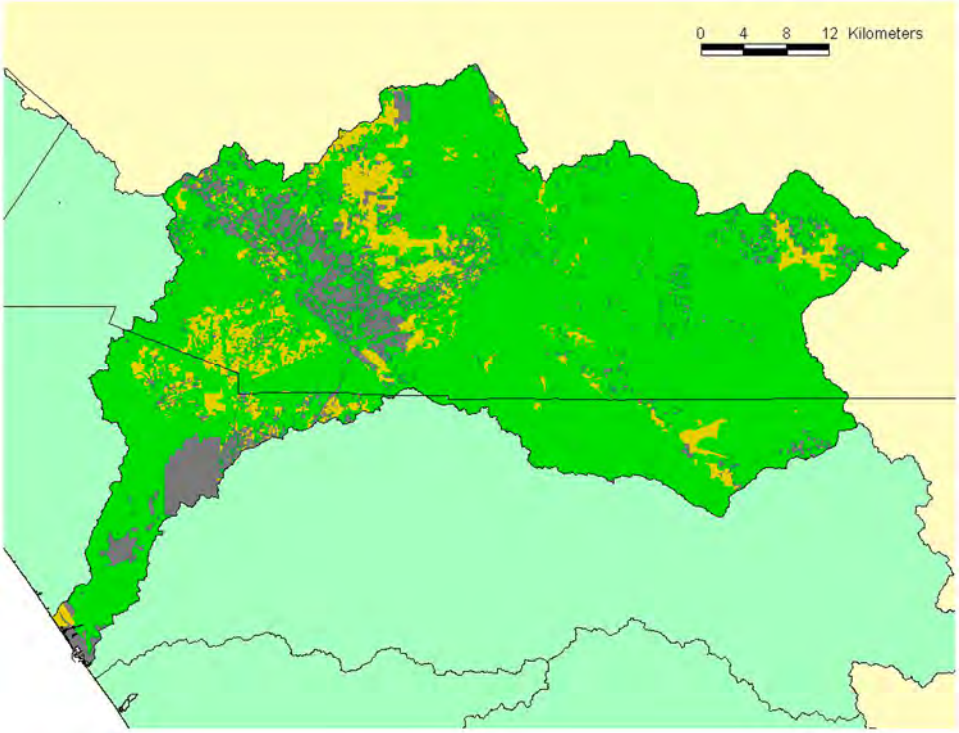


Figure 4. Land use within the Santa Margarita HU. Undeveloped open space is shown as green. Agricultural areas are shown as orange. Urban and developed lands are shown as dark gray.

2.1.4 Beneficial Uses and Known Impairments in the Watershed

Beneficial uses in the watershed include municipal; agriculture; industrial service and process supply; groundwater recharge; recreation; warm and cold freshwater habitat; wildlife habitat; rare, threatened, or endangered species; and spawning habitat (Appendix I).

Several tributaries in the Santa Margarita HU are listed as impaired on the 303(d) list of water quality limited segments, affecting a total of 102.8 stream miles. These streams include the mainstem of the Santa Margarita, De Luz Creek, Murrieta Creek, Rainbow Creek, Sandia Creek, and Temecula Creek. Known stressors include iron, manganese, nitrogen, phosphorus, sulfates, and total dissolved solids (Appendix I).

3. METHODS

This report combines data collected under SWAMP with data from California Department of Fish and Game (CDFG) and NPDES monitoring (Table 2). Five sites of interest were sampled under SWAMP in the Santa Margarita HU in 2003 (Table 3; Figure 5). Water chemistry, water and sediment toxicity, and physical habitat was measured at each site. Fish tissue was collected near one site (Sandia Creek). Bioassessment was not included as part of SWAMP monitoring in the Santa Margarita HU, but bioassessment data collected at 15 sites by the CDFG Aquatic Bioassessment Laboratory (ABL), Camp Pendleton, and San Diego County (as part of its NPDES permit) were used in this report. In addition to bioassessment, conventional water chemistry (e.g., temperature, conductivity, dissolved oxygen) was measured at sites sampled by San Diego County NPDES and by Camp Pendleton. When two non-SWAMP sites were located within 500 meters of each other, they were treated as a single site. This distance was based on published measures of spatial correlation of benthic communities in streams (Gebler 2004). Non-SWAMP samples were collected between 1998 and 2005; in some cases, non-SWAMP sites were very close to SWAMP sites (Table 4; Figure 5).

Table 2. Sources of data used in this report.

Project	Indicators	Years
SWAMP	Water chemistry, toxicity, fish tissue	2002-2003
CA Department of Fish and Game	Bioassessment	1998-2000
San Diego County NPDES	Water chemistry, bioassessment	2002-2005
Camp Pendleton	Water chemistry, bioassessment	2004-2006

Table 3: SWAMP sampling site locations. Fish tissues were collected at the site marked with (*).

Site		Description	Latitude (°N)	Longitude (°E)
1	902SMDLZ3	Deluz Creek 3	33.4564	-117.2961
2	902SMRNB4	Rainbow Creek 4	33.4106	-117.2146
3	902SMSMR1	Upper Santa Margarita 1	33.4806	-117.1142
4	902SMSND3*	Sandia Creek 3	33.4153	-117.2466
5	902SSMR10	Lower Santa Margarita 10	33.2367	-117.3918

Table 4. Non-SWAMP sampling site locations. W = sites where conventional water chemistry was sampled. B = sites where benthic macroinvertebrates were sampled.

Site	Description	SWAMP site within 500 m	Sources	W	B	Lat (N)	Long (E)
1	Deluz Creek at Murrieta Road (reference)	902SMDLZ3	CDFG (902DLCDLM)		X	33.4596	-117.2905
			SD NPDES (REF-DLC3)	X	X		
2	Murrieta Creek	None	CDFG (902MCWBxx)		X	33.5683	-117.2392
3	Rainbow Creek	None	CDFG (902RCWGRx)		X	33.4073	-117.1997
4	Roblar Creek above Deluz Creek	None	CDFG (902ROBDLZ)		X	33.3871	-117.3237
			Camp Pendleton (ROB-DL	X	X		
5	Sandia Creek at Deluz Road (reference)	None	CDFG (902SCDLRx)		X	33.4922	-117.2464
			SD NPDES (REF-SC2)	X	X		
6	Sandia Creek	None	CDFG (902SCSCRx)		X	33.4243	-117.2481
			SD NPDES (REF-SC)	X	X		
7	Santa Margarita River at Camp Pendleton	None	CDFG (902SMRCPx)		X	33.3395	-117.3311
			Camp Pendleton (SMR-CP)				
8	Sandia Creek at Santa Margarita River	902SMSND3	CDFG (902SMRDPx)		X	33.4142	-117.2406
9	Downstream site of the Santa Margarita River	902SSMR10	CDFG (902SMRSMB)		X	33.2367	-117.3918
10	Santa Margarita River at Willow Glen Road	None	CDFG (902SMRWGR)		X	33.4304	-117.1953
			SD NPDES (SMR-WGR)				
11	Temecula Creek at 15	902SMSMR1	CDFG (902TCI15x)		X	33.4747	-117.138
12	Deluz Creek downstream (reference)	None	SD NPDES (REF-DLC)	X	X	33.4414	-117.3239
13	Santa Margarita at Deluz Creek	None	SD NPDES (REF-DLR)	X	X	33.3974	-117.2622
14	Santa Margarita downstream	None	Camp Pendleton (SMR-DS	X	X	33.2834	-117.3744
15	Deluz Creek at Camp Pendleton	None	Camp Pendleton	X	X	33.3975	-117.3231

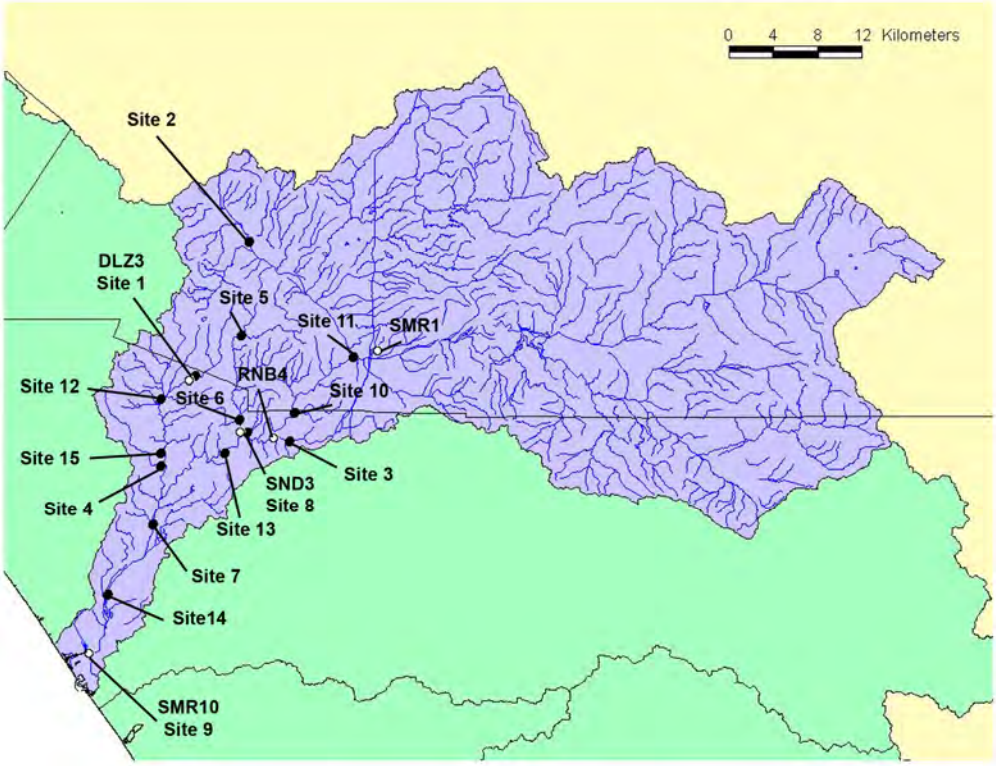


Figure 5. SWAMP (white circles) and non-SWAMP (black circles) sampling locations. The SWAMP site prefix designating the hydrologic unit (i.e., 902SM-) has been dropped to improve clarity.

3.1 Indicators

Multiple indicators were used to assess the sites in the Santa Margarita HU. Water chemistry, water and sediment toxicity, fish tissues, benthic macroinvertebrate communities, and physical habitat.

3.1.1 Water chemistry

To assess water chemistry, samples were collected at each site. Water chemistry was measured as per the SWAMP Quality Assurance Management Plan (QAMP) (Puckett 2002). Measured indicators included conventional water chemistry (e.g., pH, temperature dissolved oxygen, etc.), inorganics, herbicides, pesticides, polycyclic aromatic hydrocarbons (PAHs), dissolved metals, pesticides, and polychlorinated biphenyls (PCBs). Appendix II contains a complete list of constituents that were measured.

Limited water chemistry was collected under non-SWAMP NPDES monitoring as well. This monitoring was restricted to physical parameters, and followed procedures described in annual reports to California Regional Water Quality Control Board, San Diego Region (e.g., Weston Solutions Inc. 2007).

3.1.2 Toxicity

To evaluate water and sediment toxicity to aquatic life in the Santa Margarita HU, toxicity assays were conducted on samples from each site as per the SWAMP QAMP (EPA 1993, Puckett 2002). Water toxicity was evaluated with 7-day exposures on the water flea, *Ceriodaphnia dubia*, and 96-hour exposures to the alga *Selenastrum capricornutum.* Both acute and chronic toxicity to *C. dubia* was measured as decreased survival and fecundity (i.e., eggs per female) relative to controls, respectively. Chronic toxicity to *S. capricornutum* was measured as changes in total cell count relative to controls. Sediment toxicity was evaluated with 10-day exposures on the amphipod *Hyallela azteca.* Both acute and chronic toxicity to *H. azteca* was measured as decreased survival and growth (mg per individual) relative to controls, respectively. Chronic toxicity endpoints (i.e., *C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) were used to develop a summary index of toxicity at each site.

3.1.3 Tissue

To detect contamination in fish tissues in the Santa Margarita HU, catfish tissues were collected at one site (Sandia Creek). Tissues were analyzed for metals and Selenium as per the SWAMP QAMP (Puckett 2002). Wet-weight concentrations of each constituent were recorded.

3.1.4 Bioassessment

To assess the ecological health of the streams in Santa Margarita HU, benthic macroinvertebrate samples were collected at 25 sites by San Diego County, Camp Pendleton, and the California Department of Fish and Game. Four of these sites were designated reference sties. Samples were collected using SWAMP-comparable protocols, as per the SWAMP QAMP (Puckett 2002). Three replicate samples were collected from riffles at each site; 300 individuals were sorted and identified from each replicate, creating a total count of 900 individuals per site. Using a Monte Carlo simulation, all samples were reduced to 500 count for calculation of the Southern California Index of Biotic Integrity (IBI; Ode et al. 2005), a composite of seven metrics summed and scaled from 0 (poor condition) to 100 (good condition).

3.1.5 Physical Habitat

Physical habitat was assessed under SWAMP using semi-quantitative observations of 10 components relating to habitat quality, such as embeddedness, bank stability, and width of riparian zone. The assessment protocols are described in The California Stream Bioassessment Procedure (California Department of Fish and Game 2003). Each component was scored on a scale of 0 (highly degraded) to 20 (not degraded). Sites were assessed by the average component score.

3.2 Data Analysis

To evaluate the extent of human impacts to water chemistry in streams in the Santa Margarita HU, two frequency-based approaches were employed to detecting impacts. First, established aquatic life and human health thresholds for individual constituents were evaluated for frequency of exceedances. Second, the frequency of detection for anthropogenic constituents (such as PCBs, pesticides, and PAHs) were also evaluated.

To evaluate the overall health of each site and of the watershed, three indicators were selected for analysis: number of constituents exceeding aquatic life water chemistry thresholds; frequency of chronic toxicity to *S. capricornutum, C. dubia,* and *H. azteca*; and mean IBI score. Tissue analysis was excluded because tissue samples were collected at only one site. Physical habitat assessment was excluded due to lack of agreed-upon thresholds for evaluation of physical habitat scores. These results were plotted on a map of the watershed, indicating the severity and distribution of human impacts.

Although non-SWAMP sources of water chemistry data were used, this report focuses on SWAMP data in order to maintain consistency of sampling methods and parameters measured at each site. Analyses of non-SWAMP water chemistry data is presented separately. In contrast, bioassessment data from multiple sources is analyzed together because of the high compatibility of sampling protocols used in different programs, and because of the limited availability of bioassessment data from a single source. Toxicity, fish tissue, and physical habitat data were only available from SWAMP monitoring.

3.2.1 Thresholds

In order to use the data to assess the health of the watershed, thresholds were established for each indicator: water quality, toxicity, bioassessment, fish tissue, and physical habitat. Exceedance of appropriate thresholds was considered evidence for impact on watershed health.

Water chemistry data from this study were compared to water quality objectives established by state and federal agencies to protect the most sensitive beneficial uses designated in the Santa Margarita HU. Therefore, the most stringent water quality objectives (e.g., municipal drinking water, aquatic life, etc.) for the measured constituents were used as thresholds points to evaluate the data.

The Water Quality Control Plan For the San Diego Basin (BP) was the primary source of water chemistry thresholds. Other sources for standards used in water chemistry thresholds included the California Toxics Rule (CTR), the Environmental Protection Agency National Aquatic Life Criteria (EPA), the National Academy of Sciences Health Advisory (NASHA), United States Environmental Protection Agency Integrated Risk Information System (IRIS), and the California Code of Regulations §64449 (CCR). The sources for thresholds used in this study are shown in Table 5.

Table 5. Threshold sources

Indicator	Source	Citation
Water chemistry	Water Quality Control Plan For the San Diego Basin (BP)	California Regional Water Quality Control Board, San Diego Region. 1994. Water quality control plan for the San Diego Region. San Diego, CA. http://www.waterboards.ca.gov/sandiego/programs/basinplan.html
	California Toxics Rule (CTR)	Environmental Protection Agency. 1997. Water quality standards: Establishment of numeric criteria for priority toxic pollutants for the state of California: Proposed Rule. *Federal Register* 62:42159-42208.
	EPA National Aquatic Life Criteria (EPA)	Environmental Protection Agency. 2002. National recommended water quality criteria. EPA-822-R-02-047. Office of Water. Washington, DC.
	National Academy of Sciences Health Advisory (NASHA)	National Academy of Sciences. 1977. Drinking Water and Health. Volume 1. Washington, DC.
	US Environmental Protection Agency Integrated Risk Information System (IRIS)	Environmental Protection Agency (EPA). 2007. Integrated Risk Information System. http://www.epa.gov/iris/index.html. Office of Research and Development. Washington, DC.
	California Code of Regulations §64449 (CCR)	California Code of Regulations. 2007. Secondary drinking water standards. Register 2007, No. 8. Title 22, division 4, article 16.
Fish tissue	Office of Environmental Health Hazard Assessment (OEHHA)	Office of Environmental Health Hazard Assessment. 2006. Draft development of guidance tissue levels and screening values for common contaminants in California Sports Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. Sacramento, CA.
Bioassessment	Ode et al. 2005	Ode, P.R., A.C. Rehn and J.T. May. 2005. A quantitative tool for assessing the integrity of southern California coastal streams. *Environmental Management* 35:493-504.

Although human health thresholds (e.g., drinking water standards) were applied to relevant water chemistry data, this report focuses on aquatic life, and does not address the risks to human health in the Santa Margarita HU. When multiple thresholds were applicable to a single constituent, the most stringent threshold was used. Water chemistry thresholds for aquatic life and human health standards used in this study are presented in Table 6. Impacts were assessed as the total number of constituents exceeding threshold, as opposed to the fraction of constituents. The fraction of constituents exceeding thresholds is not an ecologically meaningful statistic because the number of constituents below thresholds does not degrade or improve the ecological health of a site.

Table 6. Water chemistry thresholds for aquatic life and human health standards. San Diego Basin Plan (BP); California Toxics Rule (CTR); Environmental Protection Agency National Aquatic Life Standards (EPA); National Academy of Science Health Advisory (NASHA); Environmental Protection Agency Integrated Risk Information System (IRIS); California Code of Regulations §64449 (CCR). (*) Sulfate threshold of 300 mg/l applies to the Ysidora, Murrieta, Cave Rocks, Aguanga, and Oakgrove hydrologic areas (HA 902.1, 902.3, 902.7, 902.8, and 902.9).

		Aquatic life			Human health		
Category	**Constituent**	**Threshold**	**Unit**	**Source**	**Threshold**	**Unit**	**Source**
Inorganics	Alkalinity as CaCO3	20000	mg/l	EPA	none	mg/l	none
Inorganics	Ammonia as N	0.025	mg/l	BP	none	mg/l	none
Inorganics	Nitrate + Nitrite as N	10	mg/l	BP	none	mg/l	none
Inorganics	Phosphorus as P,Total	0.1	mg/l	BP	none	mg/l	none
Inorganics	Selenium,Dissolved	5	µg/L	CTR	none	µg/L	none
Inorganics	Sulfate	250*	mg/l	BP	none	mg/l	none
Metals	Aluminum,Dissolved	1000	µg/L	BP	none	µg/L	none
Metals	Arsenic,Dissolved	50	µg/L	BP	150	µg/L	CTR
Metals	Cadmium,Dissolved	5	µg/L	BP	2.2	µg/L	CTR
Metals	Chromium,Dissolved	50	µg/L	BP	none	µg/L	none
Metals	Copper,Dissolved	9	µg/L	CTR	1300	µg/L	CTR
Metals	Lead,Dissolved	2.5	µg/L	CTR	none	µg/L	none
Metals	Manganese,Dissolved	0.05	µg/L	none	none	µg/L	none
Metals	Nickel,Dissolved	52	µg/L	CTR	610	µg/L	CTR
Metals	Silver,Dissolved	3.4	µg/L	CTR	none	µg/L	none
Metals	Zinc,Dissolved	120	µg/L	CTR	none	µg/L	none
PAHs	Acenaphthene	none	µg/L	none	1200	µg/L	CTR
PAHs	Anthracene	none	µg/L	none	9600	µg/L	CTR
PAHs	Benz(a)anthracene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Benzo(a)pyrene	0.0002	µg/L	BP	0.0044	µg/L	CTR
PAHs	Benzo(b)fluoranthene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Benzo(k)fluoranthene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Chrysene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Dibenz(a,h)anthracene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Fluoranthene	none	µg/L	none	300	µg/L	CTR
PAHs	Indeno(1,2,3-c,d)pyrene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Pyrene	none	µg/L	none	960	µg/L	CTR
PCBs	PCBs	0.014	µg/L	CTR	0.00017	µg/L	CTR
Pesticides	Aldrin	3	µg/L	CTR	0.00000013	µg/L	CTR
Pesticides	Ametryn	none	µg/L	none	60	µg/L	EPA
Pesticides	Atrazine	3	µg/L	BP	0.2	µg/L	OEHHA
Pesticides	Azinphos ethyl	none	µg/L	none	87.5	µg/L	NASHA
Pesticides	Azinphos methyl	none	µg/L	none	87.5	µg/L	NASHA
Pesticides	DDD(p,p')	none	µg/L	none	0.00083	µg/L	CTR
Pesticides	DDE(p,p')	none	µg/L	none	0.00059	µg/L	CTR
Pesticides	DDT(p,p')	none	µg/L	none	0.00059	µg/L	CTR
Pesticides	Dieldrin	none	µg/L	none	0.00014	µg/L	CTR
Pesticides	Dimethoate	none	µg/L	none	1.4	µg/L	IRIS
Pesticides	Endosulfan sulfate	none	µg/L	none	110	µg/L	CTR
Pesticides	Endrin	0.002	µg/L	BP	0.76	µg/L	CTR
Pesticides	Endrin Aldehyde	none	µg/L	none	0.76	µg/L	CTR
Pesticides	Endrin Ketone	none	µg/L	none	0.85	µg/L	CTR
Pesticides	Heptachlor	0.0038	µg/L	CTR	0.00021	µg/L	CTR
Pesticides	Heptachlor epoxide	0.0038	µg/L	CTR	0.0001	µg/L	CTR
Pesticides	Hexachlorobenzene	1	µg/L	BP	0.00075	µg/L	CTR
Pesticides	Methoxychlor	40	µg/L	BP	none	µg/L	none
Pesticides	Molinate	20	µg/L	BP	none	µg/L	none
Pesticides	Oxychlordane	none	µg/L	none	0.000023	µg/L	CTR
Pesticides	Simazine	4	µg/L	BP	none	µg/L	none
Pesticides	Thiobencarb	70	µg/L	BP	none	µg/L	none
Physical	Oxygen, Dissolved	5	mg/L	BP	none	mg/L	none
Physical	pH	>6 and <8	pH	BP	none	pH	none
Physical	Specific Conductivity	1600	µS/cm	CCR	none	mS/cm	none
Physical	Turbidity	20	NTU	BP	none	NTU	none

Several anthropogenic water chemistry constituents had no applicable threshold (e.g., malathion), and impacts from these constituents would not be detected using the threshold-based approach described above. To assess the impact from these constituents, the number of organic constituents (i.e., PAHs, PCBs, and pesticides) detected at each site were calculated. The total number of sites at which these compounds were detected was recorded.

Thresholds for toxicity assays were determined by comparing study samples to control samples(non-toxic reference samples). Samples meeting the following criteria were considered toxic: 1) treatment responses significantly different from controls, as determined by a statistical t-test; and 2) endpoints less than 80% of controls. To summarize the toxicity at a site using multiple endpoints, the frequency of toxic samples was calculated. To assign equal weight to all three indicators, a single endpoint of chronic toxicity per indicator was used (*C. dubia*: fecundity, *H. azteca*: growth, and *S. capricornutum*: total cell count).

Thresholds for tissue samples shown in Table 7 were derived from the Draft Development of Guidance Tissue Levels and Screening Values for Common Contaminant in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene (OEHHA 2006). Several constituents, including total Mercury, had no applicable threshold. Because Methylmercury accounts for more than 95% of Mercury in fish tissues, the threshold for Methylmercury was applied to Mercury concentrations (OEHHA 2006).

Table 7. Threshold concentrations for fish tissue contaminants established by OEHHA. All thresholds apply to wet-weight concentrations.

Category	Constituent	Source	Threshold	Unit
Inorganics	Selenium	OEHHA	1.94	ppm
PCBs	PCBs	OEHHA	20	ppm
Pesticides	Chlordane	OEHHA	200	ng/g
Pesticides	DDTs	OEHHA	560	ng/g
Pesticides	Dieldrin	OEHHA	16	ng/g
Pesticides	Toxaphene	OEHHA	220	ng/g
Metals	Mercury	OEHHA	0.08	ppm

Thresholds for bioassessment samples were based on a benthic macroinvertebrate index of biological integrity (IBI) that was developed specifically for southern California (Ode et al. 2005). The results of the IBI produces a measure of impairment with scores scaled from 0 to 100, 0 representing the poorest health and 100 the best health. Based on the IBI, samples with scores equal to or below 40 are considered to be in “poor” condition, and samples below 20 are considered to be in “very poor” condition. Therefore, in this study samples with an IBI below 40 were considered impacted.

Thresholds for the evaluation of physical habitat have not been established. Therefore, measurements of physical habitat were excluded from the overall assessment of ecological health. However, because the protocol used to evaluate physical habitat qualitatively assigns scores lower than 10 (out of 20) to streams in poor condition, this number was used to determine sites with severely degraded habitat. Sites with scores below 15 were considered moderately degraded, and those with scores greater than 15 were considered unimpacted (California Department of Fish and Game 2003).

3.2.2 Quality Assurance and Quality Control (QA/QC)

The SWAMP QAMP guided QA/QC for all data collected under SWAMP (See SWAMP QAMP for detailed descriptions of QA/QC protocols, Puckett 2002). QA/QC officers flagged non-compliant physical habitat, water chemistry, toxicity, and tissue results. No chemistry, toxicity, or tissue data were excluded as a result of QA/QC violations. QA/QC procedures for NPDES water chemistry data were similar to those used in SWAMP (Weston Solutions Inc. 2007) Non-SWAMP bioassessment samples were screened for samples containing fewer than 450 individuals. No bioassessment sample was excluded from this analysis.

4. RESULTS

4.1 Water Chemistry

Analysis of water chemistry at SWAMP sites indicated widespread, but moderate impact to water quality from multiple constituents (Table 8). Across the entire watershed, 9 PAHs, and 15 pesticides were detected, but no PCBs. PAHs ranged from two at a site (Deluz Creek and Sandia Creek) to nine (Lower Santa Margarita). Pesticides ranged from one (at Rainbow Creek) to thirteen (again at the Lower Santa Margarita) per site. Means and standard deviations of all constituents are presented in Appendix II.

Table 8. Number of anthropogenic organic compounds detected at each site in Santa Margarita HU.

	PAHs		PCBs		Pesticides	
Site	Tested	Detected	Tested	Detected	Tested	Detected
902SMDLZ3	43	2	50	0	91	2
902SMRNB4	43	4	50	0	91	1
902SMSMR1	43	6	50	0	91	6
902SMSND3	43	2	50	0	91	4
902SSMR10	43	9	50	0	91	13
All sites in watershed	43	9	50	0	91	15

Several organic compounds were widespread throughout the watershed (Table 9). For example, C2-Dibenzothiophenes were detected at every site, and most sites also had the PAHs C1-dibenzothiophenes, C3-fluorenes, C1-phenanthrene/anthracene, as well as the pesticides p,p'-DDE, diazinon, oxadiazon, and simazine.

Table 9. Frequency of detection of anthropogenic organic compounds in the Santa Margarita HU. Constituent not detected at any site (--).

Category	Constituent	Tested	Detected	Frequency
PAHs	Acenaphthene	5	0	--
PAHs	Acenaphthylene	5	0	--
PAHs	Anthracene	5	0	--
PAHs	Benz(a)anthracene	5	0	--
PAHs	Benzo(a)pyrene	5	0	--
PAHs	Benzo(b)fluoranthene	5	1	0.2
PAHs	Benzo(e)pyrene	5	0	--
PAHs	Benzo(g,h,i)perylene	5	0	--
PAHs	Benzo(k)fluoranthene	5	0	--
PAHs	Biphenyl	5	0	--
PAHs	Chrysene	5	0	--
PAHs	Chrysenes, C1 -	5	0	--
PAHs	Chrysenes, C2 -	5	0	--
PAHs	Chrysenes, C3 -	5	0	--
PAHs	Dibenz(a,h)anthracene	5	0	--
PAHs	Dibenzothiophene	5	0	--
PAHs	Dibenzothiophenes, C1 -	5	4	0.8
PAHs	Dibenzothiophenes, C2 -	5	5	1.0
PAHs	Dibenzothiophenes, C3 -	5	2	0.4
PAHs	Dimethylnaphthalene, 2,6-	5	0	--
PAHs	Fluoranthene	5	0	--
PAHs	Fluoranthene/Pyrenes, C1 -	5	0	--
PAHs	Fluorene	5	0	--
PAHs	Fluorenes, C1 -	5	1	0.2
PAHs	Fluorenes, C2 -	5	0	--
PAHs	Fluorenes, C3 -	5	3	0.6
PAHs	Indeno(1,2,3-c,d)pyrene	5	0	--
PAHs	Methylnaphthalene, 1-	5	0	--
PAHs	Methylnaphthalene, 2-	5	0	--
PAHs	Methylphenanthrene, 1-	5	0	--
PAHs	Naphthalene	5	0	--
PAHs	Naphthalenes, C1 -	5	0	--
PAHs	Naphthalenes, C2 -	5	0	--
PAHs	Naphthalenes, C3 -	5	2	0.4
PAHs	Naphthalenes, C4 -	5	0	--
PAHs	Perylene	5	0	--
PAHs	Phenanthrene	5	0	--
PAHs	Phenanthrene/Anthracene, C1 -	5	4	0.8
PAHs	Phenanthrene/Anthracene, C2 -	5	1	0.2
PAHs	Phenanthrene/Anthracene, C3 -	5	0	--
PAHs	Phenanthrene/Anthracene, C4 -	5	0	--
PAHs	Pyrene	5	0	--

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
PAHs	Trimethylnaphthalene, 2,3,5-	5	0	--
PCBs	PCB 005	5	0	--
PCBs	PCB 008	5	0	--
PCBs	PCB 015	5	0	--
PCBs	PCB 018	5	0	--
PCBs	PCB 027	5	0	--
PCBs	PCB 028	5	0	--
PCBs	PCB 029	5	0	--
PCBs	PCB 031	5	0	--
PCBs	PCB 033	5	0	--
PCBs	PCB 044	5	0	--
PCBs	PCB 049	5	0	--
PCBs	PCB 052	5	0	--
PCBs	PCB 056	5	0	--
PCBs	PCB 060	5	0	--
PCBs	PCB 066	5	0	--
PCBs	PCB 070	5	0	--
PCBs	PCB 074	5	0	--
PCBs	PCB 087	5	0	--
PCBs	PCB 095	5	0	--
PCBs	PCB 097	5	0	--
PCBs	PCB 099	5	0	--
PCBs	PCB 101	5	0	--
PCBs	PCB 105	5	0	--
PCBs	PCB 110	5	0	--
PCBs	PCB 114	5	0	--
PCBs	PCB 118	5	0	--
PCBs	PCB 128	5	0	--
PCBs	PCB 137	5	0	--
PCBs	PCB 138	5	0	--
PCBs	PCB 141	5	0	--
PCBs	PCB 149	5	0	--
PCBs	PCB 151	5	0	--
PCBs	PCB 153	5	0	--
PCBs	PCB 156	5	0	--
PCBs	PCB 157	5	0	--
PCBs	PCB 158	5	0	--
PCBs	PCB 170	5	0	--
PCBs	PCB 174	5	0	--
PCBs	PCB 177	5	0	--
PCBs	PCB 180	5	0	--
PCBs	PCB 183	5	0	--
PCBs	PCB 187	5	0	--
PCBs	PCB 189	5	0	--
PCBs	PCB 194	5	0	--
PCBs	PCB 195	5	0	--
PCBs	PCB 200	5	0	--
PCBs	PCB 201	5	0	--
PCBs	PCB 203	5	0	--

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
PCBs	PCB 206	5	0	--
PCBs	PCB 209	5	0	--
Pesticides	Aldrin	5	0	--
Pesticides	Ametryn	5	0	--
Pesticides	Aspon	5	0	--
Pesticides	Atraton	5	0	--
Pesticides	Atrazine	5	0	--
Pesticides	Azinphos ethyl	5	0	--
Pesticides	Azinphos methyl	5	0	--
Pesticides	Bolstar	5	0	--
Pesticides	Carbophenothion	5	0	--
Pesticides	Chlordane, cis-	5	0	--
Pesticides	Chlordane, trans-	5	0	--
Pesticides	Chlordene, alpha-	5	0	--
Pesticides	Chlordene, gamma-	5	0	--
Pesticides	Chlorfenvinphos	5	0	--
Pesticides	Chlorpyrifos	5	0	--
Pesticides	Chlorpyrifos methyl	5	0	--
Pesticides	Ciodrin	5	0	--
Pesticides	Coumaphos	5	0	--
Pesticides	Dacthal	5	0	--
Pesticides	DDD(o,p')	5	0	--
Pesticides	DDD(p,p')	5	1	0.2
Pesticides	DDE(o,p')	5	0	--
Pesticides	DDE(p,p')	5	3	0.6
Pesticides	DDMU(p,p')	5	0	--
Pesticides	DDT(o,p')	5	1	0.2
Pesticides	DDT(p,p')	5	2	0.4
Pesticides	Demeton-s	5	0	--
Pesticides	Diazinon	5	3	0.6
Pesticides	Dichlofenthion	5	0	--
Pesticides	Dichlorvos	5	0	--
Pesticides	Dicrotophos	5	0	--
Pesticides	Dieldrin	5	0	--
Pesticides	Dimethoate	5	0	--
Pesticides	Dioxathion	5	0	--
Pesticides	Disulfoton	5	0	--
Pesticides	Endosulfan I	5	1	0.2
Pesticides	Endosulfan II	5	0	--
Pesticides	Endosulfan sulfate	5	1	0.2
Pesticides	Endrin	5	0	--
Pesticides	Endrin Aldehyde	5	0	--
Pesticides	Endrin Ketone	5	0	--
Pesticides	Ethion	5	0	--
Pesticides	Ethoprop	5	0	--
Pesticides	Famphur	5	0	--
Pesticides	Fenchlorphos	5	0	--
Pesticides	Fenitrothion	5	0	--
Pesticides	Fensulfothion	5	0	--

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
Pesticides	Fenthion	5	0	--
Pesticides	Fonofos	5	0	--
Pesticides	HCH, alpha	5	0	--
Pesticides	HCH, beta	5	1	0.2
Pesticides	HCH, delta	5	0	--
Pesticides	HCH, gamma	5	0	--
Pesticides	Heptachlor	5	0	--
Pesticides	Heptachlor epoxide	5	2	0.4
Pesticides	Hexachlorobenzene	5	0	--
Pesticides	Leptophos	5	0	--
Pesticides	Malathion	5	0	--
Pesticides	Merphos	5	0	--
Pesticides	Methidathion	5	0	--
Pesticides	Methoxychlor	5	0	--
Pesticides	Mevinphos	5	0	--
Pesticides	Mirex	5	0	--
Pesticides	Molinate	5	0	--
Pesticides	Naled	5	0	--
Pesticides	Nonachlor, cis-	5	1	0.2
Pesticides	Nonachlor, trans-	5	1	0.2
Pesticides	Oxadiazon	5	3	0.6
Pesticides	Oxychlordane	5	1	0.2
Pesticides	Parathion, Ethyl	5	0	--
Pesticides	Parathion, Methyl	5	0	--
Pesticides	Phorate	5	0	--
Pesticides	Phosmet	5	0	--
Pesticides	Phosphamidon	5	0	--
Pesticides	Prometon	5	0	--
Pesticides	Prometryn	5	0	--
Pesticides	Propazine	5	0	--
Pesticides	Secbumeton	5	1	0.2
Pesticides	Simazine	5	4	0.8
Pesticides	Simetryn	5	0	--
Pesticides	Sulfotep	5	0	--
Pesticides	Tedion	5	0	--
Pesticides	Terbufos	5	0	--
Pesticides	Terbuthylazine	5	0	--
Pesticides	Terbutryn	5	0	--
Pesticides	Tetrachlorvinphos	5	0	--
Pesticides	Thiobencarb	5	0	--
Pesticides	Thionazin	5	0	--
Pesticides	Tokuthion	5	0	--
Pesticides	Trichlorfon	5	0	--
Pesticides	Trichloronate	5	0	--

Comparison with applicable aquatic life and human health thresholds support the conclusion that water quality is impacted for these PAHs and pesticides (Table 10; Figure 6). In addition, ammonia-N exceeded aquatic life thresholds once at every site, and total phosphorus exceeded thresholds in all

samples from three sites (Rainbow Creek and the two sites in the Santa Margarita mainstem). Sulfate, manganese, pH, specific conductivity, and turbidity also exceeded thresholds at multiple sites (Table 11). Exceedances of human health thresholds were observed at three of the sites, with the highest number at the downstream Santa Margarita site. Rainbow Creek and Deluz Creek had no human health threshold exceedances (Figure 7). All sites in Santa Margarita HU failed to achieve several aquatic life thresholds, (Table 12; Figure 6, 7). The Lower Santa Margarita had the highest number of exceedances (9). All other sites exceeded 4 or 5 thresholds.

Table 10. Frequency of water chemistry threshold exceedances. A) Frequency of aquatic life threshold exceedances at SWAMP sites. B) Frequency of human health threshold exceedances at SWAMP sites. C) Frequency of aquatic life threshold exceedances at non-SWAMP sites. D) Frequency of human health thresholds at non-SWAMP sites. Freq = Frequency of samples exceeding applicable thresholds at each site. AL = Aquatic life. HH = Human health. -- = Constituent never exceeded threshold. NA = No applicable thresholds at that site. Empty cells indicate that the constituent was not measured at the site. (*)(*) Sulfate threshold of 300 mg/l applies to the Ysidora, Murrieta, Cave Rocks, Aguanga, and Oakgrove hydrologic areas (HA 902.1, 902.3, 902.7, 902.8, and 902.9).

A. Aquatic life				902SMDLZ3		902SMRNB4		902SMSMR1		902SMSND3		902SSMR10	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Inorganics	Alkalinity as CaCO3	20000 mg/l	EPA	--	4	--	4	--	4	--	4	--	4
Inorganics	Ammonia as N	0.025 mg/l	BP	0.25	4	0.25	4	0.25	4	0.25	4	0.50	4
Inorganics	Nitrate + Nitrite as N	10 mg/l	BP	--	4	0.50	4	--	4	--	4	--	4
Inorganics	Phosphorus as P,Total	0.1 mg/l	BP	--	4	1.00	4	1.00	4	--	4	1.00	4
Inorganics	Selenium,Dissolved	5 µg/L	CTR	--	4	--	4	--	4	--	4	0.25	4
Inorganics	Sulfate	250 mg/l*	BP	0.75	4	0.75	4	--	4	1.00	4	0.50	4
Metals	Aluminum,Dissolved	1000 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Metals	Arsenic,Dissolved	50 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Metals	Cadmium,Dissolved	5 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Metals	Chromium,Dissolved	50 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Metals	Copper,Dissolved	9 µg/L	CTR	--	4	--	4	--	4	--	4	0.25	4
Metals	Lead,Dissolved	2.5 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Manganese,Dissolved	0.05 µg/L	BP	--	4	--	4	0.75	4	--	4	0.75	4
Metals	Nickel,Dissolved	52 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Silver,Dissolved	3.4 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Zinc,Dissolved	120 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	0.0002 µg/L	BP	--	4	--	4	--	4	--	4	--	4
PCBs	PCBs	0.014 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Aldrin	3 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Atrazine	3 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin	0.002 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor	0.0038 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	0.0038 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Hexachlorobenzene	1 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Methoxychlor	40 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Molinate	20 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Simazine	4 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Thiobencarb	70 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Physical	pH	>6 or <8 pH units	BP	0.50	4	--	4	--	4	0.50	4	0.25	4
Physical	SpecificConductivity	1.6 mS/cm	CCR	0.25	4	0.50	4	--	4	0.50	4	0.50	4
Physical	Turbidity	20 NTU	BP	--	4	--	4	0.25	4	0.25	4	0.25	4

Table 10, continued. Frequency of water chemistry threshold exceedances.

B. Human Health				902SMDLZ3		902SMRNB4		902SMSMR1		902SMSND3		902SSMR10	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Metals	Arsenic,Dissolved	150 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Cadmium,Dissolved	2.2 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Copper,Dissolved	1300 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Nickel,Dissolved	610 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Acenaphthene	1200 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Anthracene	9600 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benz(a)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(b)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	0.50	4
PAHs	Benzo(k)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Chrysene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Dibenz(a,h)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Fluoranthene	300 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Indeno(1,2,3-c,d)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Pyrene	960 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PCBs	PCBs	0.00017 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Aldrin	0.00000013 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Ametryn	60 µg/l	EPA	--	4	--	4	--	4	--	4	--	4
Pesticides	Atrazine	0.2 µg/l	OEHHA	--	4	--	4	--	4	--	4	--	4
Pesticides	Azinphos ethyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	4
Pesticides	Azinphos methyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	4
Pesticides	DDD(p,p')	0.00083 µg/l	CTR	--	4	--	4	--	4	--	4	0.25	4
Pesticides	DDE(p,p')	0.00059 µg/l	CTR	--	4	--	4	0.25	4	0.50	4	0.50	4
Pesticides	DDT(p,p')	0.00059 µg/l	CTR	--	4	--	4	0.25	4	--	4	0.25	4
Pesticides	Dieldrin	0.00014 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Dimethoate	1.4 µg/l	IRIS	--	4	--	4	--	4	--	4	--	4
Pesticides	Endosulfan sulfate	110 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin Aldehyde	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin Ketone	0.85 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor	0.00021 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	0.0001 µg/l	CTR	--	4	--	4	0.25	4	--	4	0.25	4
Pesticides	Hexachlorobenzene	0.00075 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Oxychlordane	0.000023 µg/l	CTR	--	4	--	4	--	4	--	4	0.25	4

C. Aquatic life (non-SWAMP)

Aquatic life (non-SWAMP)	Dissolved oxygen		pH		Specific conductivity		Turbidity	
	5 mg/L		6 or 8		1.6 mS/cm		20 NTU	
	BP		BP		CCR		BP	
Site	Frequency	N	Frequency	n	Frequency	n	Frequency	n
Site 1	--	3	0.33	3	0.33	3	n.t.	0
Site 4	--	1	1.00	1	--	1	--	1
Site 5	--	3	0.67	3	0.67	3	n.t.	0
Site 6	--	4	1.00	4	0.50	4	--	1
Site 7	0.13	8	0.63	8	--	8	0.33	3
Site 10	--	6	0.67	6	--	6	--	1
Site 12	--	4	0.50	4	--	4	--	1
Site 13	--	1	1.00	1	--	1	n.t.	0
Site 14	0.33	3	0.33	3	--	3	0.50	2
Site 15	--	1	--	1	--	1	--	1

Table 11. Frequency of SWAMP sites with aquatic life and human health threshold exceedances of each constituent. Number of SWAMP sites included in evaluation (n). Constituent never exceeded threshold at any site (--). No applicable threshold for constituent (NA).

Category	Constituent	n	Aquatic life	Human health
Inorganics	Alkalinity as CaCO3	5	--	NA
Inorganics	Ammonia as N	5	1	NA
Inorganics	Nitrate + Nitrite as N	5	0.2	NA
Inorganics	Phosphorus as P,Total	5	0.6	NA
Inorganics	Selenium,Dissolved	5	0.2	NA
Inorganics	Sulfate	5	0.8	NA
Metals	Aluminum,Dissolved	5	--	NA
Metals	Arsenic,Dissolved	5	--	--
Metals	Cadmium,Dissolved	5	--	--
Metals	Chromium,Dissolved	5	--	NA
Metals	Copper,Dissolved	5	0.2	--
Metals	Lead,Dissolved	5	--	NA
Metals	Manganese,Dissolved	5	0.4	NA
Metals	Nickel,Dissolved	5	--	--
Metals	Silver,Dissolved	5	--	NA
Metals	Zinc,Dissolved	5	--	NA
PAHs	Acenaphthene	5	NA	--
PAHs	Anthracene	5	NA	--
PAHs	Benz(a)anthracene	5	NA	--
PAHs	Benzo(a)pyrene	5	--	--
PAHs	Benzo(b)fluoranthene	5	NA	0.2
PAHs	Benzo(k)fluoranthene	5	NA	--
PAHs	Chrysene	5	NA	--
PAHs	Dibenz(a,h)anthracene	5	NA	--
PAHs	Fluoranthene	5	NA	--
PAHs	Indeno(1,2,3-c,d)pyrene	5	NA	--
PAHs	Pyrene	5	NA	--
PCBs	PCBs	5	--	--
Pesticides	Aldrin	5	--	--
Pesticides	Ametryn	5	NA	--
Pesticides	Atrazine	5	--	--
Pesticides	Azinphos ethyl	5	NA	--
Pesticides	Azinphos methyl	5	NA	--
Pesticides	DDD(p,p')	5	NA	0.2
Pesticides	DDE(p,p')	5	NA	0.6
Pesticides	DDT(p,p')	5	NA	0.4
Pesticides	Dieldrin	5	NA	--
Pesticides	Dimethoate	5	NA	--
Pesticides	Endosulfan sulfate	5	NA	--
Pesticides	Endrin	5	--	--
Pesticides	Endrin Aldehyde	5	NA	--
Pesticides	Endrin Ketone	5	NA	--
Pesticides	Heptachlor	5	--	--
Pesticides	Heptachlor epoxide	5	--	0.4
Pesticides	Hexachlorobenzene	5	--	--
Pesticides	Methoxychlor	5	--	NA
Pesticides	Molinate	5	--	NA
Pesticides	Oxychlordane	5	NA	0.2
Pesticides	Simazine	5	--	NA
Pesticides	Thiobencarb	5	--	NA
Physical	pH	5	0.6	NA
Physical	SpecificConductivity	5	0.8	NA
Physical	Turbidity	5	0.6	NA

Table 12. Number of constituents exceeding thresholds at each SWAMP site.

Site	Aquatic life	Human health
902SMDLZ3	4	0
902SMRNB4	5	0
902SMSMR1	4	3
902SMSND3	5	1
902SSMR10	9	6

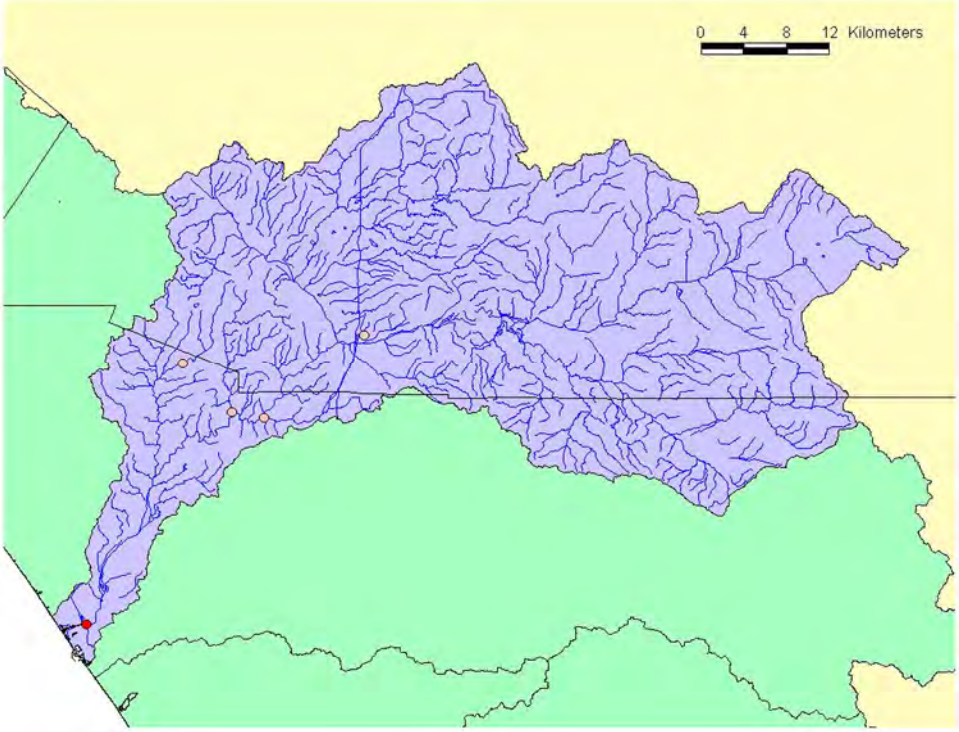


Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At all sites, 31 constituents were assessed.

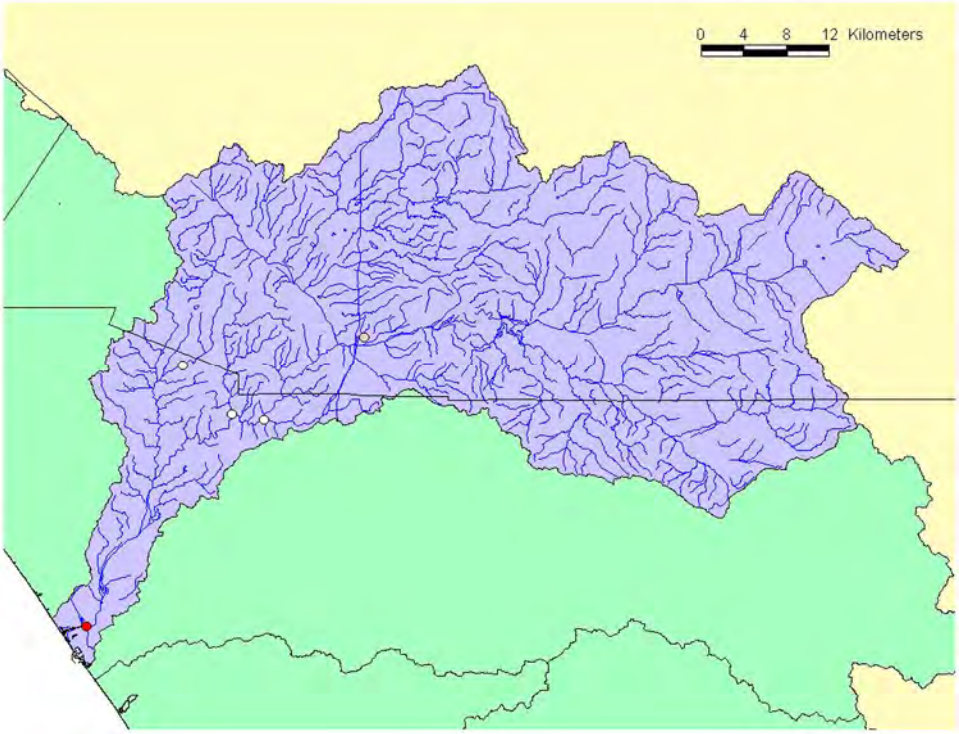


Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At all sites, 34 constituents were assessed.

Results from NPDES water chemistry monitoring at 9 sites were similar to results from SWAMP (Table 10C). For example, pH exceeded thresholds at every site monitored under NPDES. However, exceedances of specific conductivity was less frequent at sites monitored under NPDES. Dissolved oxygen and turbidity rarely exceeded aquatic life thresholds.

4.2 Toxicity

Toxicity was evident at every sites within the watershed, although the results suggest moderate or low levels of toxicity at most sites (Table 13; Figure 8; Appendix III). Severity was highest at the downstream site on the Santa Margarita River. Samples from this site were toxic to all indicators on at least one sampling date, and chronic toxicity was observed in 44% of all samples from this site. Acute toxicity to *C. dubia* was observed in one sample from this site, but from no other sample from the Santa Margarita HU. At the Upper Santa Margarita River, Deluz Creek, and Sandia Creek, *S. capricornutum* was the only sensitive indicator. In contrast, samples from Rainbow Creek, like the Lower Santa Margarita River site, was toxic to *H. azteca* on one sampling date. At no site did toxicity persist on all sampling dates, suggesting that toxicity is not a permanent condition at these sites.

Table 13. Frequency of toxicity detected for each endpoint and at each site. A sample was considered toxic if the percent control of the endpoint was less than 80% of reference samples, and the difference was considered significant at 0.05. Number of samples where the endpoint was evaluated (n). Toxicity not detected in any sample (--).

	C. dubia				*H. azteca*				*S. capricornutum*		Multiple indicators	
Site	Surival	n	Young/Female	n	Survival	n	Growth	n	Total cell count	n	Frequency	n
902SMDLZ3	--	4	--	4	--	4	--	4	0.75	4	0.25	12
902SMRNB4	--	4	--	4	--	4	0.25	4	0.50	4	0.25	12
902SMSMR1	--	4	--	4	--	1	--	1	0.50	4	0.22	9
902SMSND3	--	4	--	4	--	1	--	1	0.25	4	0.11	9
902SSMR10	0.25	4	--	3	--	2	0.50	2	0.75	4	0.44	9
All sites	0.05	20	--	19	--	12	0.17	12	0.55	20	0.25	51

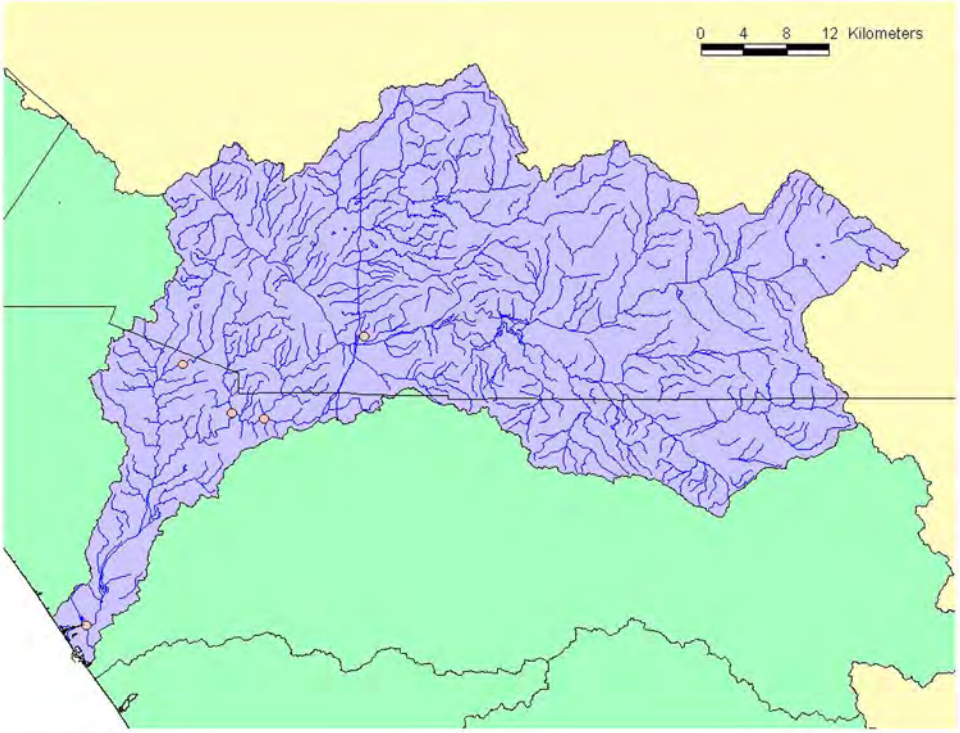


Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity. Red circles indicate high (0.5 to 1.0) frequency of toxicity.

S. capricornutum was the most sensitive indicator, as total cell count was less than 80% of control at all sites in most samples. Toxicity to *S. capricornutum* was least frequent at Sandia Creek and most frequent at Deluz Creek and the Lower Santa Margarita site. Across the watershed, 55% of samples were toxic to this indicator.

Toxicity to arthropod indicators was much less frequent. Only one sample from one site was toxic to *C. dubia* (5% of all samples from the watershed). Toxicity to *H. azteca* was observed at two sites (Rainbow Creek and the Lower Santa Margarita River), and only on one sampling date at each site. Across the watershed, 17% of samples were toxic to *H. azteca.*

4.3 Tissue

Analysis of fish tissue from Sandia Creek did not find evidence of impact (Table 14; Figure 9). Selenium did not exceed OEHHA thresholds. All other measured constituents lacked applicable thresholds. Six constituents (i.e., Aluminum, Arsenic, Chromium, Copper, Manganese, Selenium, and Zinc) were detected in the catfish tissues. Four of the constituents (i.e., Silver, Cadmium,

Nickel, and Lead) did not occur at detectable concentrations. Fish tissue concentrations of PCBs, PAHs, and pesticides were not assessed.

Table 14. Concentrations of contaminants in catfish tissues collected at Sandia Creek, compared with OEHHA thresholds.

Constituent	Threshold (ppm)	Concentration (ppm)
Ag		0.00
Al		0.13
As		0.06
Cd		0.00
Cr		0.11
Cu		0.36
Mn		0.1
Ni		0.000
Pb		0.00
Se	1.94	0.17
Zn		3.9

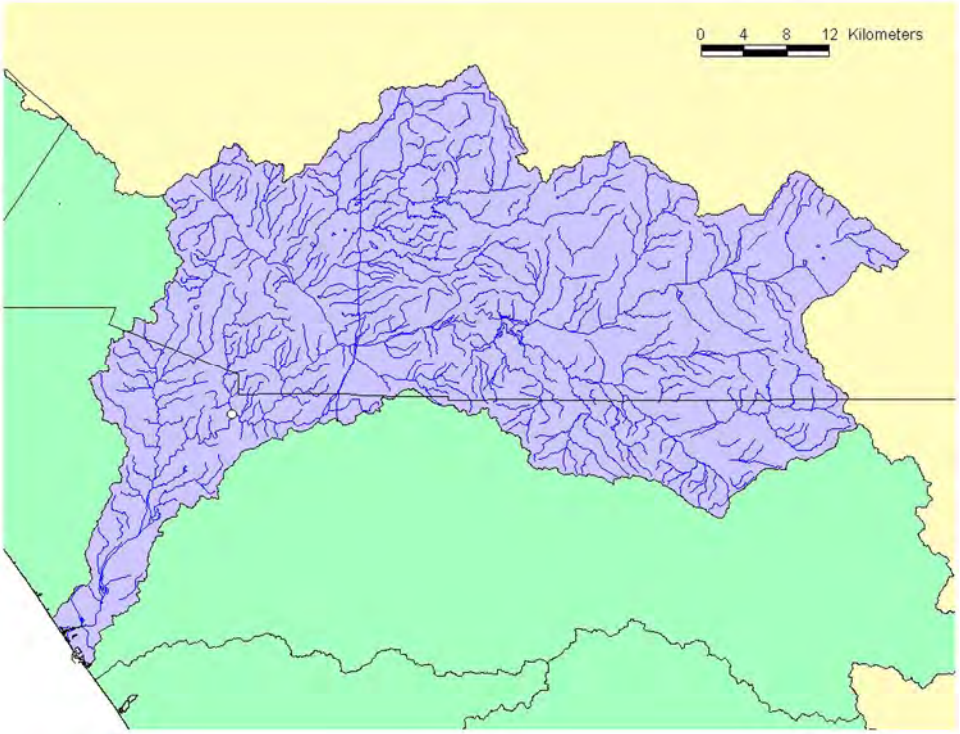


Figure 9. Fish tissue exceedances at SWAMP sites. White circles indicate 1 or fewer exceedances. Pink circles indicate 2 to 3 exceedances (this value did not occur in this watershed). Red circles indicate 4 to 5 exceedances (this value did not occur in this watershed).

4.4 Bioassessment

Biological health varied widely across the watershed. For example, a bioassessment sample from reference site on the Santa Margarita River at

Deluz Creek (site 13) had an IBI score of 72.9—the highest score observed in the watershed (Table 15; Figure 10). Five other sites were in fair condition, with IBI scores greater than 40: Roblar Creek (site 4), Sandia Creek (sites 5 and 6), the Santa Margarita River mainstem (site 12), and Deluz Creek (site 1). The last three of these sites were designated reference sites. Most of the higher IBI scores were clustered around Deluz Creek and other streams draining the Santa Rosa Plateau. Average metric values for each site and season are presented in Appendix IV.

Table 15. Mean and standard deviation of IBI scores at bioassessment sites within the Santa Margarita HU. Number of samples collected within each season (n). Range from first to last year of sampling at each site (Years). Frequency of poor or very poor IBI scores (IBI <40) at each site and season (Frequency). -- = Poor conditions not detected.

				IBI			
Site	Season	n	Years	Mean	SD	Condition	Freq
1	Average	7	2000-2004	56.5	2.1	Fair	--
1	Fall	5	2000-2004	58	9.7	Fair	--
1	Spring	2	2001-2003	55	3	Fair	--
2	Spring	1	1998-1998	12.9		Very poor	1.00
3	Average	12	1998-2005	29.6	11.6	Poor	0.83
3	Fall	4	1998-2003	37.9	10.1	Poor	0.75
3	Spring	8	1998-2005	21.4	14.1	Poor	0.88
4	Spring	4	2001-2006	49.6	5.1	Fair	--
5	Average	6	2000-2005	57.1	15.2	Fair	0.17
5	Fall	2	2000-2004	67.9	1	Good	--
5	Spring	4	2000-2005	46.4	7.8	Fair	0.25
6	Average	14	1998-2003	51.5	8.4	Fair	0.14
6	Fall	6	1998-2003	57.4	9.6	Fair	--
6	Spring	8	1998-2003	45.5	9.3	Fair	0.25
7	Average	17	1998-2006	33.8	0.5	Poor	0.76
7	Fall	7	1999-2005	34.1	10.4	Poor	0.71
7	Spring	10	1998-2006	33.4	9	Poor	0.80
8	Average	8	1998-2001	35.9	9.9	Poor	0.50
8	Fall	3	1998-2000	42.9	2.9	Fair	--
8	Spring	5	1998-2001	28.9	8.3	Poor	0.80
9	Spring	2	1998-1999	8.6	2	Very poor	1.00
10	Average	18	1998-2005	34	6.1	Poor	0.78
10	Fall	6	1998-2004	38.3	9.6	Poor	0.67
10	Spring	12	1998-2005	29.8	12.7	Poor	0.83
11	Average	13	1998-2000	26.7	10.3	Poor	0.85
11	Fall	5	1998-2000	34	11.7	Poor	0.60
11	Spring	8	1998-2000	19.5	12	Very poor	1.00
12	Average	4	2002-2004	50.5	1.3	Fair	--
12	Fall	1	2003-2003	51.4		Fair	--
12	Spring	3	2002-2004	49.5	8.1	Fair	--
13	Fall	1	2002-2002	72.9		Good	--
14	Average	4	2004-2006	31.1	0.5	Poor	1.00
14	Fall	2	2004-2005	30.7	7.1	Poor	1.00
14	Spring	2	2005-2006	31.4	4	Poor	1.00
15	Spring	1	2006-2006	35.7		Poor	1.00

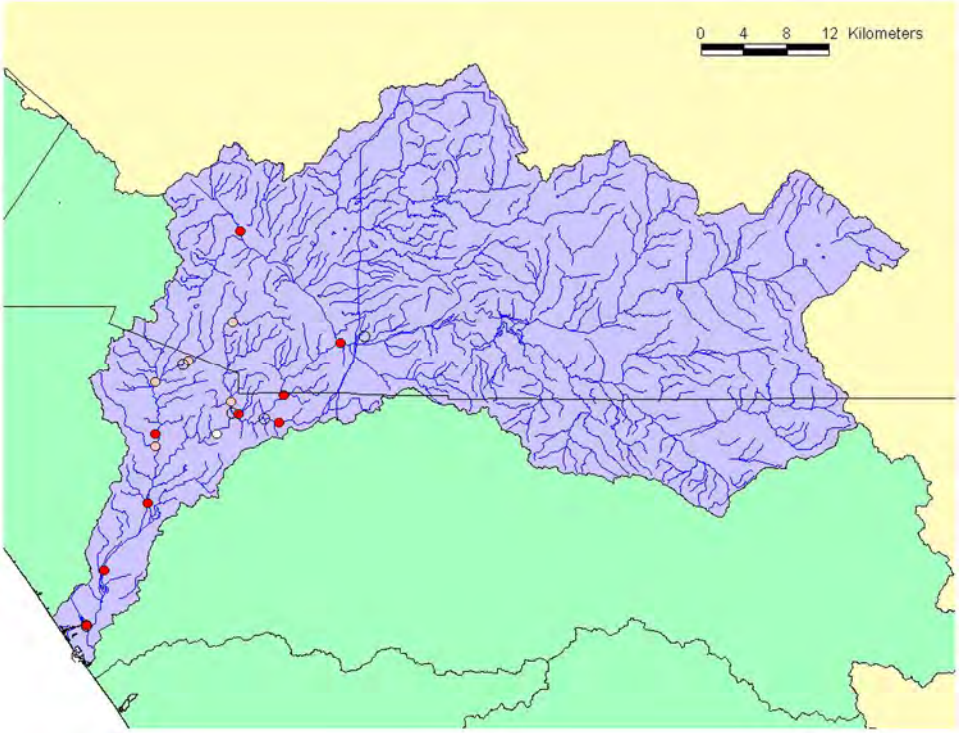


Figure 10. IBI scores at sites in the Santa Margarita HU. White circles indicate good or very good (60 to 100) IBI scores. Pink circles indicate fair (40 to 60) IBI scores. Red circles indicate poor (0 to 40) IBI scores. Open circles represent 500-m buffers around SWAMP sites; five of these buffers included bioassessment sites, and six of these buffers did not.

The remaining eight sites were in poor or very poor ecological condition. Most of these sites were on the mainstem of the Santa Margarita River (e.g., site 7, 9, 10, and 14). However, sites at Sandia Creek (site 8), Murrieta Creek (site 2), Temecula Creek (site 11), and Rainbow Creek (site 3) were also in poor ecological condition.

At most sites, IBI scores were lower in Spring than in Fall (Table 15; Figure 11). These differences were small or reversed in the Santa Margarita River and Deluz Creek, but large at Sandia, Temecula, and Rainbow Creeks.

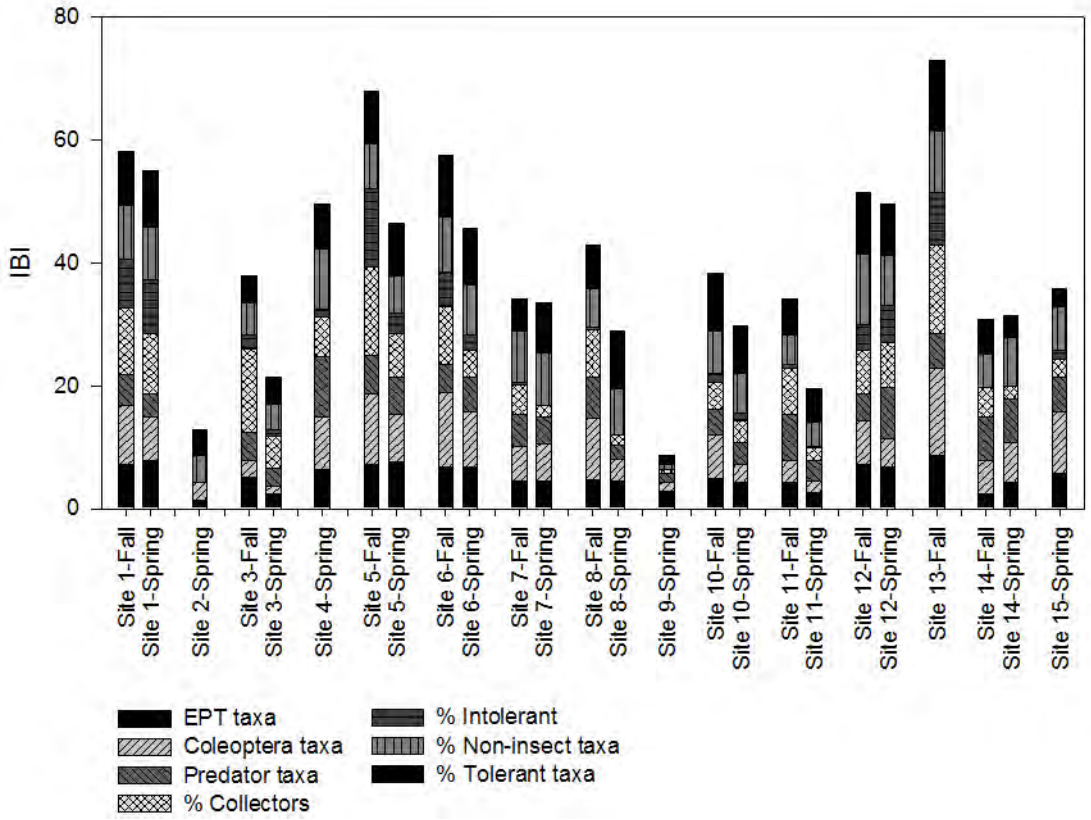


Figure 11. Mean IBI scores at each bioassessment site and each season. The height of the bar indicates the mean IBI score, and the size of each component of the bar represents the contribution of each metric to the IBI.

Examination of IBI scores over time did not indicate a trend towards improving or deteriorating biological condition (Figure 12). Variability among years was high, which may obscure trends in the data. Furthermore, a different set of sites were sampled in the early and late periods of study, increasing spatial variability and obscuring trends.

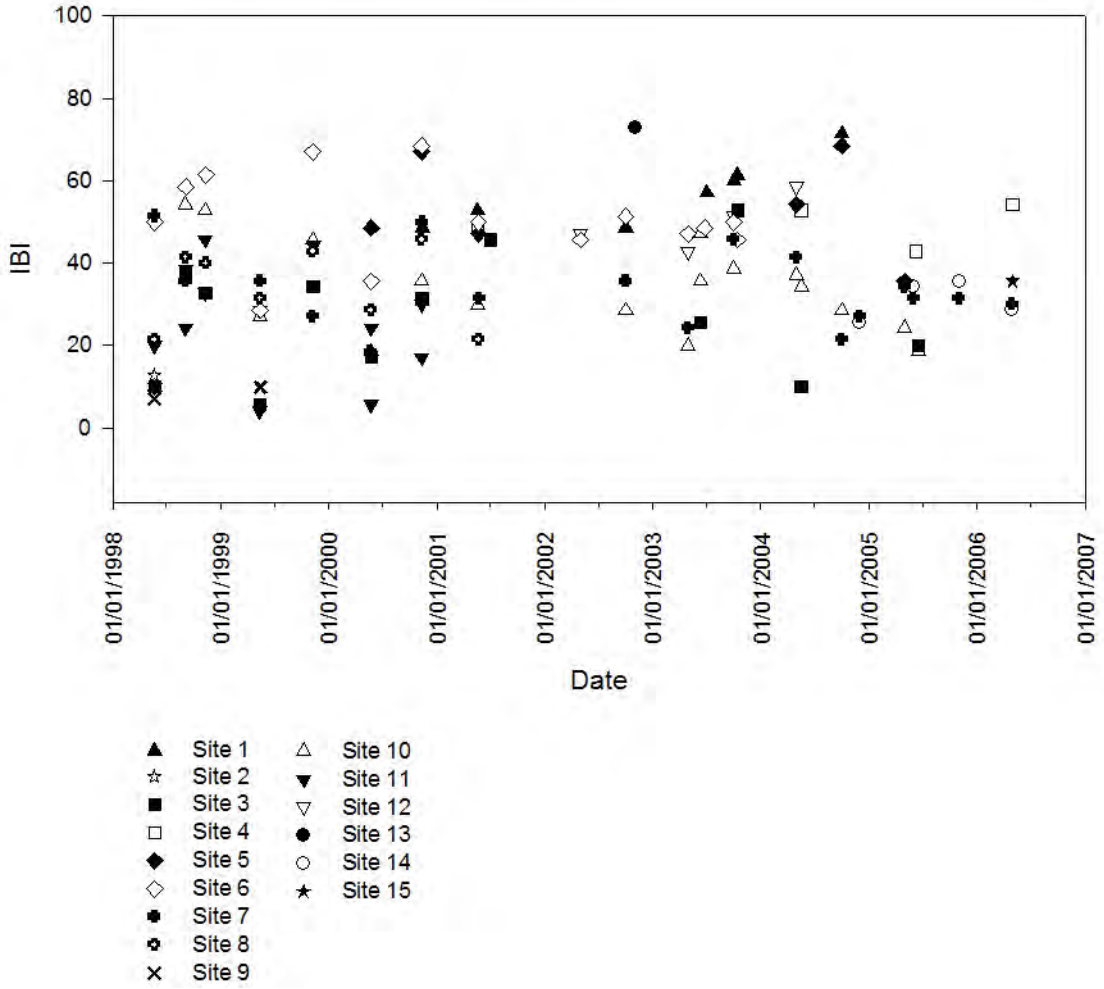


Figure 12. IBI values for each year and site. Each symbol represents a single sample.

None of these sites were monitored under SWAMP, and all bioassessment data came from monitoring efforts by NPDES permittees, Camp Pendleton, or the California Department of Fish and Game.

4.5 Physical Habitat

Physical habitat good or very good at every site in the watershed (Table 16; Figure 13). At four sites, the mean physical habitat score was greater than 15, and no site was the mean score below 10. The greatest degradation was observed at the downstream site in the Santa Margarita River, which had a mean physical habitat score of 14.9.

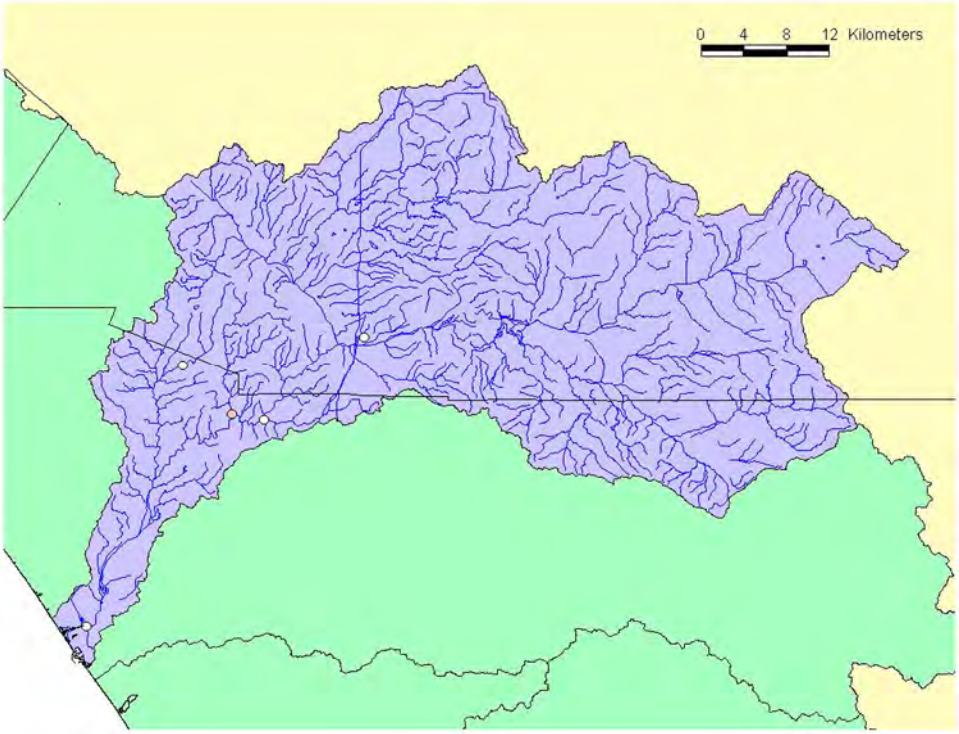


Figure 13. Assessment of physical habitat at SWAMP sites. White circles indicate sites with a mean physical habitat scores between 15 and 20. Pink circles indicate mean scores between 10 and 15. Red circles indicate mean scores between 0 and 10.

At most sites, embeddedness of substrate was high, contributing to poor physical habitat. At four of the five sites, this component of physical habitat received a score of 5 or less. At Roblar Creek, embeddedness was moderate and received a score of 13. All other components of physical habitat received high (i.e., >10) or very high (i.e., >15) scores at all sites.

5. DISCUSSION

This analysis of the Santa Margarita HU suggests that the watershed is in good ecological health, although moderate to severe impacts were evident at every site (Table 17; Figure 14). At most sites, water chemistry was moderately impacts. Toxicity was evident at every site, but generally moderate. Biological communities were severely impacted at many sites, although in some regions these communities were in fair or good condition. Physical habitat showed little evidence of severe degradation at any site in the Santa Margarita HU. Fish tissues collected at one site showed no signs of impact.

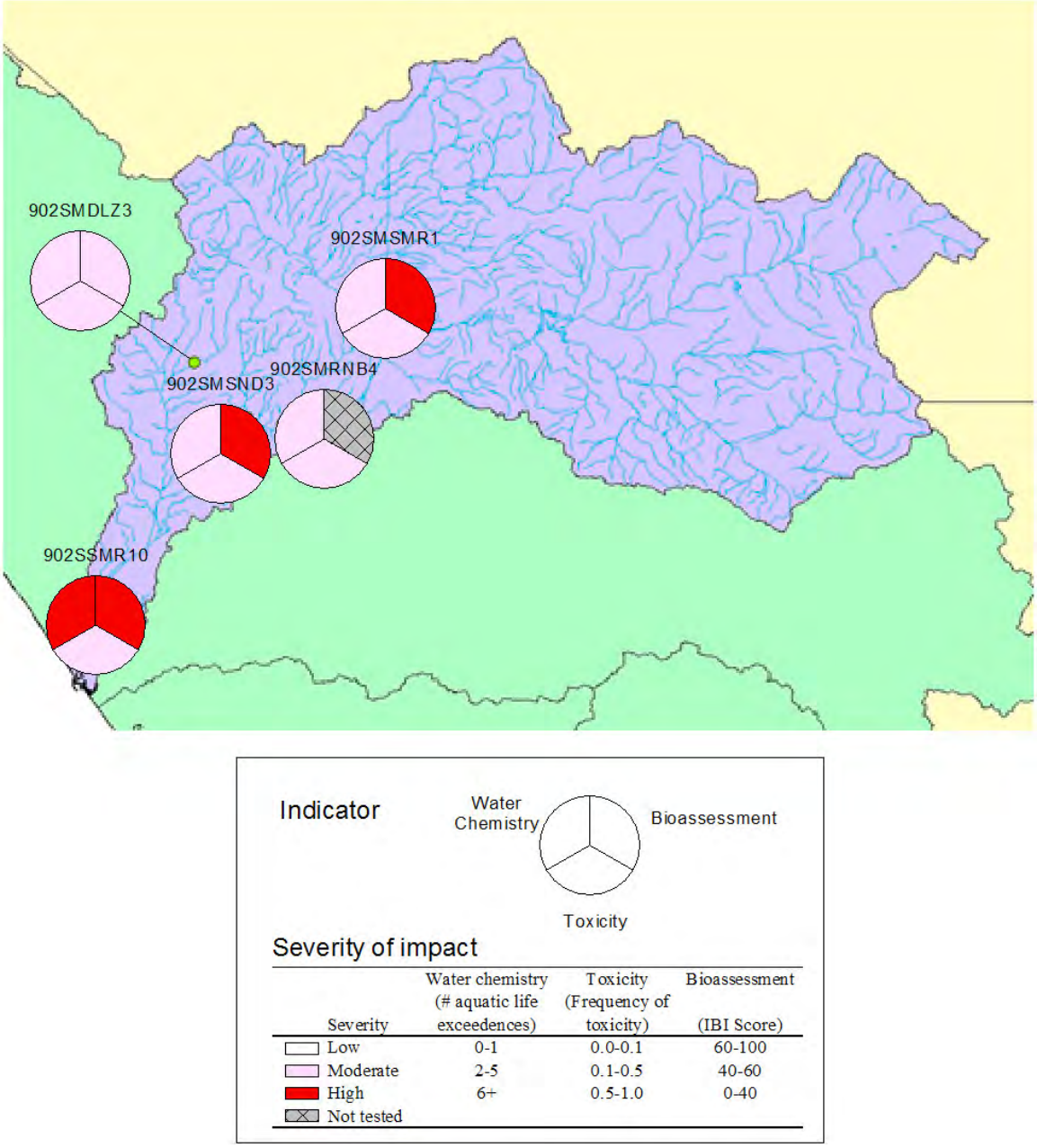


Figure 14. Summary of the ecological health of SWAMP sites in the Santa Margarita HU, as determined by water chemistry, toxicity, and bioassessment indicators. Each pie slice corresponds to a specific indicator, as described in the inset, with darker colors corresponding to more degraded conditions (unmeasured indicators are shown in cross-hatched gray). The top-left slice corresponds to the number of water chemistry constituents exceeding aquatic life thresholds. The bottom slice corresponds to the frequency of toxicity among three endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). The top-right slice corresponds to the IBI of bioassessment samples.

Table 17. Summary of the ecological health for five SWAMP sites in Santa Margarita HU. Aquatic life (AL). Human health (HH). Toxicity frequency is frequency of toxicity for three chronic toxicity endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). Biology frequency is the frequency of IBIs below 40. n.t. = Indicator not tested.

	Water chemistry		Tissue	Toxicity	Biology	Physical habitat
Site	# constituents (AL)	# constituents (HH)	# constituents (OEHHA)	Frequency	Frequency	Mean score
902SMDLZ3	4	0	n.t.	0.25	--*	15.2
902SMRNB4	5	0	n.t.	0.25	n.t.	15.2
902SMSMR1	4	3	n.t.	0.22	0.85*	18.4
902SMSND3	5	1	0	0.11	0.50*	14.9
902SSMR10	9	6	n.t.	0.44	1.00*	15.9

* = Estimated from data collected at nearby (within 500 meters) non-SWAMP sites.

The most severely impacted site was the downstream site on the Lower Santa Margarita River. This site had the highest number of aquatic life (9) and human health (6) exceedances in the watershed. These constituents included nutrients (especially total Phosphorus), Selenium, Sulfate, Copper, Manganese, pH, specific conductivity, and turbidity. Toxicity to all indicator species was evident, and 44% of samples from this site produced chronic toxicity to multiple indicators. Some of the lowest IBI scores observed in the watershed were from samples collected near this site (at site 9).

The Upper Santa Margarita River site was in better ecological health than the downstream site. For example, half as many constituents exceeded aquatic life and human health thresholds. These constituents were limited to nutrients, Manganese, and turbidity. Toxicity was moderate at this site, and was restricted to a single indicator species, *S. capricornutum.* Physical habitat was good at this site, receiving the highest physical habitat score (18.4) in the Santa Margarita HU. However, bioassessment samples collected near this site (at site 11) were in poor ecological condition, having a mean IBI score of 26.7. The high total phosphorus levels at both sites in the Santa Margarita is consistent with the 303(d) list, which specifies phosphorus as a known stressor in the Santa Margarita river.

The tributaries of the Santa Margarita River were in similar ecological health to the upstream site. For example, water chemistry constituents Sandia Creek exceeded 5 aquatic life thresholds. Unlike the mainstem sites, nutrients did not exceed aquatic life thresholds, except for Ammonia-N on a single sampling date. However, sulfate, pH, specific conductivity, and turbidity exceeded these thresholds on at least one sampling date. These data are partially consistent with the 303(d) list, which specifies sulfate as a known stressor in Sandia Creek; however, other known stressors, such as Manganese and Nitrogen, did not exceed thresholds for aquatic life. Toxicity was rarely observed at this site—only one sample from a single sampling date was toxic to a single indicator species, *S. capricornutum.* Many bioassessment samples collected near this site (at site 8) were in poor ecological condition. However,

50% of the bioassessment samples (mostly collected in the Fall) were in fair condition, suggesting that good ecological condition persists for at least part of the year. Furthermore, fish tissue collected at this site did not show evidence of impacts, and physical habitat was in good condition. Physical habitat at this site was good, although the mean physical habitat score was lower than other sites in the Santa Margarita HU.

Rainbow Creek, like Sandia Creek, had moderate impacts for multiple indicators. For example, 5 water chemistry constituents exceeded aquatic life thresholds. These constituents included nutrients, sulfate, and specific conductivity. These data were consistent with the inclusion of Rainbow Creek on the 303(d) list, which specifies nitrogen, phosphorus, and sulfates as known impairments.. Toxicity was evident for two indicator species (*S. capricornutum* and *H. azteca*). Physical habitat was in good condition. Although no bioassessment samples were collected within 500 m of the SWAMP site, samples collected over several years from upstream (at site 3) were in poor ecological condition, with a mean IBI of 29.6; only 17% of samples from this site were in fair condition.

The site at Deluz Creek was in good ecological health, although impacts were evident. It had only 4 water chemistry constituents that exceeded aquatic life thresholds, and none that exceeded human health thresholds. Apart from Ammonia-N on one sampling date, no nutrient exceeded these thresholds. Other exceedances include Sulfate, pH, and specific conductivity. Manganese did not exceed thresholds, although this is a known stressor for De Luz Creek on the 303(d) list. Although toxicity to *S. capricornutum* was frequently observed, no other indicator species was sensitive to samples from this site. Bioassessment samples collected near this site (at site 1) were in fair condition, with a mean IBI of 56.5. Furthermore, none of the 7 bioassessment samples collected over 5 years were ever in poor or very poor ecological condition, which is unique for sites sampled in multiple seasons in the Santa Margarita HU. Physical habitat was good at this site.

This study's assessment of the Santa Margarita HU suggests that the watershed is in moderate to good health, although many impacts were evident, particularly in the lower portions of the mainstem. Multiple lines of evidence support this conclusion. For example, several water chemistry constituents exceeded aquatic life and human health thresholds at all sites. Toxicity was observed at every site, although never on every sampling date. Bioassessment samples suggested that poor ecological conditions were widespread, although conditions were better at Deluz and Roblar Creeks. Physical habitat was good throughout the watershed.

Despite the strength of the evidence, limitations of this study affect the assessment. These limitations include difficulties integrating data from SWAMP and non-SWAMP sources, the non-randomization of sample sites, small sample

size, and the lack of applicable thresholds for several indicators. Although these limitations require that results be interpreted with caution, it is unlikely that they would alter the conclusion that the Santa Margarita HU is in moderate to good ecological health.

The geographical approach to integrating SWAMP and non-SWAMP data relies on assumptions about the spatial and temporal variability of the variables measured by these programs. For example, bioassessment data may have been collected up to 500 meters away and up to 4 years before or 3 years after water chemistry, toxicity, and tissue data were collected. This study assumes that anthropogenic impacts do not change across these distances or over these spans of time. There is little published research on either of these assumptions, although there may be greater support for the assumptions about spatial variability (e.g., Gebler 2004) than for temporal variability (e.g., Sandin and Johnson 2000, Bêche et al. 2006).In this study, bioassessment data were observed to be highly variable, and the use of data collected many years before water chemistry data is questionable.

The targeted selection of sites monitored under the SWAMP program facilitated integration of pre-existing data from non-SWAMP sources, but this non-probabilistic approach severely limits the extrapolation of data from these sites to the rest of the watershed. Non-random sampling violates assumptions underlying most statistical analyses, and the sites selected in this study cannot be assumed to represent the entire watershed (Olsen et al. 1999, Stevens Jr. and Olsen 2004). Although reference sites were designated for monitoring under SWAMP and NPDES, it is unclear if the proportion of reference sites sampled reflect the proportion of minimally degraded streams in the HU.

The small number of sites monitored under SWAMP also limits the certainty of this study's assessment. For example, tissue samples were collected at only one site, and only a small number of constituents were evaluated; therefore, tissue contamination may have gone undetected in unsampled regions of the watershed. Although SWAMP has produced a wealth of data about the Santa Margarita watershed using limited resources, some indicators (especially those with high variability) may require more extensive sampling to produce more precise and accurate assessments.

Thresholds are an essential tool for assessing water quality and ecological health. However, their use is limited to indicators that have been well studied, and they cannot provide a holistic view watershed health. This limitation is exacerbated by the fact that many constituents and indicators lack applicable thresholds. For example, of the 54 water chemistry constituents, 20 (37%) had no applicable water quality objectives that could be used as thresholds for water quality. No thresholds exist for physical habitat scores. Furthermore, thresholds applied to IBI scores and toxicity were based on statistical distributions and professional judgment (respectively), rather than on risks to ecological health.

For example, the 80% threshold used to identify toxic samples is based on the assumption that this level is ecologically meaningful, although this assumption has not been verified in the field. The development of biocriteria to establish meaningful thresholds for bioassessment is subject of active interest in California (Bernstein and Schiff 2002).

Despite these limitations, the data gathered under SWAMP and other programs strongly support the conclusion that portions of the Santa Margarita HU is in moderate to good ecological health, and that other portions are in poor ecological health. Some of these limitations (such as the lack of applicable thresholds and the small sample size) may in fact have caused this assessment to underestimate the severity of degradation in the watershed. All indicators showed signs of human impacts. Multiple stressors, including degraded water quality, sediment, and physical habitat are the likely cause of the impact. Future research (see final report on the SWAMP monitoring program for further study recommendations) is necessary to determine which stressors are responsible for the impacts seen in the watershed.

6. LITERATURE CITED

Bêche, L.A., E.P. McElravy and V.H. Resh. 2005. Long-term seasonal variation in the biological traits of benthic-macroinvertebrates in two Mediterranean climate streams in California, USA. *Freshwater Biology* 51:56-75.

California Code of Regulations. 2007. Barclay's Official California Code of Regulations. Title 22. Social Security Division 4. Environmental Health Chapter 15. Domestic Water Quality and Monitoring Regulations Article 16. Secondary Drinking Water Standards. §64449.

California Department of Fish and Game. 2003. California Stream Bioassessment Procedure: Protocol for Biological and Physical/Habitat Assessment in Wadeable Streams. Available from www.dfg.ca.gov/cabw/cabwhome.html.

California Department of Water Resources. 2007. http://www.water.ca.gov/.
Environmental Protection Agency (EPA). 1993. Methods for measuring acute toxicity of effluents and receiving waters to freshwater and marine organisms, Fourth Edition. EPA 600/4-90/027. US Environmental Protection Agency, Environmental Research Laboratory. Duluth, MN.

Environmental Protection Agency (EPA). 1997. Water quality standards: Establishment of numeric criteria for priority toxic pollutants for the state of California: Proposed Rule. *Federal Register* 62:42159-42208.

Environmental Protection Agency (EPA). 2002. National recommended water quality criteria. EPA-822-R-02-047. Environmental Protection Agency Office of Water. Washington, DC.

Environmental Protection Agency (EPA). 2007. Integrated Risk Information System. http://www.epa.gov/iris/index.html. Office of Research and Development. Washington, DC.

Gebler, J.B. 2004. Mesoscale spatial variability of selected aquatic invertebrate community metrics from a minimally impaired stream segment. J*ournal of the North American Benthological Society* 23:616-633.

National Academy of Sciences. 1977. Drinking Water and Health. Volume 1. Washington, DC.

National Oceanic and Atmospheric Administration. 2007. National Weather Service data. Available from http://www.wrh.noaa.gov/sgx/obs/rtp/rtpmap.php?wfo=sgx

Ode, P.R., A.C. Rehn and J.T. May. 2005. A quantitative tool for assessing the integrity of southern California coastal streams. *Environmental Managemen*t 35:493-504.

Office of Environmental Health Hazard Assessment (OEHHA). 2006. Draft development of guidance tissue levels and screening values for common contaminants in California Sports Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. OEHHA. Sacramento, CA.

Olsen, A.R., J. Sedransk, D. Edwards, C.A. Gotway, W. Liggett, S. Rathburn, K.H. Reckhow and L.J. Young. 1999. Statistical issues for monitoring ecological and natural resources in the United States. *Environmental Management and Assessment* 54:1-45.

Puckett, M. 2002. Quality Assurance Management Plan for the State of California's Surface Water Ambient Monitoring Program: Version 2. California Department of Fish and Game, Monterey, CA. Prepared for the State Water Resources Control Board. Sacramento, CA.

California Regional Water Quality Control Board, San Diego Region. 1994. Water quality control plan for the San Diego Region. San Diego, CA. http://www.waterboards.ca.gov/sandiego/programs/basinplan.html

SANDAG. 1998. Watersheds of the San Diego Region. SANDAG INFO.

Sandin, L. and R.K. Johnson. 2000. The statistical power of selected indicator metrics using macroinvertebrates for assessing acidification and eutrophication of running waters. *Hydrobiologia* 422/423:233-243.

SCAG. 2000. Southern California Association of Governments Land Use Data. Available from http://www.scag.ca.gov/landuse/index.htm

Stevans, Jr., D.L. and A.R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association: Theory and Methods* 99:262-278.

Weston Solutions, Inc. 2007. San Diego County Municipal Copermittees 2005-2006 Urban Runoff Monitoring. Final Report. County of San Diego. San Diego, CA. Available at http://www.projectcleanwater.org/html/wg_monitoring_05-06report.html.

7. APPENDICES

APPENDIX I

A. Beneficial uses of streams in the Santa Margarita HU (California Regional Water Quality Control Board, San Diego Region 1994). B. Streams on the 303(d) list of impaired water bodies in the Santa Margarita. HUC = Hydrologic Unit Code. MUN = Municipal and domestic supply. AGR = Agricultural supply. IND = Industrial service supply. PROC = Industrial process supply. GWR = Groundwater recharge. REC1 = Contact recreation. REC2 = Non-contact recreation. WARM = Warm freshwater habitat. COLD = Cold freshwater habitat. WILD = Wildlife habitat. RARE = Rare, threatened, or endangered species. SPWN = Spawning, reproduction, and/or early development. X = Exempted from municipal supply. E = Existing beneficial use. P = Potential beneficial use.

A. Beneficial uses of streams in the Santa Margarita HU.
Appendix Ia, continued.

Santa Margarita HU (902)	HUC	MUN	AGR	IND	PROC	GWR	REC1	REC2	WARM	COLD	WILD	RARE	SPWN
Santa Margarita River	902.22	E	E	E			E	E	E	E	E	E	
Murrieta Creek	902.31	E	E	E	E		P	E	E		E		
Bundy Canyon	902.31	E	E	E	E		P	E	E		E		
Slaugherhouse Canyon	902.31	E	E	E	E		P	E	E		E		
Murrieta Creek	902.32	E	E	E	E		P	E	E		E		
Murrieta Creek	902.52	E	E	E	E	E	P	E	E		E		
Cole Canyon	902.32	E	E	E	E		P	E	E		E		
Miller Canyon	902.32	E	E	E	E		P	E	E		E		
Warm Springs Creek	902.36	E	E	E	E		P	E	E		E		
Diamond Valley	902.36	E	E	E	E		P	E	E		E		
Goodhart Canyon	902.36	E	E	E	E		P	E	E		E		
Pixley Canyon	902.36	E	E	E	E		P	E	E		E		
Warm Springs Creek	902.35	E	E	E	E		P	E	E		E		
Domenigoni Valley	902.35	E	E	E	E		P	E	E		E		
Warm Springs Creek	902.34	E	E	E	E		P	E	E		E		
Warm Springs Creek	902.33	E	E	E	E		P	E	E		E		
French Valley	902.33	E	E	E	E		P	E	E		E		
Santa Gertrudis Creek	902.42	E	E	E	E	P	E	E	E		E		
Long Valley	902.42	E	E	E	E	P	E	E	E		E		
Glenoak Valley	902.42	E	E	E	E	P	E	E	E	E	E		
Tucalota Creek	902.43	E	E	E	E	P	E	E	E	E	E		
Willow Canyon	902.44	E	E	E	E	P	E	E	E	E	E		
Tucalota Creek	902.41	E	E	E	E	P	E	E	E		E		
Crown Valley	902.41	E	E	E	E	P	E	E	E	E	E		
Rawson Canyon	902.41	E	E	E	E	P	E	E	E	E	E		
Tucalota Creek	902.42	E	E	E	E	P	E	E	E		E		
Santa Gertrudis Creek	902.32	E	E	E	E		P	E	E		E		
Long Canyon	902.32	E	E	E	E	E	P	E	E		E		
Temecula Creek	902.93	E	E	E	E	E	P	E	E		E		
Kohler Canyon	902.93	E	E	E	E	E	P	E	E	E	E		
Rattlesnake Creek	902.93	E	E	E	E	E	P	E	E	E	E		
Temecula Creek	902.92	E	E	E	E	E	P	E	E		E		
Chihuahua Creek	902.94	E	E	E	E	E	P	E	E		E		
Chihuahua Creek	902.92	E	E	E	E	E	P	E	E		E		
Copper Canyon	902.92	E	E	E	E	E	P	E	E		E		
Iron Springs Canyon	902.92	E	E	E	E	E	P	E	E		E		
Temecula Creek	902.91	E	E	E	E	E	P	E	E		E		
Culp Valley	902.91	E	E	E	E	E	P	E	E		E		
Temecula Creek	902.84	E	E	E	E	E	E	E	E	E	E		E
Tule Creek	902.84	E	E	E	E	E	E	E	E		E		
Million Dollar Canyon	902.84	E	E	E	E	E	E	E	E		E		
Cottonwood Creek	902.84	E	E	E	E	E	E	E	E	E	E		E
Temecula Creek	902.83	E	E	E	E	E	E	E	E	E	E		E
Long Canyon	902.83	E	E	E	E	E	E	E	E	E	E		E
Wilson Creek	902.63	E	E	E	E	E	P	E	E		E		
Wilson Creek	902.61	E	E	E	E	E	P	E	E		E		
Cahuila Creek	902.73	E	E	E	E	E	P	E	E		E		
Hamilton Creek	902.74	E	E	E	E	E	P	E	E		E		
Hamilton Creek	902.73	E	E	E	E	E	P	E	E		E		
Cahuila Creek	902.72	E	E	E	E	E	P	E	E		E		

Appendix I, continued.
B. 303(d)-listed streams in the Santa Margarita HU.

Name	HUC	Stressor	Potential source	Affected length
DeLuz Creek	902.21	Iron	Sources unknown	14 miles
		Manganese	Sources unknown	14 miles
Long Canyon Creek	902.83	Total dissolved solids	Sources unknown	8.3 miles
Murrieta Creek	902.52	Iron	Sources unknown	12 miles
		Manganese	Sources unknown	12 miles
		Nitrogen	Sources unknown	12 miles
Rainbow Creek	902.22	Iron	Sources unknown	5 miles
		Nitrogen	Agricultural return flows, other urban runoff, nurseries, onsite wastewater systems (septic tanks), nonpoint/point source	5 miles
		Phosphorus	Agricultural return flows, other urban runoff, nurseries, onsite wastewater systems (septic tanks), nonpoint/point source	5 miles
		Sulfates	Sources unknown	5 miles
		Total dissolved solids	Sources unknown	5 miles
Sandia Creek	902.22	Iron	Sources unknown	1.5 miles
		Manganese	Sources unknown	1.5 miles
		Nitrogen	Sources unknown	1.5 miles
		Sulfates	Sources unknown	1.5 miles
Santa Margarita River	902.22	Phosphorus	Urban runoff/storm sewers, unknown nonpoint source, unknown point source	18 miles
Temecula Creek	902.51	Nitrogen	Sources unknown	44 miles
		Phosphorus	Sources unknown	44 miles
		Total dissolved solids	Sources unknown	44 miles

APPENDIX II

Means, standard deviations (SD), and number of samples (n) of water chemistry constituents in (A) SWAMP sites and (B) Non-SWAMP (NPDES) sites. The watershed average was calculated as the mean of the site averages. Blank cells indicate that the constituent was not analyzed at that site. -- = Constituent not detected at that site. SWAMP sites were monitored in (2003). Non-SWAMP sites were monitored in Spring and Fall between 2002 and 2005.

A. SWAMP sites.

			902SMDLZ3			902SMRNB4			902SMSMR1			902SMSND3			902SSMR10			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Inorganics	Alkalinity as CaCO3	mg/l	189	15	4	180	35	4	221	82	4	163	12	4	169	63	4	184	23	5
Inorganics	Ammonia as N	mg/l	0.01	0.03	4	0.02	0.04	4	0.04	0.09	4	0.02	0.04	4	0.03	0.03	4	0.03	0.01	5
Inorganics	Nitrate + Nitrite as N	mg/l	8.08	0.96	4	11.05	3.14	4	0.43	0.24	4	5.41	0.88	4	0.53	0.74	4	5.1	4.67	5
Inorganics	Nitrate as N	mg/l	8.04	0.96	4	11.04	3.15	4	0.41	0.24	4	5.39	0.87	4	0.52	0.74	4	5.08	4.66	5
Inorganics	Nitrite as N	mg/l	0.03	0.01	4	0.02	0.01	4	0.03	0.01	4	0.02	0.01	4	0.01	0.01	4	0.02	0.01	5
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.27	0.31	4	0.44	0.64	4	0.71	0.35	4	0.42	0.17	4	1.58	1.13	4	0.68	0.53	5
Inorganics	OrthoPhosphate as P	mg/l	0.03	0.01	4	0.2	0.08	4	0.18	0.1	4	0.05	0.02	4	0.34	0.16	4	0.16	0.13	5
Inorganics	Phosphorus as P,Total	mg/l	0.02	0.03	4	0.19	0.08	4	0.26	0.15	4	0.06	0.04	4	0.54	0.21	4	0.21	0.21	5
Inorganics	Selenium,Dissolved	µg/L	1.8	0.3	4	2.2	0.3	4	2	0.4	4	3.2	0.4	4	20.4	38	4	5.9	8.1	5
Inorganics	Sulfate	mg/l	267	20	4	327	63	4	107	21	4	295	15	4	824	800	4	364	271	5
Metals	Aluminum,Dissolved	µg/L	1	1	4	0.5	0.6	4	0.2	0.4	4	1.2	0.9	4	5.2	8.3	4	1.6	2	5
Metals	Arsenic,Dissolved	µg/L	1.1	0.5	4	1.2	0.2	4	1.8	0.2	4	1.6	0.3	4	6.3	8.8	4	2.4	2.2	5
Metals	Cadmium,Dissolved	µg/L	0.02	0.01	4	0.04	0.03	4	0.03	0.01	4	0.03	0	4	0.07	0.06	4	0.04	0.02	5
Metals	Chromium,Dissolved	µg/L	0.11	0.02	4	0.16	0.01	4	0.26	0.18	4	0.11	0.04	4	0.5	0.79	4	0.23	0.17	5
Metals	Copper,Dissolved	µg/L	2.79	0.88	4	4.31	1.36	4	1.78	1.07	4	2.92	0.89	4	4.31	4.95	4	3.22	1.09	5
Metals	Lead,Dissolved	µg/L	0.01	0	4	0.01	0.01	4	0.01	0.01	4	0	0	4	0.02	0.02	4	0.01	0.01	5
Metals	Manganese,Dissolved	µg/L	25	15	4	5	1	4	139	97	4	13	6	4	275	217	4	92	116	5
Metals	Nickel,Dissolved	µg/L	0.2	0.3	4	0.2	0.4	4	0.7	0.7	4	0.3	0.6	4	1.4	2	4	0.5	0.5	5
Metals	Silver,Dissolved	µg/L	--	--	4	--	--	4	0	0.01	4	--	--	4	0.16	0.33	4	0.03	0.07	5
Metals	Zinc,Dissolved	µg/L	2	0.4	4	3.2	1.1	4	1.6	0.9	4	2.2	0.5	4	2.7	3.2	4	2.3	0.6	5
PAHs	Acenaphthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Acenaphthylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benz(a)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benzo(a)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benzo(b)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.005	0.006	4	0.001	0.002	5
PAHs	Benzo(e)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benzo(g,h,i)perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benzo(k)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Biphenyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Chrysene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Chrysenes, C1 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Chrysenes, C2 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Chrysenes, C3 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Dibenz(a,h)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Dibenzothiophene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Dibenzothiophenes, C1 -	µg/L	0.006	0.007	4	0.003	0.005	4	0.009	0.011	4	--	--	4	0.009	0.012	4	0.005	0.004	5
PAHs	Dibenzothiophenes, C2 -	µg/L	0.008	0.009	4	0.008	0.009	4	0.016	0.019	4	0.007	0.008	4	0.014	0.019	4	0.011	0.004	5
PAHs	Dibenzothiophenes, C3 -	µg/L	--	--	4	--	--	4	0.006	0.012	4	--	--	4	0.005	0.011	4	0.002	0.003	5
PAHs	Dimethylnaphthalene, 2,6-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluorene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluorenes, C1 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.003	0.006	4	0.001	0.001	5
PAHs	Fluorenes, C2 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluorenes, C3 -	µg/L	--	--	4	0.013	0.027	4	0.004	0.009	4	--	--	4	0.004	0.007	4	0.004	0.005	5
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Methylnaphthalene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Methylnaphthalene, 2-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Methylphenanthrene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Naphthalene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Naphthalenes, C1 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Naphthalenes, C2 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Naphthalenes, C3 -	µg/L	--	--	4	--	--	4	0.004	0.007	4	--	--	4	0.005	0.01	4	0.002	0.002	5
PAHs	Naphthalenes, C4 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			902SMDLZ3			902SMRNB4			902SMSMR1			902SMSND3			902SSMR10			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PAHs	Perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Phenanthrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	--	--	4	0.008	0.01	4	0.007	0.009	4	0.003	0.006	4	0.007	0.014	4	0.005	0.003	5
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.003	0.005	4	0.001	0.001	5
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 005	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 008	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 015	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 018	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 027	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 028	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 029	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 031	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 033	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 044	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 049	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 052	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 056	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 060	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 066	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 070	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 074	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 087	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 095	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 097	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 099	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 101	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 105	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 110	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 114	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 118	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 128	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 137	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 138	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 141	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 149	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 151	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 153	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 156	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 157	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 158	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 170	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 174	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 177	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 180	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 183	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 187	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 189	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 194	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 195	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 200	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 201	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 203	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 206	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 209	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCBs	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			902SMDLZ3			902SMRNB4			902SMSMR1			902SMSND3			902SSMR10			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Aldrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Ametryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Aspon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Atraton	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Atrazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Azinphos ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Azinphos methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Bolstar	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Carbophenothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlordane, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlordane, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlordene, alpha-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlordene, gamma-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlorfenvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlorpyrifos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlorpyrifos methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Ciodrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Coumaphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dacthal	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	DDD(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	DDD(p,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	DDE(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	DDE(p,p')	µg/L	--	--	4	--	--	4	0.003	0.006	4	0.001	0.001	4	0.001	0.001	4	0.001	0.001	5
Pesticides	DDMU(p,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	DDT(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.001	0.001	4	0	0	5
Pesticides	DDT(p,p')	µg/L	--	--	4	--	--	4	0.001	0.001	4	--	--	4	0.002	0.004	4	0	0.001	5
Pesticides	DDTs	µg/L	--	--	4	--	--	4	0.004	0.007	4	0.001	0.001	4	0.004	0.006	4	0.002	0.002	5
Pesticides	Demeton-s	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Diazinon	µg/L	0.002	0.005	4	--	--	4	0.025	0.03	4	--	--	4	0.011	0.023	4	0.008	0.011	5
Pesticides	Dichlofenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dichlorvos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dicrotophos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dieldrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dimethoate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dioxathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Disulfoton	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Endosulfan I	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Endosulfan II	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Endosulfan sulfate	µg/L	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	4	0	0	5
Pesticides	Endrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Endrin Aldehyde	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Endrin Ketone	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Ethion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Ethoprop	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Famphur	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fenchlorphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fenitrothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fensulfothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fonofos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	HCH, alpha	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	HCH, beta	µg/L	--	--	4	--	--	4	--	--	4	0.001	0.001	4	--	--	4	0	0	5
Pesticides	HCH, delta	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	HCH, gamma	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Heptachlor	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Heptachlor epoxide	µg/L	--	--	4	--	--	4	0	0.001	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Hexachlorobenzene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Leptophos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			902SMDLZ3			902SMRNB4			902SMSMR1			902SMSND3			902SSMR10			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Malathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Merphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Methidathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Methoxychlor	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Mevinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Mirex	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Molinate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Naled	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Nonachlor, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Nonachlor, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Oxadiazon	µg/L	--	--	4	0.097	0.142	4	0.009	0.008	4	--	--	4	0.005	0.011	4	0.022	0.042	5
Pesticides	Oxychlordane	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Parathion, Ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Parathion, Methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Phorate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Phosmet	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Phosphamidon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Prometon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Prometryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Propazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Secbumeton	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.009	0.018	4	0.002	0.004	5
Pesticides	Simazine	µg/L	0.029	0.039	4	--	--	4	0.006	0.012	4	0.036	0.073	4	0.108	0.217	4	0.036	0.043	5
Pesticides	Simetryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Sulfotep	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Tedion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Terbufos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Terbuthylazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Terbutryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Tetrachlorvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Thiobencarb	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Thionazin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Tokuthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Trichlorfon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Trichloronate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Physical	Fine-ASTM	%																		
Physical	Fine-ASTM,Passing No. 200 Sieve	%	4.2	2.6	4	3.8	2.3	4	23.2	--	1	1.7	--	1	10.4	11.2	2	8.7	8.8	5
Physical	Oxygen, Dissolved	mg/L																		
Physical	Oxygen, Saturation	%	105	12	4	84	6	4	84	9	4	99	17	4	121	48	4	99	16	5
Physical	pH	pH	7.5	0.9	4	7.4	1	4	7.3	0.9	4	7.6	1	4	7.4	0.9	4	7.4	0.1	5
Physical	Salinity	ppt	0.7	0.2	4	0.7	0.2	4	0.5	0.2	4	0.7	0.2	4	10.5	11.7	4	2.6	4.4	5
Physical	SpecificConductivity	mS/cm	1356	354	4	1443	446	4	924	390	4	1390	315	4	16884	18575	4	4399	6982	5
Physical	Suspended Sediment Concentration	%																		
Physical	Temperature	ºC	14.8	3.2	4	14.2	4.3	4	17.2	3.1	4	14.1	3.8	4	20.1	4.1	4	16.1	2.6	5
Physical	Total Organic Carbon	mg/L																		
Physical	Total Suspended Solids	mg/L	11.2	10.1	4	2.3	2.2	4	21.6	20.6	4	26.9	28.1	4	68.8	101.7	4	26.2	25.6	5
Physical	Turbidity	NTU	5.4	7.8	4	2.9	2.7	4	29.1	54	4	10.4	10.8	4	118.1	221.3	4	33.1	48.6	5
Physical	Velocity	ft/s	0.7	0.7	4	0.2	0.4	4	--	--	4	0.7	0.8	4	--	--	4	0.3	0.4	5

IIb. Non-SWAMP sites.

	Dissolved oxygen (mg/l)			pH			Specific conductivity (mS/cm)			Turbidity (NTU)			Water Tempurature (C)		
	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Site 1	12.4	4.6	3	7.9	0.6	3	1.45	0.29	3			0	15.6	1.7	3
Site 3	11.7	3.7	6	8.3	0.3	6	1.04	0.13	6	7.7		1	21.3	2.6	6
Site 5	10.5	1.1	3	8	0.2	3	1.63	0.4	3			0	16	2.3	3
Site 6	10.6	0.8	4	8.4	0.2	4	1.58	0.13	4	13.3		1	16.4	1.5	4
Site 7	11	3.8	8	8.1	0.3	8	1.24	0.19	8	24.9	19.3	3	17.2	6	8
Site 12	9.5	0.8	4	8	0.3	4	1.54	0.04	4	7.5		1	18.4	1.6	4
Site 13	10.7		1	8.9		1	1.26		1			0	15.3		1
Site 14	8.6	5.9	3	7.9	0.6	3	1.15	0.2	3	28.4	15.8	2	12.7	5.4	3
Site 15	9.2		1	8.2		1	1.13		1			0	13.9		1

APPENDIX III

Results from toxicity assays for each endpoint at each site in the watershed. Mean = mean percent control. SD = standard deviation.

	C. dubia						*H. azteca*						*S. capricornutum*		
	Survival			Young / female			Survival			Growth			Total cell count		
Site	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
902SMDLZ3	98	5	4	90	27	4	100	8	4	117	33	4	88	57	4
902SMRNB4	100	0	4	78	18	4	99	8	4	103	45	4	96	74	4
902SMSMR1	95	6	4	109	9	4	105		1	83		1	96	49	4
902SMSND3	100	0	4	103	10	4	100		1	104		1	117	61	4
902SSMR10	73	49	4	90	45	3	102	0	2	103	55	2	54	37	4

APPENDIX IV

Mean IBI and metric scores for bioassessment sites in the Santa Margarita HU. Note that the number listed under IBI is the mean IBI for each site, and not the IBI calculated from the mean metric values.

				IBI		Coleoptera taxa		EPT taxa		Predator taxa		% Collectors		% Intolerant		% Non-insect taxa		% Tolerant taxa	
Site	Season	n	Years	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Site 1	Average	7	2000-2004	56.5	2.1	5.9	1.3	5.3	0.4	3	0.6	7.3	0.4	5.8	0.3	6.1	0.1	6.3	0
Site 1	Fall	5	2000-2004	58	9.7	6.8	1.1	5	1.6	3.4	2.1	7.6	2.9	5.6	3.6	6.2	1.8	6	0.1
Site 1	Spring	2	2001-2003	55	3	5	0	5.5	0.7	2.5	2.1	7	1.4	6	4.2	6	0	6.5	0
Site 2	Spring	1	1998-1998	12.9		2		1		0		0		0		3		3	
Site 3	Average	12	1998-2005	29.6	11.6	1.5	0.7	2.6	1.3	2.6	0.9	6.6	4.2	1.1	0.5	3.3	0.6	3.1	0
Site 3	Fall	4	1998-2003	37.9	10.1	2	1.6	3.5	1.7	3.3	1	9.5	1	1.5	2.4	3.8	2.2	3	0.1
Site 3	Spring	8	1998-2005	21.4	14.1	1	1.5	1.6	1.7	2	2.1	3.6	4	0.8	1.4	2.9	2.4	3.1	0.1
Site 4	Spring	4	2001-2006	49.6	5.1	6	1.8	4.5	1.3	6.8	1.5	4.5	4	1	1.4	6.8	3.2	5.3	0
Site 5	Average	6	2000-2005	57.1	15.2	6.8	1.8	5.1	0.2	4.4	0.2	7.5	3.5	5.6	4.8	4.6	0.5	6	0
Site 5	Fall	2	2000-2004	67.9	1	8	0	5	1.4	4.5	2.1	10	0	9	0	5	2.8	6	0.1
Site 5	Spring	4	2000-2005	46.4	7.8	5.5	1.7	5.3	1	4.3	1.3	5	2.2	2.3	0.5	4.3	0.5	6	0
Site 6	Average	14	1998-2003	51.5	8.4	7.4	1.5	4.8	0.1	3.5	0.5	4.9	2.5	2.9	1.6	6	0.4	6.7	0
Site 6	Fall	6	1998-2003	57.4	9.6	8.5	1.2	4.8	0.8	3.2	2.9	6.7	2.7	4	3	6.3	1.8	7	0
Site 6	Spring	8	1998-2003	45.5	9.3	6.4	1.8	4.8	0.7	3.9	1.6	3.1	1.4	1.8	1.2	5.8	1.8	6.4	0.1
Site 7	Average	17	1998-2006	33.8	0.5	4.1	0.1	3.2	0	3.3	0.3	2.3	1.6	0.1	0.2	5.9	0.3	4.7	0
Site 7	Fall	7	1999-2005	34.1	10.4	4	3.2	3.1	0.7	3.6	3.3	3.4	4.1	0.3	0.5	5.7	3	3.7	0.1
Site 7	Spring	10	1998-2006	33.4	9	4.2	2.9	3.2	0.4	3.1	2.5	1.2	0.6	0	0	6.1	1.4	5.6	0.1
Site 8	Average	8	1998-2001	35.9	9.9	4.7	3.3	3.3	0.1	3.1	2.2	3.3	2.9	0.2	0.2	4.8	0.6	5.8	0
Site 8	Fall	3	1998-2000	42.9	2.9	7	0	3.3	0.6	4.7	2.9	5.3	3.2	0.3	0.6	4.3	0.6	5	0
Site 8	Spring	5	1998-2001	28.9	8.3	2.4	3.4	3.2	0.8	1.6	1.5	1.2	1.6	0	0	5.2	1.9	6.6	0
Site 9	Spring	2	1998-1999	8.6	2	1	1.4	2	1.4	1	1.4	0.5	0.7	0	0	0.5	0.7	1	0
Site 10	Average	18	1998-2005	34	6.1	3.5	2.1	3.3	0.4	2.7	0.2	2.8	0.5	1	0.1	4.7	0.2	6.1	0
Site 10	Fall	6	1998-2004	38.3	9.6	5	3.3	3.5	0.8	2.8	2.3	3.2	2.5	1	0.6	4.8	1.7	6.7	0.1
Site 10	Spring	12	1998-2005	29.8	12.7	2	2.4	3	1	2.6	3	2.4	2.3	0.9	1.7	4.5	1.9	5.5	0.1
Site 11	Average	13	1998-2000	26.7	10.3	1.8	0.8	2.4	0.8	3.9	2.1	3.4	2.6	0.3	0.2	3.1	0.5	3.9	0
Site 11	Fall	5	1998-2000	34	11.7	2.4	1.7	3	0.7	5.4	1.1	5.2	1.5	0.4	0.5	3.4	2.3	4	0.1
Site 11	Spring	8	1998-2000	19.5	12	1.3	1.5	1.9	1.2	2.4	2.4	1.5	2.1	0.1	0.4	2.8	2.6	3.8	0.1
Site 12	Average	4	2002-2004	50.5	1.3	4.2	1.2	5	0	4.5	2.1	5.2	0.2	3.7	0.9	7	1.4	6.5	0
Site 12	Fall	1	2003-2003	51.4		5		5		3		5		3		8		7	
Site 12	Spring	3	2002-2004	49.5	8.1	3.3	1.2	5	0	6	2	5.3	2.1	4.3	1.5	6	0	6	0
Site 13	Fall	1	2002-2002	72.9		10		6		4		10		6		7		8	
Site 14	Average	4	2004-2006	31.1	0.5	4	0.7	2.3	1.1	4.8	0.4	2.3	1.1	0	0	4.5	1.4	3	0
Site 14	Fall	2	2004-2005	30.7	7.1	3.5	2.1	1.5	0.7	4.5	4.9	3	4.2	0	0	3.5	4.9	3.5	0.2
Site 14	Spring	2	2005-2006	31.4	4	4.5	0.7	3	0	5	1.4	1.5	0.7	0	0	5.5	0.7	2.5	0
Site 15	Spring	1	2006-2006	35.7		7		4		4		2		1		5		2	

Appendix B
Toxicity Reduction Evaluation (TRE) for Pyrethroid Pesticides

Riverside County Flood Control and Water Conservation District

Riverside County – Santa Margarita Region Pyrethroid Source Identification Toxicity Reduction Evaluation

Final Phase II Report
January 2009

MACTEC
9177 Sky Park Court
San Diego, California 92123
858-278-3600 FAX 858-278-5300

Executive Summary

This document is the Phase II report for the Santa Margarita Region (SMR) Pyrethroid Source Identification Toxicity Reduction Evaluation (TRE) conducted by the SMR Permittees to identify the source(s) of toxicity in the SMR and develop a plan to reduce the toxicity. This report documents the Permittees' ongoing and proposed efforts to identify and reduce sources of pyrethroid pesticide toxicity associated with urban runoff.

Data gathered under this TRE was compared to data from neighboring counties. Based on available data, problems with pyrethroid-induced toxicity in urban runoff are common among municipalities in Southern California, and methods for addressing the problems are comparable.

A literature review was conducted to determine appropriate source control and treatment control BMPs for reducing the concentration and load of pyrethroids in storm water runoff. The literature source, the estimated potential for reducing pyrethroid-induced toxicity, and possible concerns about implementing the BMP are summarized.

Based on the results of the literature review, BMPs are evaluated for applicability and potential effectiveness in the SMR watershed. Many of the most effective and appropriate BMPs are currently being implemented by the Permittees.

A search for pending legislation did not identify any pending legislation pertaining to pyrethroid pesticides.

The most effective strategy to prevent water quality impacts from legal pesticide uses was identified as state or federal regulatory change involving effective labeling and use restrictions. The Permittees propose a five year plan to continue, review, and enhance current activities to reduce pyrethroid-induced toxicity.

Table of Contents

1.0 Introduction ... 1
1.1 Purpose and Overview of Approach ... 2
1.2 Regulatory Framework ... 3
1.3 Project Background ... 4
1.4 Watershed Description ... 6
1.5 Pyrethroid Pesticide Background and Usage ... 8
1.6 Management Questions and Objectives ... 10
2.0 Data Comparison ... 12
3.0 Literature Review ... 17
4.0 BMP Analysis ... 22
4.1 Source Control BMPs ... 22
4.1.1 Regulatory Action ... 23
4.1.2 Integrated Pest Management ... 26
4.1.3 Public Outreach and Education ... 33
4.1.4 Low Impact Development (LID) ... 38
4.2 Treatment Control BMPs ... 39
4.2.1 Pervious Pavement ... 40
4.2.2 Media Filter ... 41
4.2.3 Extended Detention Basin ... 41
4.2.4 Infiltration Basin ... 42
4.2.5 Infiltration Trench ... 43
4.3 BMP Evaluation ... 44
5.0 Pending Legislation ... 46
6.0 Proposed Course of Action ... 47
7.0 References ... 51

Figures

Figure 1-1 Riverside County Santa Margarita Watershed ... 8
Figure 2-1 Percentage of Samples with Bifenthrin Detections ... 16
Figure 2-2 Percentage of Samples with Acute Toxicity to *Hyalella* ... 17

Tables

Table 1-1 San Diego Region Populations ... 9
Table 3-1 Literature Review Matrix ... 19
Table 6-1 BMP Comparison Table ... 45

1.0 Introduction

This document is the Phase II report for the Santa Margarita Region (SMR) Pyrethroid Source Identification Toxicity Reduction Evaluation (TRE) conducted by the County of Riverside, the City of Murrieta, the City of Temecula, and the Riverside County Flood Control and Water Conservation District (District, collectively Permittees). The Phase I Status Report (RCFCWCD, 2008) contains the work plan for Phase II and an outline of the topics in this report, as well as additional background information. This Phase II report is divided into six sections.

Section 1 describes the purpose of the TRE and provides an overview of the approach taken by the Permittees. Section 1 also contains a discussion of the regulatory framework of the TRE, a brief project background, a description of the Santa Margarita watershed, pyrethroid pesticide background and usage, and management questions and objectives.

Section 2 describes available pyrethroid and toxicity data from other counties in Southern California, and compares the data to data from Riverside County. The data and comparisons are included to demonstrate that the problems and solutions relating to pyrethroid pesticides facing the Permittees are similar to those of neighboring counties in the region.

Section 3 presents the results of the literature review conducted for this study of pesticide reduction Best Management Practices (BMPs).

Section 4 discusses potential pesticide reduction BMPs, the status of the Permittees implementation of the BMPs, and, when applicable, examples of the implementation of the BMPs in other municipalities. Section 4 also contains a table summarizing the potential BMPs, their advantages and disadvantages, and relative cost.

Section 5 discusses pending legislation relating to pyrethroid pesticides.

Section 6 presents the five-year course of action the Permittees propose to follow to reduce pyrethroid-induced toxicity in the SMR.

1.1 Purpose and Overview of Approach

The purpose of the TRE is to identify the source(s) of toxicity in the SMR and develop a plan to reduce the toxicity. The results of Phase I of the TRE are contained in the TRE Status Report (Riverside, 2008). This Phase II report for the TRE study documents the Permittees' ongoing and proposed efforts to identify and reduce sources of pyrethroid pesticide toxicity associated with urban runoff. The goal of Phase II is to establish a course of action and develop modifications to the Permittee's Storm Water Management Plans (SWMPs) to more effectively control the sources of toxicity that were identified in Phase I of the TRE. The Permittees will incorporate the course of action and SWMP modifications into the Report of Waste Discharge (ROWD) that will be submitted to the RWQCB in January 2009.

Phase II activities included:

- A comparison of toxicity and chemistry results to data from adjacent Phase I municipal separate storm sewer system (MS4) permit areas, including San Diego County and Orange County.
- A literature review of current studies and a survey of pesticide reduction BMPs.
- A search for pending legislation regarding pyrethroid pesticides.
- Development of a proposed course of action for the Permittees.

A literature review was conducted of BMP information available from the Urban Pesticide Pollution Prevention (UP3) Project and other pesticide management programs and documents. Information on relevant BMPs was compiled and evaluated to identify potential BMPs that are available to mitigate urban sources of pyrethroids. Existing Permittee programs, such as outreach, regulation, and BMP implementation, were then evaluated for improvement opportunities.

The proposed course of action was determined with consideration of the adequacy of data collection (sufficient precipitation and runoff to collect adequate data) and pending

regulatory actions by California Department of Pesticide Regulation (DPR), and the United States Environmental Protection Agency (EPA).

Land uses in Riverside County are comparable to those in neighboring Orange County and San Diego County, and pyrethroid pesticide-induced toxicity has been observed in those counties. The Permittees are committed to identifying and addressing water quality issues with methods consistent with those used by other stakeholders in Southern California. To this end, data gathered under this TRE was compared to data from neighboring counties, and current pesticide reduction programs used by municipalities throughout California were reviewed.

Source control and treatment control BMPs were researched and evaluated for potential effectiveness in reducing pyrethroid pesticide-induced toxicity in the Santa Margarita watershed. Many of the most effective BMPs are currently implemented by the Permittees, and several have been implemented within the previous Permit term (2004-2008). A proposed five-year course of action for the Permittees was developed by combining the results of the research with the existing programs.

1.2 Regulatory Framework

At the federal level, the authority to regulate pesticide manufacture and use is assigned to the United States Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). In California, pesticide use is regulated at the state level by the DPR. In the SMR, the Permittees are required under the Clean Water Act to control discharges of pollutants, including pesticides that produce water toxicity, to and from their MS4 under the National Pollutant Discharge Elimination System (NPDES).

This TRE was performed as required by Monitoring and Reporting Program (MRP) R9-2004-001.

The MRP, Section II. A. I. 4, states:

> *"When results from the chemistry, toxicity, and bioassessment monitoring…indicate urban runoff-induced degradation, Permittees shall evaluate the extent and causes of urban runoff pollution in receiving waters and prioritize management actions to eliminate or reduce sources. Toxicity Identification Evaluations (TIEs) shall be used to determine the cause of the toxicity, and Toxicity Reduction Evaluations (TREs) shall be used to identify sources and implement management actions to reduce pollutants in urban runoff causing toxicity."*

As local regulation of pesticide use is generally preempted by federal and state law, the Permitttees' authorities are limited to addressing illegal disposal of pesticides, promoting public education, setting the example for minimum pesticide use, and coordinating with the federal and state agencies to facilitate regulatory changes at the state and federal level.

1.3 Project Background

Phase I of the TRE consisted of the toxicity monitoring begun in 2004 and the Toxicity Identification Evaluations (TIE) was initiated in the spring of 2007. The Phase I Status Report (RCFCWCD, 2008) provides a full project background. Toxicity monitoring at Temecula Creek and Murrieta Creek was initiated in 2004 using EPA protocol with the following indicator species: *Ceriodaphnia dubia*, *Selenastrum capricornutum*, and *Hyalella azteca*. Toxicity testing during the 2004-2008 reporting period indicated persistent wet weather toxicity to *Hyalella* in both Temecula Creek and Murrieta Creek. Toxicity was not observed to either *Ceriodaphnia* or *Selenastrum* in any of the samples collected over the four annual reporting periods beginning in the fall of 2004.

Toxicity Identification Evaluations (TIEs) were conducted on the wet weather samples collected from Temecula Creek and Murrieta Creek beginning in April 2007, in accordance with Table 2 of the MRP. The TIEs indicated that pyrethroids were the primary source of toxicity and biological degradation in both Murrieta Creek and Temecula Creek.

As a result of the toxicity and TIEs, storm water monitoring for pyrethroids was initiated in 2007-2008. Results indicate that the pyrethroids permethrin and/or bifenthrin are present in wet weather water samples taken at Murrieta Creek and Temecula Creek.

To further assess the impacts of pyrethroid pesticides the Permittees instituted Dry Weather Toxicity Testing and direct measurement of pyrethroid pesticide concentrations in dry weather water samples during the 2007-2008 reporting period. Toxicity and pyrethroid pesticides were not detected in dry weather water samples at either Murrieta Creek or Temecula Creek.

Phase I of the TRE concluded with the Phase I Status Report. The Phase I Status Report included studies to better characterize patterns and sources of toxicity and to evaluate the hypothesis that the *Hyalella* toxicity is due to pyrethroids.

Bifenthrin and permethrin appear to be the primary toxic elements in Temecula Creek and Murrieta Creek. While bifenthrin and permethrin were applied to both agricultural and non-agricultural land uses, the major sources of pyrethroid toxicity in the SMR are non-agricultural activities. Permethrin was applied more than any other pyrethroid pesticide in the urban landscape. Bifenthrin and permethrin application rates were one and three orders of magnitude higher for structural control applications than agricultural applications in Riverside County. Structural control appears to represent 93% of the total pyrethroids use for Riverside County.

The Status Report outlined the plan for Phase II of the TRE, and this report presents the results of Phase II.

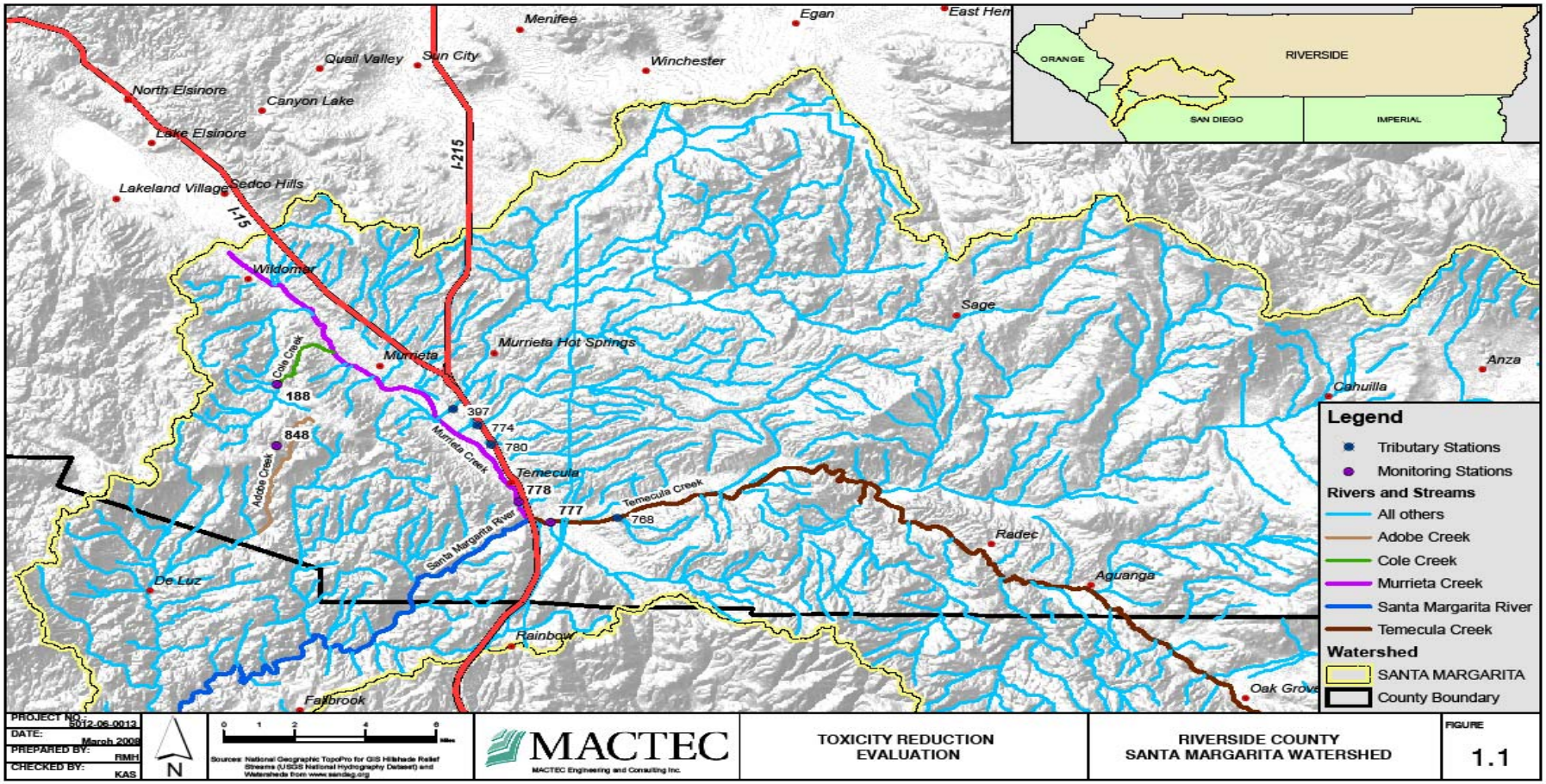
1.4 Watershed Description

The SMR encompasses approximately 750 square miles in southwestern Riverside and northern San Diego Counties (see Figure 1-1). The upper (northeast) portion of the SMR is in Riverside County with the remainder in San Diego County. The SMR is subdivided into the Temecula Creek and Murrieta Creek sub-watersheds and has an arid Mediterranean climate. Creeks in the SMR are ephemeral. Flow in Temecula Creek and in Murrieta Creek results almost exclusively from groundwater during the dry season. It is rare to find flow during dry weather at the tributary stations, and usually this flow infiltrates before reaching Temecula Creek or Murrieta Creek (2006-2007 Monitoring Annual Report). While the ephemeral streams in the SMR are technically receiving waters, the term "Receiving Waters" as used in this TRE Status Report refers exclusively to Murrieta Creek and Temecula Creek.

The Santa Margarita River is formed by the confluence of Murrieta Creek and Temecula Creek. The confluence is located in Riverside County, approximately five miles northeast of San Diego County. The Santa Margarita River flows from Riverside County into San Diego County through the community of Fallbrook and Marine Corps Base Camp Pendleton. The lower estuary and river are protected by Camp Pendleton and are much less developed than surrounding areas in Southern California. The Santa Margarita River is able to support a relative abundance of wildlife and habitats in part because of its undeveloped state.

Figure 1-1

Riverside County Santa Margarita Watershed



As presented in Table 1-1, the total population in the SMR of Riverside County is significantly less than adjacent watersheds covered under similar Phase I MS4 NPDES permits.

Table 1-1

San Diego Region Populations

Jurisdiction	Population
Orange County	3,002,048
San Diego County	2,941,454
SMR/Riverside County	250,483
Unincorporated	55,291
Murrieta	97,257
Temecula	97,935

1.5 Pyrethroid Pesticide Background and Usage

A statewide compilation of the presence and effects of pyrethroid pesticides in urban surface waters, prepared in July 2008 and presented at the 2008 California Association of Stormwater Quality Agencies (CASQA) Conference, outlined the rise in pyrethroid use and its increased presence in urban waterways (Ruby, 2008). A comprehensive survey of pesticide use in Sacramento, San Diego, and Orange Counties also concluded that, as the older pesticides chlorpyrifos and diazinon have been phased out, pyrethroid pesticides have seen increased usage (Wilen, 2005). The Urban Pesticide Pollution Prevention (UP3) Project confirms that pyrethroids are the cause of toxicity in numerous California waterways, particularly in urban waterways. The UP3 Project (www.up3project.org) publishes an annual review of new scientific findings on pesticides in urban surface water (TDC, 2007). Since 2005, the reviews have consistently indicated that pyrethroid use continues to increase and that pyrethroids are found to be the cause of toxicity in urban waterways. The pyrethroid use information is confirmed by data published by the DPR.

Pyrethrins are natural insecticides that are derived from an extract of chrysanthemum flowers. Pyrethroids are synthetic versions of pyrethrins. These chemicals act on the nervous system of insects. Commercial pyrethroid pesticides often contain a synergist that works by restricting the enzymes insects use to detoxify pyrethroids. While pyrethroids have been shown to be one of the least poisonous insecticides to mammals, the effects depend on the level of exposure, the health of the animal, and the environmental circumstances.

Pyrethroids applied in urban areas enter the storm drainage system of the MS4 by surface runoff and are transported directly to receiving waters. Other potential urban sources are runoff from irrigation with reclaimed water, application overspray, and atmospheric deposition. Pyrethroids transported via the MS4, from whatever source, are considered to be non-point discharges. Agriculture, nursery, and urban/suburban uses are the main categories of sources of pyrethroids in the receiving waters of the SMR.

Outdoor structural pest control is the predominant urban use of pyrethroids in most watersheds. However, in the SMR, the acreage dedicated to agricultural land use exceeds the urban land use area by approximately 2:1. Pyrethroid insecticides are applied to a variety of crops in the SMR and California throughout the year. According to the DPR, pyrethroids are commonly used on fruit and nut trees, row crops, and in nurseries. Six of the primary pyrethroids used in California agriculture, in order of decreasing amount applied in 2003, are permethrin, esfenvalerate, lambda-cyhalothrin, cyfluthrin, bifenthrin, and cypermethrin. Therefore, agricultural sources of pyrethroids were considered.

TIE methods for pyrethroids are still being developed. Effective methods require the ability to measure low concentrations of pyrethroids, and this remains a challenge. Fortunately, the development of TIE methods for pyrethroids is progressing and moving towards standardization (San Francisco Estuary Project, 2007). TIEs are planned for storm water samples collected during 2008-2009 when toxicity is evident.

1.6 Management Questions and Objectives

This TRE is designed to confirm the toxic element observed in the samples collected in the Santa Margarita Region, identify likely sources of the toxic element, and propose mitigation measures for those sources. TIEs identified pyrethroids pesticides as the likely toxic element. As the MRP specifies that a TRE must be conducted following toxicant identification through a TIE, Phase I of the TRE focused on the pyrethroids identified as the source of toxicity in the 2007 TIEs. To support this TRE, the Permittees commissioned additional wet and dry weather toxicity testing, water column pyrethroid testing, additional TIEs to verify the persistence of pyrethroids as the toxicant. Based on the resulting information, the TRE evaluates the specific sources of toxicity and likely mitigation.

This TRE study assumes that pyrethroid sources and resultant toxicity patterns in the SMR are similar to those in neighboring counties, in particular San Diego and Orange Counties. Under this assumption, the Permittees hypothesized that pyrethroids would be detected in samples at most if not all monitoring locations, that the samples would exhibit toxicity to *Hyalella*, and that TIEs would indicate pyrethroids as the cause of the toxicity. Unlike other regions, dry weather toxicity is not expected in the SMR, as dry weather flows are supported primarily by groundwater.

Based on this assumption, this TRE was designed to provide information to help answer the following five management questions related to the toxicity:

1) Is the pyrethroid toxicity persistent in Temecula Creek and Murrieta Creek?
2) Does the toxicity occur during dry weather?
3) Are there any obvious sources of illicit discharge of pyrethroids that can be abated?
4) What are the likely sources of pyrethroid toxicity in the SMR?
5) What potential management measures are available to the Permittees to mitigate the impacts of pyrethroid pesticide application?

Answers to the first four questions are detailed in the Phase I Status Report. Briefly, toxicity is persistent in the creeks during wet weather, but is not evident in dry weather samples. No

obvious sources of illicit discharge were found. The likely primary source of pyrethroids is structural control performed by pest control operators (PCOs). The final question is addressed during Phase II and is the focus of this report.

2.0 Data Comparison

An assumption of this TRE study is that pyrethroid sources and resultant toxicity patterns in the SMR are analogous to those in similar counties, in particular neighboring San Diego and Orange Counties. To verify this assumption, it was necessary to compare data collected in SMR to data collected in other locations. As part of the 2008 CASQA pyrethroids data compilation, monitoring results were summarized from studies that investigated the presence and effects of pyrethroid pesticides in urban areas of California (Ruby, 2008). The CASQA summary listed the frequency of detection of various pyrethroid pesticides and results of toxicity testing for different indicator species. Results from various northern and Southern California locations were detailed, including results of water column studies from Orange, San Diego and Sacramento Counties.

Pyrethroids, as a class of chemicals, have an affinity for particles and they are considered to be relatively hydrophobic; they are therefore commonly found in sediments of waterways downstream of their application sites. The initial toxicity studies leading to the identification of pyrethroids as pervasive environmental contaminants in California were performed on sediment samples by Don Weston and his colleagues at the University of California, Berkeley (Weston et al., 2005; Amweg et al., 2006). Recently, improvements in analytical methods for pyrethroids in water, and modification of toxicity studies to more effectively test for pyrethroid-based toxicity in water, have lead to increasing evidence of the presence of pyrethroids in water column samples, and toxic effects in the water matrix (see citations for Orange and San Diego County in Ruby, 2008).

Extensive work has been performed on the environmental presence and effects of pyrethroids in urban areas of the neighboring Orange and San Diego counties; however, much of this work has been performed on sediment samples. Although the sediment monitoring results do not correspond directly with the SMR water column test results, sediments are considered to be effective integrators of contaminants from the contributing storm water flows. The deposited sediments are produced as particles settle out from the passing water over some

period of time, and tend to accumulate until they are washed away by higher-velocity flows. Summaries of the relevant sediment study results are therefore included in the discussion that follows.

In Orange County, an ongoing study being performed by UC Davis, in conjunction with UC Riverside and the Orange County UC Cooperative Extension, has consistently found bifenthrin and permethrin in water column runoff samples from residential areas (Haver et al., 2007; Oki, personal communication). In samples from four residential sites they have detected bifenthrin in 100% of samples, with the number of samples varying from 48 to 57 per site (Oki, personal communication). In sediment samples collected in recent years from the Santa Ana Region of Orange County, bifenthrin is commonly detected (32 of 56 samples) and permethrin less frequently so (4 of 56 samples), with sediment toxicity to *Hyalella* common (39 of 54 samples tested were moderately or highly toxic; see summary in Ruby, 2008).

In a 2005 study of six Orange County residential storm drainages and seven tributary streams draining commercial/residential land uses, bifenthrin was detected in 95% of dry weather samples and 100% of wet weather samples (Budd et al., 2007). Because treatment of nursery products is mandatory to control Red Imported Fire Ants, an older DPR study, conducted in 1999-2002, found occasional detects of bifenthrin in urban runoff samples, along with frequent detects in nursery runoff from several Orange County sites.

In San Diego County, under NPDES Permit monitoring conducted since 2004, pyrethroids have been commonly detected in water samples from several receiving waters, and toxicity to *Hyalella* has been increasingly observed in water samples (see summary in Ruby, 2008). Bifenthrin was detected in 12 of 15 samples collected from 2005-2006 and 2006-2007; detection frequency was 100% in samples from Chollas Creek, Agua Hedionda, and Tecolote Creek. Toxicity to *Hyalella* was observed in 22 of 57 samples tested over the three year period, 2004-2007. In a TIE study performed on Chollas Creek samples during 2005-2006,

67% of samples were acutely toxic to *Hyalella*, and the toxicity was found to be likely due to pyrethroids.

In a 2004-2005 study performed by UC Davis and others, sediments from Switzer Creek at its outlet to San Diego Harbor were found to be highly toxic; bifenthrin and permethrin were detected at high concentrations, and a sediment TIE identified pyrethroids as the likely cause of the observed toxicity (Anderson et al., in press). As part of a statewide survey of urban waterways, sediments were tested from several receiving waters in San Diego County. All were found to be highly toxic to *Hyalella* (Holmes et al., in press).

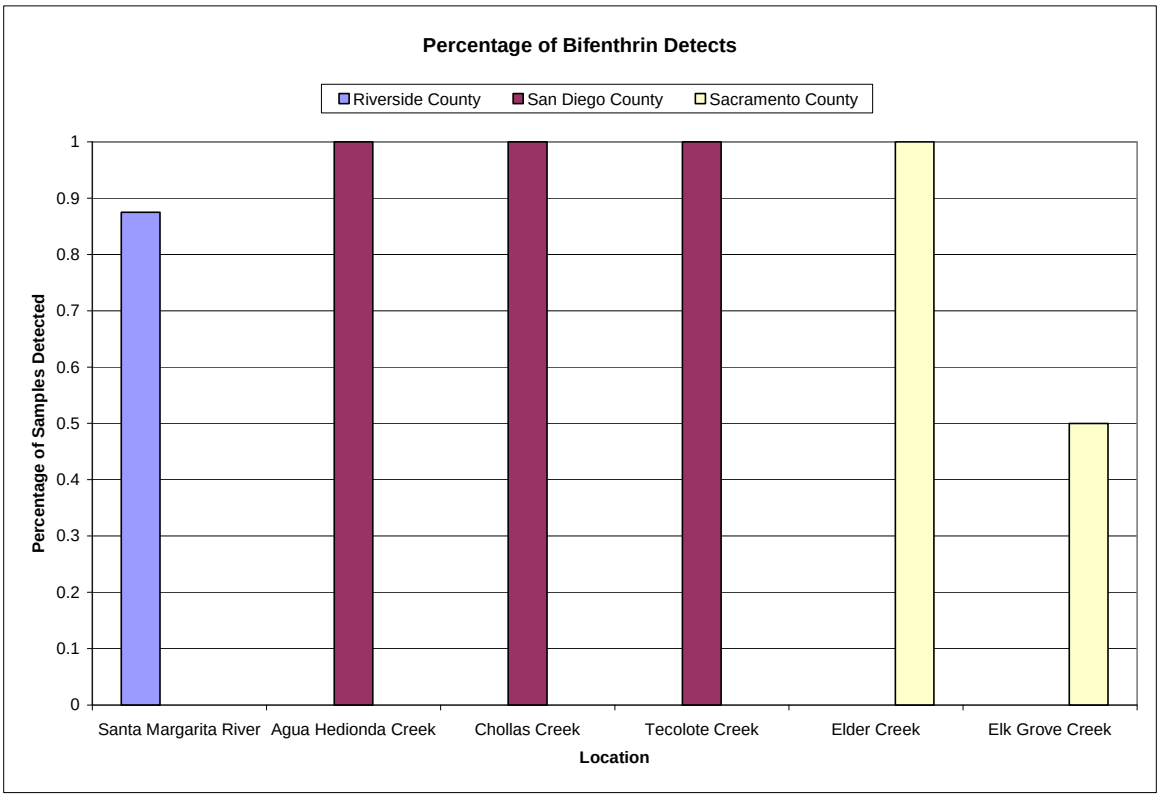
To further compare the pyrethroid sources and toxicity patterns in the SMR to other counties, the CASQA data summary was analyzed to select the studies which reported results for the same constituents and effects identified in the SMR, specifically permethrin, bifenthrin, and toxicity to *Hyalella.* The total number of detections for the different monitoring locations was divided by the total number of samples taken at the sites to calculate the percentage of samples with detectable concentrations of pyrethroids. This normalized metric allowed for comparison of the various datasets.

While permethrin is among the more commonly-used pyrethroids, it is much less toxic to aquatic life than bifenthrin (TDC, 2007). For the purposes of this assessment, bifenthrin detection frequency and frequency of toxic effects were used as the metrics for comparison.

Comparative results for bifenthrin are summarized in Figure 2-1. Data were available for two creeks in Sacramento County and three locations in San Diego County, in addition to the data collected for SMR. Two samples were taken at the Sacramento County sampling locations. For San Diego County, each creek was sampled three times except for Chollas Creek, which was sampled six times. The SMR was sampled a total of eight times. In most cases, bifenthrin was detected in over 80% of samples. Only at Elk Grove Creek in Sacramento County was bifenthrin detected at a notably lower percentage.

Figure 2-1

Percentage of Samples with Bifenthrin Detections

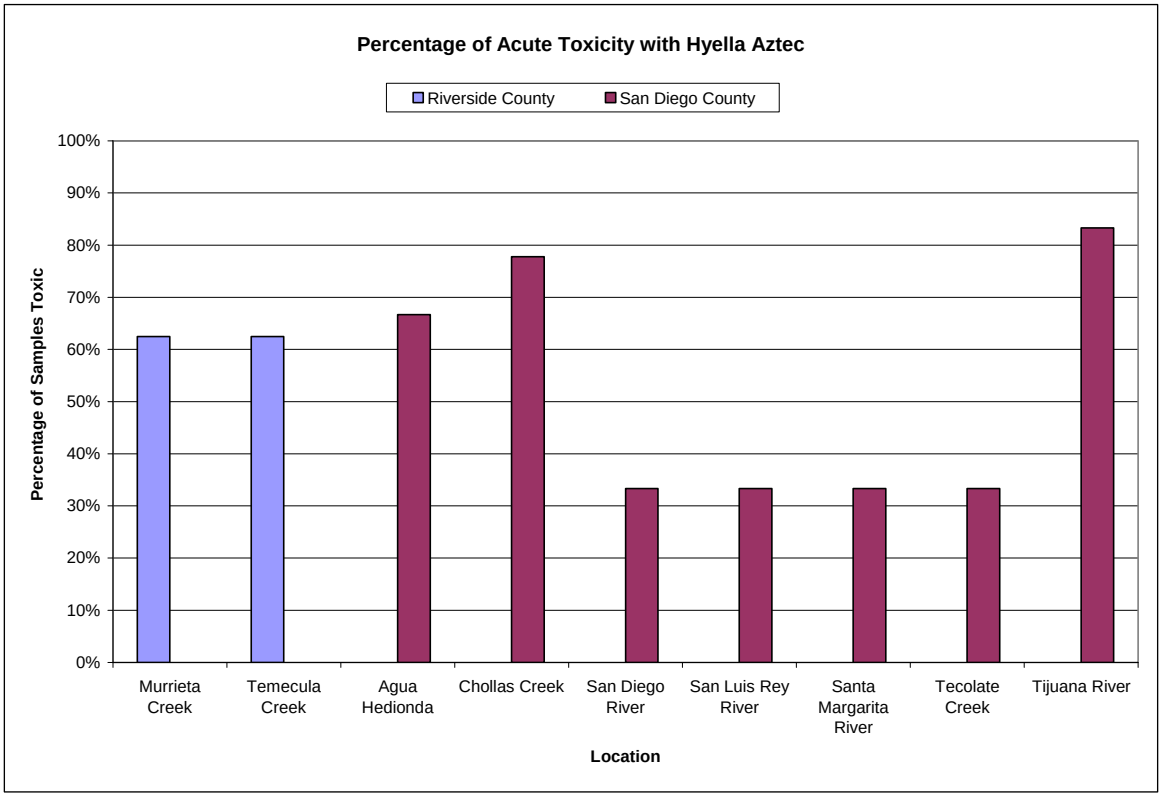


Toxicity to *Hyalella* was documented in water samples from San Diego County, along with the SMR. Toxicity testing was performed on samples from seven San Diego County water bodies. The sample sets ranged from three to nine toxicity tests (Aqua Hedionda, San Dieguito River, Tijuana River, and Chollas Creek). In the SMR, a total of eight toxicity tests were performed on samples from Murrieta Creek and Temecula Creek. The results for frequency of acute toxicity from the SMR were within the range of the results for similar sites in San Diego County (see Figure 2-2).

After comparing the results from different locations, the assumption that pyrethroid sources and resultant toxicity patterns in the SMR are similar to those in similar counties appears to be valid.

Figure 2-2

Percentage of Samples with Acute Toxicity to *Hyalella*



3.0 Literature Review

A literature review was conducted during December, 2008 to determine appropriate BMPs for reducing the concentration and load of pyrethroids in storm water runoff. An initial search was made of the Urban Pollution Prevention Program (UP3) website (www.up3program.org) for potential examples of BMP strategies implemented specifically for pyrethroids. The United States Environmental Protection Agency website and the CASQA website were also reviewed for pyrethroid specific BMPs. Widespread use of pyrethroids is relatively recent, and there has been little direct evaluation of BMPs for pyrethroids. Further research was conducted on general storm water BMPs, and their potential for pyrethroid reduction was evaluated based on the design of the BMP and the chemical behavior of pyrethroids.

To identify pending legislation that may be related to pyrethroid pesticides, web searches were conducted on the websites for DPR, the California legislature, the EPA, and the Library of Congress. However, no pending legislation was identified as relevant to pyrethroid pesticides.

Table 3-1 below presents the findings of the literature review. BMPs are categorized as either source control or treatment control, and within each category they are sorted by type. The literature source, a summary of the BMP, the estimated potential for reducing pyrethroid-induced toxicity, and possible concerns about implementing the BMP are provided. See Section 4 for further information about each type of BMP.

Table 3-1
Literature Review Matrix

Type of BMP	Literature Source	Summary	Ability to Reduce Toxicity Caused by Pyrethroids	Storm Water Concerns
Source Control				
Regulatory	Pesticides of Interest for Urban Surface Water Quality. Urban Pesticides Use Trends Annual Report. July 2008.	Suggests regulatory changes as a result of increased toxicity due to pyrethroid use	Potentially High	Supplementary to other BMPs, Will take years to show results
Regulatory	Improving Urban Pesticide Regulatory Activities to Protect Water Quality – Annual Update 2007. November 2007.	Discusses recent state and federal regulatory pesticide activities on an annual basis	Potentially High	Supplementary to other BMPs, Will take years to show results
Regulatory	California Department of Pesticide Regulation. http://www.cdpr.ca.gov/docs/registration/reevaluation/chemicals/pyrethroids.htm. 2007.	The reevaluation of the widespread presence of synthetic pyrethroid residues in the sediment of both agricultural and urban dominated California waterways at levels toxic to Hyalella azteca (H. azteca).	Potentially High	Supplementary to other BMPs, Will take years to show results
Integrated Pest Management (IPM)	Building Maintenance - Structural Integrated Pest Management. June 2008.	Promotes reduction in pesticide use through use of municipality IPM and hiring of PCO's trained in IPM	Potentially High	Does not eliminate all uses of pyrethroids
IPM	California Stormwater BMP Handbook. January 2003.	Promotes prevention of pesticide use through use hiring of PCOs that use IPM as an alternative	Potentially High	Does not eliminate all uses of pyrethroids
IPM	City of Santa Monica Toxics Use Reduction Program Integrated Pest Management. June 1997.	Overview of IPM program initiated by the City of Santa Monica	Potentially High	Does not eliminate all uses of pyrethroids
IPM	National Management Measures to Control Nonpoint Source Pollution from Urban Areas. November 2005.	EPA document discussing management practices to help reduce pesticide use	Potentially High	Does not eliminate all uses of pyrethroids
IPM	National Pollutant Discharge Elimination System (NPDES) Phase II BMP & Measureable Goal Examples. February 2008.	Provides examples and goals of good housekeeping BMPs	Potentially High	Does not eliminate all uses of pyrethroids
IPM	The Monterey Bay Green Gardener Program "sample curriculum". www.green-gardener.org/about. Accessed December 2008.	Informs the public and landscapers about the green gardener program and how to get involved	Potentially High	Does not eliminate all uses of pyrethroids

Table 3-1 (continued)
Literature Review Matrix

Type of BMP	Literature Source	Summary	Ability to Reduce Toxicity Caused by Pyrethroids	Storm Water Concerns
Source Control				
IPM	Western IPM Center. www.wripmc.org. Last updated 12/23/2008.	Pest management information specific to region, state, or territory.	Potentially High	Does not directly address pyrethroids
IPM	EcoWise Certified. www.ecowisecertified.com. Accessed December 2008.	Information on IPM program design, developing contracts for structural IPM, and pilot program aimed at developing IPM certification.	Potentially High	Does not directly address pyrethroids
IPM	Our Water Our World. www.ourwaterourworld.org. Copyright 2008.	Contains assorted fact sheets on specific pests and methods to manage them without using hazardous materials.	Potentially High	Addresses pyrethroids in water pollution fact sheet.
IPM	UP3 Project. www.up3project.org. November 2008.	Provides tools to municipalities to reduce municipal pesticide use and to conduct outreach to their communities on less-toxic methods of pest control	Potentially High	Addresses pyrethroids toxic impact on water bodies.
IPM	State of California Green California. www.green.ca.gov/EPP/building/structipm.htm. Accessed December 2008.	Provides information on structural IPM.	Potentially High	Addresses pyrethroids impact on storm water.
IPM	San Francisco Department of the Environment. http://www.sfenvironment.org/our_programs/topics.html?ti=1. Accessed December 2008.	Contains information regarding key components of integrated pest management.	Potentially High	Addresses pyrethroids impact on storm water.
Low Impact Development	Low-Impact Development Design Strategies: An Integrated Approach. June 1999.	Discusses LID design strategies and successes, including storm water controls	Potentially High	Does not directly address Pyrethroids
Low Impact Development	Low Impact Development Handbook: Stormwater Management Strategies. December 2007.	Reviews many LID techniques appropriate for Southern California's climate	Potentially High	Does not directly address Pyrethroids
Public Outreach	County of Los Angeles Department of Public WorksStorm Water/Urban Runoff Public Education Model Program. Fiscal Year 2002.	Provides Los Angeles specific examples of Public Outreach and Education	Potentially High	Change is up to individuals, needs cumulative effect

Table 3-1 (continued)
Literature Review Matrix

Type of BMP	Literature Source	Summary	Ability to Reduce Toxicity Caused by Pyrethroids	Storm Water Concerns
Source Control				
Public Outreach	Drainage Area Management Plan - Santa Ana and Santa Margarita Regions. July 2005.	Discusses local outreach actions conducted by the Permittees	Potentially High	Change is up to individuals, needs cumulative effect
Public Outreach	Environmental Justice Pilot Project Pest Management Assessment: Soil Fumigant and Organophosphate Insecticide Use and Alternatives - Parlier, Fresno County, California. October 2007.	Study of Agricultural pesticide use in Fresno area, including use of reduced risk pesticides	Potentially High	Unknown potential water quality and toxicity issues
Public Outreach	National Management Measures to Control Nonpoint Source Pollution from Urban Areas. November 2005.	EPA document discussing management practices to help reduce pesticide use	Potentially High	Change is up to individuals, needs cumulative effect
Public Outreach	National Pollutant Discharge Elimination System (NPDES) Phase II BMP & Measureable Goal Examples. February 2008.	Provides examples and goals of public outreach BMPs	Potentially High	Change is up to individuals, needs cumulative effect
Public Outreach	Pesticides of Interest for Urban Surface Water Quality. Urban Pesticides Use Trends Annual Report. July 2008.	Contains recommendations for public education based on analysis of pyrethroid use trends	Potentially High	Change is up to individuals, needs cumulative effect
Treatment Control				
Extended Detention Basin	Santa Clara Valley Urban Runoff Pollution Prevention Program Commercial Site Design Examples. February 2007.	Shows examples of different structural treatment methods and their effectiveness	Moderate	Improper maintenance could lead to other water quality issues
Extended Detention Basin	California Stormwater BMP Handbook. January 2003.	Reviews extended detention basin BMP methods, concerns, and goals	Moderate	Improper maintenance could lead to other water quality issues
Extended Detention Basin	Ventura Countywide Stormwater Quality Management Program Technical Guidance Manual for Stormwater Quality Control Measures. July 2002.	Reviews many BMP methods and contains information specific to Southern California	Moderate	Improper maintenance could lead to other water quality issues

Table 3-1 (continued)
Literature Review Matrix

Type of BMP	Literature Source	Summary	Ability to Reduce Toxicity Caused by Pyrethroids	Storm Water Concerns
Treatment Control				
Infiltration Basin	California Stormwater BMP Handbook. January 2003.	Reviews infiltration basin BMP methods, concerns, and goals	Potentially High	Improper maintenance could lead to other water quality issues
Infiltration Basin	Ventura Countywide Stormwater Quality Management Program Technical Guidance Manual for Stormwater Quality Control Measures. July 2002.	Reviews infiltration basin BMP methods, concerns, and goals	Potentially High	Improper maintenance could lead to other water quality issues
Infiltration Trench	California Stormwater BMP Handbook. January 2003.	Reviews infiltration trench methods of BMP methods, concerns, and goals	Potentially High	Improper maintenance could lead to other water quality issues
Infiltration Trench	Ventura Countywide Stormwater Quality Management Program Technical Guidance Manual for Stormwater Quality Control Measures. July 2002.	Reviews infiltration trench methods of BMP methods, concerns, and goals	Potentially High	Improper maintenance could lead to other water quality issues
Media Filter	California Stormwater BMP Handbook. January 2003.	Reviews media filter BMP methods, concerns, and goals	Potentially High	Improper maintenance could lead to other water quality issues
Media Filter	Ventura Countywide Stormwater Quality Management Program Technical Guidance Manual for Stormwater Quality Control Measures. July 2002.	Reviews many BMP methods and contains information specific to Southern California	Potentially High	Improper maintenance could lead to other water quality issues
Pervious Pavement	California Stormwater BMP Handbook. January 2003.	Reviews pervious pavement BMP methods, concerns, and goals	Potentially High	Improper maintenance could lead to other water quality issues
Pervious Pavement	Low Impact Development Handbook: Stormwater Management Strategies. December 2007.	Discusses LID strategies for assistance in storm water management	Potentially High	May contaminate groundwater

4.0 BMP Analysis

Based on the literature review and the findings of Phase I of the TRE, BMPs were evaluated for their applicability to the SMR. Because the toxicity appears to be principally a wet weather phenomenon, and because the Permittees' jurisdiction includes the urbanized area of the watershed, the analysis focused on BMPs designed to reduce the amount of storm water pollution caused by urban runoff.

The potentially applicable BMPs are divided into Source Control and Treatment Control BMPs and are discussed in detail below. Through the Permittee's proactive efforts to protect the quality of the receiving waters and their beneficial uses, many programs addressing these broad categories are either already in place or are actively being developed. The implementation status for each specific BMP is discussed. Examples of BMP implementation by other municipalities in the region are included as a tool for evaluating the consistency of the Permittees' program with other programs in the region.

4.1 Source Control BMPs

Source control BMPs are designed to curtail pollution at the source before it has the opportunity to enter the storm drain system and pollute waterways. They are generally the preferred type of BMP because reduction of pollution occurs at the source, before runoff has become contaminated (CASQA, 2003). The types of broad categories of source control BMPs that identified as most appropriate for the Santa Margarita watershed are: pursuing regulatory change, implementing IPM strategies including LID, and public outreach and education.

4.1.1 Regulatory Action

Status: Currently being implemented by the Permittees.

Pesticide manufacturers are required to receive approval by USEPA and California DPR for specific pesticide uses, and both agencies can impose use restrictions to prevent unwanted impacts on the environment and public health. At the federal level, a fundamental regulatory disconnect exists between pesticide approval (registration) under FIFRA and water pollution control programs under the Clean Water Act. This has resulted in a repeating pattern, in which a) pesticides are approved for use without sufficient consideration of potential environmental effects, b) water quality and other ecological impacts accrue, c) use restrictions are applied to the offending products (sometimes involving widespread bans on use), and d) new pesticides are approved for use, with subsequent environmental impacts.

In 1962 Rachel Carson published *Silent Spring*, documenting the widespread ecological consequences of pesticide applications. The federal government responded by banning the use of DDT and other organochlorine pesticides, based on extensive evidence of environmental impacts through the process of bioaccumulation. The ban has lead to dramatic recoveries in affected populations of bald eagles and other species; however, the legacy of these long-lasting pesticides near-shore dumping areas in Los Angeles County and elsewhere remains (IWS, 2007).

Eventually the organochlorine pesticides were replaced principally by organophosphate pesticides, especially in urban uses. In the mid-1990s municipal storm water monitoring programs began to document that commonly-used organophosphate pesticides, especially diazinon and chlorpyrifos, were present at toxic levels and causing toxicity to aquatic organisms, principally the common water flea, *Ceriodaphnia*. Although not bioaccumulative, diazinon and chlorpyrifos were discovered to cause widespread toxicity in urban runoff and local receiving waters (TDC, 2001). USEPA subsequently banned most urban uses of diazinon and chlorpyrifos, although EPA's main motivation involved human health effects

on the pesticide applicators, and water quality was not an important factor in those decisions. Again, the ban was also immediately effective, reflected in reduced concentrations of diazinon and chlorpyrifos in urban water samples, and fewer occurrences of organophosphate-based water column toxicity (c.f., references in Ruby, 2008 for San Diego County Municipal Copermittees Annual Urban Runoff Monitoring Reports). But pesticide manufacturers simply replaced the OP pesticides in their products with other active ingredients, principally pyrethroids. Shortly thereafter, researchers and municipal storm water programs began documenting toxic effects from the new pyrethroid products. The pyrethroid impacts were first documented in sediments, and the affected test organism shifted from *Ceriodaphnia* to the sediment-dwelling *Hyalella*.

In the cases of both organochlorine (DDT) and organophosphate (diazinon, chlorpyrifos) pesticides, federal limitations or bans on uses were effective in ameliorating the associated environmental impacts. In both cases, however, new pesticide products were approved for use that then caused related but different impacts to the environment. Therefore it is clear that the most effective strategy for preventing environmental impacts from pesticide use involves implementing an effective process of pesticide approval and registration that comprehensively accounts for and mitigates against such impacts.

For more than ten years CASQA and various other California state and local agencies have promoted better regulation of pesticides at the federal level, encouraging use restrictions as the most effective means of source control. California water quality agencies have sent comment letters to USEPA and DPR on guidance pertaining to the application of pesticides to surface waters and on recommended environmental hazard statements for residential outdoor pesticides (TDC, 2007). These efforts are beginning to show some modest signs of success. In a recent letter to stakeholders, EPA outlined an approach to provide better cooperation between the Office of Pesticide Programs (OPP) and the Office of Water (OW), to allow for “environmentally protective and scientifically defensible effects assessment judgments about contaminants that are or may be found in ambient water”. The Riverside County Permittees plan to continue their support of these efforts through ongoing

participation in the CASQA Pesticides Subcommittee, the Urban Pesticide Pollution Prevention (UP3) Project, and the Urban Pesticide Committee. The Permittees also plan to request that the RWQCB become involved in advocating for more effective pesticide regulation at the state and federal levels.

The Permittees are members of a CASQA subcommittee that addresses pesticide uses impacting stormwater discharges. Effort focuses on providing input to the USEPA and the California Department of Pesticide Regulation (DPR) to improve pesticides regulations so that they more fully protect water quality and are better aligned with the Clean Water Act and California Water Code. (RCFCWCD, 2008). CASQA has also been active in supporting DPR's ongoing reevaluation of allowable pyrethroid pesticide uses (TDC, 2007).

Increasingly, the regulatory response to the water quality impacts resulting from *legal uses of approved pesticides* has been for regional water boards to impose limitations on the allowable loadings of pesticides to impaired waters through the TMDL process. Local agencies have little or no jurisdiction over sales or use of these pesticide products, and therefore do not have the full authority needed to perform loading reductions in resulting TMDLs. An effective regulatory solution must occur at the state and federal levels, to regulate allowable pesticide uses to effectively prevent such water quality impacts.

Current legislation requires users of certain pesticides to be trained, often certified, in the use of those pesticides and to report the amounts applied (State of California, 2008). A similar regulatory approach could be used to promote pesticide alternatives, such as for PCOs to train and certify their technicians in the use of IPM methods (Quarles, 2002). The Permittees are considering supporting regulatory action by the state to include IPM training for PCOs in the requirements for certification and training on the use of pesticides.

Environmentally sensitive and flexible zoning ordinances may be adopted to facilitate the use of LID principles, thereby encouraging private developers to use LID principles (Prince Georges County, 1999). Additional land use restrictions or alternatives to present zoning

laws may help reduce urban storm water runoff, potentially reducing pyrethroid loadings in receiving waters. The Permittees plan to continue promoting LID implementation through interagency communications and cooperation.

4.1.2 Integrated Pest Management

Status: Currently being implemented by the Permittees.

IPM is "a decision-making process for managing pests that uses monitoring to determine pest injury levels, and combines biological, cultural, mechanical, physical, and chemical tools and other management practices to control pests in a safe, cost effective, and environmentally sound manner that contributes to the protection of public health" (Carlsen, 2008). IPM can further be described as an approach to solving pest problems by using information about the pest and landscape to eradicate the pest's habitat in a manner that poses the least risk to humans (Ecology Action, 2007). IPM has many different aspects that help to reduce pests and in turn cause a reduction in pesticide use, including green gardening and structurally integrated pest management (SIPM). BMPs that are typically used as part of an IPM strategy are described in the following sub-sections.

4.1.2.1 Green Gardening

Status: Not currently being implemented by the Permittees, program under consideration and will be enacted in the near future.

The Green Gardener program, implemented through landscapers, promotes environmentally responsible landscaping to reduce the use and need for pesticides. In general, education of gardening and landscape maintenance staff is beneficial for pest reduction as part of an IPM program. It provides alternative methods to landscapers, such as reducing outdoor sources of ants by elimination of their food and water sources through management of honeydew producing insects and plants associated with them (UC Davis, 2007). The Green Gardener

program encourages businesses to participate in environmentally sound landscape maintenance. Healthy landscapes are more resistant to pests (Ecology Action, 2007). Pests that do not have a suitable habitat will leave to find a more hospitable environment. When the pests leave, then there is a lessened need for pesticide applications and lower risk of pyrethroids entering storm water.

The County of Santa Barbara implemented a Green Gardener Program, in which landscapers are encouraged to take a class at the local city college, covering subjects such as IPM strategies and environmentally beneficial landscaping to obtain a "Green Gardener" card. They are then placed on the Green Gardener list, which is then promoted to the public by the County (County of Santa Barbara, 2008). The program benefits both parties; gardeners receive education and advertising at a nominal cost, and the County receives the benefit of more environmentally-friendly landscaping and a reduction in the use of pesticides. Municipalities may promote this type of program by contracting with landscaping companies that have their employees trained in green gardening practices.

Encouraged by the success of the Santa Barbara Green Gardener Program, the Monterey Bay area instituted a similar program. "The goal of the program was to educate and certify local gardeners in resource efficient and pollution prevention landscape management practices" (Ecology Action, 2007). With the support of the State of California Water Resources Control Board, more municipalities are likely to follow (Ecology Action, 2007).

4.1.2.2 Pest Control Contracting

Status: Currently partially implemented by the Permittees.

Many municipalities contract pesticide applications to professional PCOs. Contracting only with PCOs that have IPM training and certification can help realize IPM models and goals. The recently completed EcoWise Certified IPM Contracting Tool Kit (www.EcoWiseCertified.org), provides resources for municipal agencies to use in developing such a program. The EcoWise IPM Tool Kit includes:

- Elements to consider when developing an IPM policy
- Roles and responsibilities of the agency or business in an IPM program
- How to hire and work with a professional IPM service provider

The Took Kit also includes the EcoWise IPM Process along with a number of other helpful resources and sample documents.

Because PCOs are responsible for the majority of pesticides applied in urban areas, distribution of information regarding less-toxic alternatives, lower-use application techniques, and proper disposal, practices to professional applicators is an essential component of the Permitee's pesticide control effort. The Permittees currently distribute information to PCOs through the Public Outreach and Education Program (see Section 4.1.3).

The City of Palo Alto's Regional Water Quality Control Plant includes IPM requirements in their contracts with PCOs (City of Palo Alto, 2008). The City of Santa Monica, as a part of their SIPM program, specified IPM requirements in their PCO contracts (Raphael, 1997). Use of PCOs with IPM training and certification by municipalities encourages local PCOs to invest in IPM training and certification, which in turn, allows their expertise in IPM to expand beyond just the municipality itself (Quarles, 2002). Education of PCOs, hiring only PCOs that have IPM training, and contracting specifically for IPM by local agencies may

create more public awareness and reduce the use of pyrethroids in the Santa Margarita watershed.

4.1.2.3 Structurally Integrated Pest Management Program

Status: Currently being implemented by the Permittees, with additional programs under consideration.

SIPM is a program that controls the access of pests to buildings and the potential food sources within them by protecting the structure itself from pests, with minimal use of pesticides. The Permittees intend to lead by example, sharing success through public outreach programs and encouraging individuals and businesses to do the same. SIPM is a long term solution offering positive potential impacts on budget, reduction of pests and, reduction of pyrethroid pesticide use. Note that SIPM should not be confused with category of pesticide use referred to as structural pest control. SIPM is a BMP designed to reduce the use of pesticides in a structural pest control program.

The City of Santa Monica implemented an SIPM program and experienced a reduction in pests and in the use of pesticides. In addition, Santa Monica reduced pest management costs by 30% (State of California, 2008). California law requires a SIPM strategy for all state-owned buildings and schools (State of California, 2008). The three main aspects of a SIPM strategy are facility design and LID, monitoring, and facility maintenance.

<u>Facility Design</u>

Status: Currently being implemented by the Permittees.

Facility design can play a large role in the exclusion of potential pests. "A facility's planning, design, and construction provides an opportunity to incorporate features that help to exclude pests, minimize pest habitat, and promote proper sanitation" (NIH, 1999). It can also reduce

storm water runoff (NAHB, 2008). Exclusion of pests helps reduce pest infestations and in turn the need for pyrethroid pesticide use. For example, ensuring that the design holds plants and mulch several inches away from the foundation of a building may assist the reduction of ant populations immediately adjacent to the building (UC Davis, 2007). A reduction in storm water runoff may also reduce the amount of pyrethroids that enter receiving waters. Facility designs can incorporate aspects of LID, as discussed below. New development and redevelopment may incorporate designs that aid in the exclusion of pests and the reduction of urban runoff, which may contribute to a reduction of pollutant loads, including pyrethroids.

Pest Monitoring

Status: Currently in not use by the Permittees, program under consideration.

Monitoring structures and adjacent areas may help prevent pest infestations and quickly identify potential problems. Traps, visual inspections, and staff interviews assist in the identification of areas and conditions that may foster pest activity (NIH, 1999). Monitoring for ants, for example, may consist of simple inspections of facilities such as looking under sinks and along pipes and electrical wires (UC Davis, 2007). The City of Santa Monica, as a part of their SIPM, provided training to all general staff, purchasing, carpenters and custodial staff. Specific presentations were given to groups, such as the custodial staff, who learned about products used in control of ant and cockroach populations and general sanitation. The staff is trained in the identification of potential pest infestations and habitat conditions that may foster pest activity (Raphael, 1997). Early identification of pest infestations can increase the effectiveness of specific treatments and reduce the overall need for pesticide use.

Sanitation and Facility Maintenance

Status: Currently not being implemented by the Permittees, program under consideration.

Proper sanitation includes reducing clutter and pest habitat and incorporating proper facility and waste management practices. Records of maintenance and housekeeping conditions may help track pest problems and assist in the determination of whether corrective action is needed or has been taken in a timely manner (NIH, 1999). Sanitation and facility maintenance involves the housekeeping staff, the building maintenance staff, and the landscaping staff.

Improper storage of waste may affect urban runoff, and it may create a hospitable environment for pests, particularly ants. Initial, low-cost steps that municipalities may take to improve waste handling are: controlling litter, keeping waste collection areas clean, and insuring proper disposal of pyrethroid pesticide products, if used, and educating employees and the public. Simple solutions such as rinsing out soda bottles and emptying trash daily prove effective to reduce insect infestations, particularly ants (UC Davis, 2007). An important component of an SIPM monitoring program is regular inspections of solid waste containers for structural damage or leaks (CASQA, 2004).

Educating custodial staff, such as was done in the City of Santa Monica, can reduce the amount of improperly disposed pesticides (Raphael, 1997). Designating staff members to perform a daily checklist of areas around the structure to ensure cleanliness and proper storage of waste can assist the efforts to reduce potential pest infestations and leakage of hazardous waste (CASQA, 2004).

Building maintenance staff also benefit from education and acceptance of responsibility for pest management. Maintenance crews can contribute to an SIPM strategy by securing the structure, such as caulking holes and cracks, assisting in the removal of clutter, and installing

door sweeps (State of California, 2008). Caulking holes in structures can prove effective in keeping ants out of facilities (UC Davis, 2007). Upkeep on building maintenance helps reduce potential pest habitat, and thus may reduce the need for application of pyrethroid pesticides.

Reduction of pest habitat around structures may reduce pest populations in and around structures. Marin County, as part of its integrated pest management program, has reduced rat habitat around the local Civic Center and in turn has seen suppression of the rat population (Carlsen, 2008). Programs similarly tailored to ants may result in a positive effect of pest reduction within the SMR. For example, banding tree trunks with tanglefoot or similar sticky substances can keep ants away from trees (UC Davis, 2007). Education and training may be provided to Permittee landscaping crews to assist in proper vegetation removal and, when necessary, pesticide use. Landscaping crews may be informed that pyrethroid pesticides or any less toxic pesticides are to be used only when a pest problem arises to an intolerable level, that they are not administered when a wet weather event is expected and only when low wind speeds are present (CASQA, 2004). Education of landscaping crews to remove pest habitat may reduce the need for pyrethroid use thus reducing the potential risk of pyrethroids entering storm water runoff.

Also, utilizing low water using vegetation and alternative landscaping techniques such as xeriscaping or naturescaping are efforts that landscape crews can take to reduce pyrethroids in urban runoff. Landscaping crews may also help preserve the water efficiency of the landscape through properly timed fertilizing, weeding, pruning, and pest control. For example, proper collection and disposal of yard clippings can prevent loose vegetation that has possibly been treated with pyrethroid pesticides from entering waterways or storm water drainage systems such as MS4s (CASQA, 2004). Reduction in pest habitat and proper landscaping maintenance may help reduce pest problems, and thus the need for pyrethroid pesticides.

4.1.3 Public Outreach and Education

Status: Currently being implemented by the Permittees.

Public Outreach and Education programs inform the public about storm water issues, proper use and disposal of publically available chemicals, and alternatives to pyrethroid pesticides. Reaching out to the public and providing information about the dangers of pyrethroids pesticides encourages citizens to make educated decisions about pesticide use. It also may accelerate state and federal regulatory changes regarding pyrethroid use through public promotion of such changes. According to the EPA, public education and awareness can be a "key component" in any BMP program for storm water management (EPA, 2008).

The District has enacted a public outreach program to help reduce the potential for pyrethroid pesticides to contaminate receiving waters. This program has initiated: distribution of educational materials to hardware store employees, active participation and distribution of outreach for HHW/ABOP facilities to provide for free venues to dispose of excess pesticides, and distribution of EPA and CalEPA materials to the public. The District also promotes the use of less toxic pesticides, provides education on storm water issues in public schools, and has enacted a multimedia campaign to control urban sources of pyrethroid pesticides (RCFCWCD, 2005).

<u>Education and Outreach to Businesses</u>

Status: Currently being implemented by the Permittees.

Distribution of information regarding pesticides to businesses, particularly hardware stores, is crucial for reducing pyrethroid use and misuse at its source. Education on pyrethroid runoff to local hardware stores may assist local hardware store employees to educate their customers on alternative methods of pest control. An Orange County survey from 2001 found that 55% of pest control products were purchased at hardware stores (Wilen, 2001). In

2006, Riverside County had 177,562 pounds of reported non-agricultural usage of pyrethroid pesticides (RCFCWCD, 2008). Reduction in usage may lead to a reduction of pyrethroids in urban storm water runoff. Educating hardware store employees about urban water quality impacts of pyrethroid pesticides may help reduce the usage and thus the toxicity of runoff in the Santa Margarita Watershed resulting from pyrethroid use, as employees have the ability to recommend alternative methods of pest management to their customers.

Education of nursery employees about pyrethroid management and IPM techniques may also yield significant source control benefits. In general, nursery employees tend to be more knowledgeable about pesticides than employees at hardware stores (Wilen, 2001). Nurseries that use and sell pyrethroids offer the highest return on outreach resources, while those nurseries that have chosen alternate pest management methods serve as examples of IPM in practice. In a recent Riverside County survey, one nursery stated that they do not use pesticides and if their nursery does experience a pest infestation, it is treated naturally (RCFCWCD, 2008). Such nurseries are likely to encourage their clients and customers to use the same methods. Education and outreach can lead to cooperation and sharing of successful and unsuccessful methods of IPM and ultimately reduce pyrethroid pesticide use and toxicity of storm water runoff.

Businesses not in the industry of pesticide sales may also benefit from outreach. The District directs outreach efforts to all businesses; those in the business of selling or using pesticides, and those that are not. The District has coordinated with the County's Business License Department to include an educational insert of the "Only Rain Down the Storm Drain" program to new business license applicants and annual renewal reminders (CRWQCBSD, 2008). Informing companies on proper disposal of hazardous materials such as pesticides is crucial to prevent pyrethroid containers from being improperly disposed of, leaking, and then contributing to storm water pollution.

Several Southern California cities conduct general business outreach as well. Cities such as Carson, Gardena, Inglewood, and Lomita distribute informational pamphlets on storm water

pollution relating to landscaping and gardening practices to general businesses (DCWMAC, 2007). Such information informs businesses of alternate methods of pest control beyond pesticide use and imparts knowledge about storm water quality issues. Thus, dissemination of educational materials to local businesses is intended to help reduce pyrethroid runoff by ensuring proper disposal of pesticides and encouraging alternate methods of pest control.

Educational and Outreach to the General Public

Status: Currently being implemented by the Permittees.

The District distributes educational materials within the Santa Margarita Region such as EPA sponsored pamphlets in order to promote reduced use of pyrethroid pesticides and educate the public about alternate practices of pest management. The public purchases retail pesticides and uses them, presumably, according to the manufacturer's instructions and in compliance with regulations listed on the packaging, including proper disposal of empty containers in the municipal waste stream. However, even when used properly, retail pesticides have the potential to contaminate urban runoff, and homeowners may be unaware of the downstream consequences of pesticide use. Depending on the landscaping practices in a neighborhood, promoting alternative pest management strategies and educating the public on storm water quality and pesticide use may be the most beneficial way to reduce the source of pyrethroids in urban runoff (Wilen, 2005).

The District distributes educational materials within other public outreach programs and maintains pest management information on the internet. The District also distributes brochures to educate the public on lawn and garden maintenance, fertilization, and pesticide and household chemical use (RCFCWCD, 2005). These educational materials provide public education on alternative pest control methods, limiting individual use of pyrethroids, and proper disposal of pesticide containers.

Many municipalities perform storm water outreach at festivals and public events by participating in the events and by distributing brochures. The Cities of Lawndale and Torrance plan and attend public festivals and rent booth space to educate the public about storm water quality and the use of pyrethroids (DCWMAC, 2007). Cities including Carson, Gardena, Inglewood, and Lomita distribute informational pamphlets on storm water pollution relating to household activities and landscaping and gardening practices to the general public (DCWMAC, 2007). The District participates in events such as the Children's Groundwater Festival, the Southern California Fair, the Community Water Festival, and the Santa Margarita Watershed Clean Up (RCFCWCD, 2005). The Permittees, as well as other municipalities within California, participate in public events and distribute informative materials as a portion of their current public outreach programs.

Education on proper disposal of pesticides

Status: Currently being implemented by the Permittees.

Improper disposal of pesticides is a potential contributor to storm water contamination. Empty containers be disposed of in the municipal waste stream are not likely to contribute to storm water pollution, however, unused pesticides may enter the MS4 by leaking in transit. In Orange County in 2001, 54.5% of people surveyed claimed to have disposed of unwanted pesticides in the municipal waste stream, and 78.6% did not know the location of a household waste disposal site (Wilen, 2001). The District has created a partnership with Riverside County Waste Management to provide educational programs and materials on proper disposal of unwanted waste, including pesticide containers (RCFCWCD, 2005).

Multimedia Outreach

Status: Currently being implemented by the Permittees.

The EPA suggests using multiple media sources to promote and educate on storm water impacts, particularly through public service messages (EPA, 2007). Mass media has proven to be a key source of pollution prevention information for the general public (LADPW, 2002). The District currently participates in a multimedia advertising campaign including: maintaining a website that provides information, distributing mailing inserts regarding water quality issues through various county entities, and billboard advertising campaigns. Many other municipalities, such as the Cities of Palo Alto and Lawndale, also use the world wide web to provide information to the public (City of Palo Alto, 2008) (DCWMAC, 2007).

Public School Programs

Status: Currently being implemented by the Permittees.

A storm water education program for public schools is a concept supported by the EPA (EPA, 2007). The County of Los Angeles has incorporated public school educational programs into its outreach program (LADPW, 2002). The District focuses storm water education efforts on elementary school students (RCFCWCD, 2005). For example, sixth-grade students at Warm Springs Middle School were given an interactive presentation regarding storm water pollution with an enviroscape model that excited and engaged the students; a presentation that has been given over 150 times during the 2003-2004 school year (Jamescourie, 2004). Educational programs in public schools are intended to produce long-term benefits to storm water runoff quality.

Education on Lower Risk Alternative Pesticides

Status: Currently being implemented by the Permittees.

Part of Public outreach includes suggesting less toxic alternatives to pyrethroid pesticides, such as those listed on the Our Water Our World website (www.ourwaterourworld.org). Lower risk pesticides have reduced impacts on human health, lessened toxicity to non-target organisms, decreased potential for water contamination, and lower pest resistance potential (Matteson et al., 2007). The District distributes materials associated with the "Our Water Our World" organization (RCFCWCD, 2008).

However, some of the lower risk pesticides are toxic to beneficial arthropods and still have the potential to pollute surface and ground water (Matteson et al., 2007). Pyrethroids were developed as a less toxic alternative from organophosphate pesticides (Quarles, 2002). In the Santa Margarita Watershed, there was a decrease in water toxicity to *Ceriodaphnia* and an increase in toxicity to *Hyalella* as organophosphate pesticides such as chlorpyrifos and diazinon and were replaced by pyrethroids (RCFCWCD, 2008). The effects on storm water runoff of lower risk pesticides must be carefully evaluated before they are promoted as effective solutions to urban storm water runoff pollution.

4.1.4 Low Impact Development (LID)

Status: Currently being implemented by the Permittees.

LID involves environmentally-friendly building and development designs that mitigate impacts to land and water. LID functions by managing storm water at its source, incorporating a variety of runoff control techniques, using natural features as design features, and protecting natural resources (NAHB, 2008). Municipalities that promote LID have the potential to reduce municipal infrastructure and maintenance costs while balancing growth needs with environmental protection (NAHB, 2008). LID practices include "small scale,

decentralized treatment practices" that include conservation of open space, a reduction of impervious surfaces, and the incorporation of water controls (NAHB, 2008). Reduction of urban runoff volumes may reduce the loadings of pyrethroids to receiving waters in urban areas.

In 2007, EPA implemented a retrofit of the agency headquarters in Washington, D.C., incorporating LID designs to assist with storm water retention (EPA, 2007). Retention of storm water on the land helps prevent pollutants from entering streams and rivers (EPA, 2007). One of the main goals of the EPA LID retrofit was to demonstrate several LID techniques and encourage government agencies and developers to use them (EPA, 2007). LID may be used in conjunction with IPM programs, which would reduce the amount of pesticides used and minimize the urban storm water runoff of pyrethroids. The County of San Diego's most recent MS4 permit requires implementation of LID techniques (County of San Diego, 2007); this appears likely to continue as a trend with other permits in the region as they are renewed. The incorporation of LID principles into development regulations in the Santa Margarita watershed provides a potential solution to runoff of pyrethroids into receiving waters.

4.2 Treatment Control BMPs

Treatment Control BMPs are typically structural devices engineered with the intent to remove pollutants from storm water. Treatment BMPs require construction and long term maintenance, but can be extremely effective (CASQA, 2003). Although treatment BMP's have not been thoroughly investigated specifically for reduction of pyrethroids, some methods may be useful. Pyrethroids bind tightly to soil particles so there is a high probability that pyrethroids would be removed with suspended solids when they pass through treatment BMPs. In addition, pyrethroids degrade over time; permethrin, for example, has a half life in soil of about 30 days and about 10 days on certain plant life. Because pyrethroids have low mobility in soil, infiltration-based treatment BMPs have a low probability of contributing to groundwater contamination (NPTN, 1997).

From the list of available treatment BMP's identified in Table 3-1, the types of treatment BMPs feasible for pyrethroid treatment in the Santa Margarita Watershed, considering the climate, local vegetation, and soil types present are: pervious pavement, media filters, extended detention basins, infiltration basins, and infiltration trenches.

These BMPs and their potential to remove pyrethroids from storm water runoff are described below.

4.2.1 Pervious Pavement

Status: Currently being implemented by Permittees under LID program.

Pervious or porous pavement is "a system comprising a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet" (CASQA, 2003). Pervious surfaces include grass, gravel, and porous concrete and asphalt (CASQA, 2003). The multi layer system assists in preventing pyrethroid pollution by providing a stable structure for pyrethroids to bind to and degrade, thus helping to prevent their transport in to receiving waters. Silts that are deposited within the pavement may need infrequent controlled waste disposal (CASQA, 2003).

The advantage of porous pavement is that urban runoff is reduced while treatment is provided and it is an effective drainage solution in confined urban areas. However, porous pavement is not a viable option on high traffic or high speed roads due to safety issues. There is a small chance that it may contaminate groundwater. It is fairly easy to replace, should there be a clog or damaged area, as small areas can individually be paved (CASQA, 2003). The use of pervious pavement appears to be a growing trend.

4.2.2 Media Filter

Status: Currently being implemented by Permittees via sand filters.

Storm water media filters are usually two-chambered including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As storm water flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as storm water flows through the filtering media in the second chamber. Media filters are highly effective at removing sediment from storm water flows (CASQA, 2003). They are appropriate in low flow areas, particularly with sandy soil. Washington D.C. and Austin, TX have both successfully implemented media filters to treat storm water (VCSQMP, 2002). They "are well suited to Southern California because they do not require vegetation and require less space than other treatment control measures with similar removal efficiencies when a partial treatment sedimentation basin is used" (VCSQMP, 2002).

However, media filters clog easily when exposed to high sediment loads and may decrease in effectiveness after being in use for a few years (CASQA, 2003). A media filter is not appropriate for areas with erosive soil upstream from the treatment filter (VCSQMP, 2002). The lack of abundant native vegetation in the Santa Margarita watershed contributes to a high potential for erosion, so media filters may not be effective in the long term due to clogging. When clogging does occur, media filters may become a nuisance due to mosquito or midge breeding in pooled waters (CASQA, 2003).

4.2.3 Extended Detention Basin

Status: Currently not being implemented by the Permittees for pyrethroid reduction.

An extended detention basin (EDB) is a permanent basin "formed by excavation and/or construction of embankments to temporarily detain the Stormwater Quality Design Volume

(SQDV) of storm water runoff to allow sedimentation of particulates to occur before the runoff is discharged"(VCSQMP, 2002). EDBs are constructed with an outlet at the bottom that allows for a slow, time-controlled release. The ultimate goal of EDBs is to level off peak storm water runoff rates (VCSQMP, 2002). Santa Clara Valley and the City of Palo Alto have noted that their detention basins have helped with the reduction of pollutants (EOA, 2004) (City of Palo Alto, 2008). Pyrethroids could be removed in the basin through settling of particulates.

Extended detention basins can serve multiple purposes as they provide for significant trash removal as well (CASQA, 2003). Maintenance is needed to ensure that the pond fully drains after large wet weather events, to avoid creation of standing pools causing mosquito or other vector habitats (CASQA, 2003). Extended detention basins are most effective when used in conjunction with other control measures, and are only moderately successful at removal of sediment. EDBs require relatively large amounts of land and therefore may not be feasible in urban areas of the Santa Margarita watershed (VCSQMP, 2002). There are no available examples of test results from municipalities using an extended detention basin for reduction of pyrethroid pesticides.

4.2.4 Infiltration Basin

Status: Currently not being implemented by the Permittees for pyrethroid reduction.

An infiltration basin is a shallow impoundment that is designed to infiltrate storm water and utilize the natural ability of soil to remove pollutants in storm water runoff (CASQA, 2003). Infiltration basins store runoff until it eventually enters the soil and infiltrates into the water table (CASQA, 2003). The soil present in the Santa Margarita Region is extremely pervious and may work well with an infiltration basin treatment structure.

Since pyrethroids adsorb onto soil, pyrethroids are likely to be removed from the storm water into the soil. However, there is a slight possibility that they may be resuspended into the

groundwater. Monitoring of pilot sites would be required to determine if there is transport of pyrethroids to the water table.

As with detention basins, maintenance is needed to ensure that the basin fully drains after large wet weather events to avoid creation of standing pools causing mosquito or other vector habitats. Infiltration basins may fail if the storm water volume is greater than the design volume (VCSQMP, 2002). Since infiltration basins require a large amount of open space, installation in urban areas is problematic. There are no available examples of test results from municipalities using infiltration basins for reduction of pyrethroid pesticides.

4.2.5 Infiltration Trench

Status: Currently not being implemented by the Permittees for pyrethroid reduction.

An infiltration trench is a long and narrow ditch that collects storm water runoff by storing it in the voids in a rock bed and allowing it to infiltrate to the soil matrix (CASQA, 2003). Infiltration trenches are extremely effective at removing fine sediment particles and associated pollutants (CASQA, 2003). Naturally pervious soils are required (VCSQMP, 2002). The Santa Margarita watershed has naturally pervious soils, which would allow for the removal of pyrethroids from the water and into the sandy soil.

Infiltration trenches are typically used in conjunction with grass lined channels or grass filter areas located upstream for maximum removal of sediment and larger particles (VCSQMP, 2002). Due to the arid environment in the Santa Margarita Region, grass lined channels, or even vegetated strips, would require irrigation to maintain the vegetation. If the infiltration trench clogs, it can become a source for mosquito breeding. There are no available examples of test results from municipalities using infiltration trenches for reduction of pyrethroid pesticides.

4.3 BMP Evaluation

A summary of the relative advantages, disadvantages and costs of the various BMPs identified in Sections 4.1 and 4.2 above is presented in Table 6.1 below. The table includes advantages, disadvantages, and the relative cost of implementing the BMPs.

Table 6.1
BMP Comparison Table

BMP Technology	Advantages	Disadvantages	Relative Cost*
Source Control			
Regulatory Change	Reduces the availability of pyrethroids on the market	May take years to achieve full effect	$
Integrated Pest Management	Engages businesses and the public in environmentally sound gardening practices	Need to ensure that employees are following protocols	$
	Has been implemented in various locations throughout CA and the US	Could have some resistance from employees who are use to standard practices	
	SIPM can be put in place directly by the Permittees	Some may find the organic methods of gardening to be too time consuming	
	SIPM can be incorporated directly into current maintenance activities		
	Includes LID aspects		
Public Outreach and Education	EPA states that Public Outreach is key for any BMP program	Cannot control the direct actions of public but only educate	$
	Copermittees have already implemented a public outreach program	Hard to measure the direct impact of pollutant reduction	
	Employees of business have direct impact on the buying choices of the general public		
	Programs have been implemented by many municipalities		

Table 6.1 (continued)
BMP Comparison Table

BMP Technology	Advantages	Disadvantages	Relative Cost*
Treatment Control			
Porous Pavement	Reduces runoff volume while reducing pollutant load as well	Requires ongoing minimal maintenance	$ to $$ depending on size
	Can be easily replaced depending on the size and location of design	No known measured reduction of pyrethroids.	
Media Filter	Do not require vegetation	No known measured reduction of pyrethroids.	$$$
	Highly effective in removal of sediments	Clogging is an issue because of the erosion potential in the watershed.	
	Requires less space than other treatment controls for sediment removal		
Extended Detention Basin	Known for significant trash	Large footprint Moderately successful at removing sediment	$$$
	Standard BMP with many years of maintenance and operational information available	Create an area with vector breeding potential	
		No known measured reduction of pyrethroids.	
Infiltration Basin and Trench	Uses natural ability of soil to remove pollutants.	Unknown if pyrethroids would be transported to the groundwater table.	$ to $$$
	Local soils would allow infiltration	Would require a pilot study to determine transport.	
		No known measured reduction of pyrethroids.	
		Clogging of outlet structure	
		Accumulation of metals in soil	

*Relative Cost: $ = $0 to $50,000, $$ = $50,001 to $100,000, $$$>100,000

5.0 Pending Legislation

There is no relevant pending state legislation relating to pyrethroid pesticides from the California Department of Pesticide Regulation or, in general, the State of California as of December, 2008 (State of California, 2008) (CDPR, 2008). In August 2006, the DPR put rules in place to control insecticide sprays during the dormant season. During winter, pesticides are applied to dormant tree and vine crops to kill overwintering pests and diseases. The new rules restrict the use of most dormant insecticides when residuals can run off into water (DPR 2007-08 Progress Report). However, there are no additional updates relating to pending pyrethroid legislation at this time.

There is no relevant pending federal legislation relating to pyrethroid pesticides from the United States Congress as of December, 2008 (Library of Congress, 2008). Although the EPA is working on proposed mitigation labeling for non-agricultural pyrethroids, there is no indication as to when this legislation may be enacted (TDC, 2007).

6.0 Proposed Course of Action

The Permittees intend to use a phased approach to address the identified sources of pyrethroid pesticides causing toxicity in surface waters of the SMR watershed. As described in Section 4, various source control BMPs and treatment control BMPs are available to address these sources. However, the use of pyrethroid pesticides can not be directly regulated by local governments. The most effective control strategy involves effective labeling and use restrictions via state or federal regulatory action, to prevent water quality impacts from legal pesticide uses. The proposed course of action involves an adaptive management approach with the following broad elements:

- Pursue state and federal regulatory change through CASQA
- Implement a set of source controls targeted specifically at urban pesticide use,
- Through the annual reporting process, monitor the implementation of those controls, assess effectiveness, and identify sources or areas where additional effort is needed,
- Evaluate whether additional controls, including treatment controls, may be needed to further reduce pyrethroid pollution,
- Implement additional controls as needed,
- Continue to monitor implementation, as well as conditions within the target receiving waters, assess effectiveness, and re-evaluate control program

The Permittees will continue to support CASQA and/or other agencies pursuing regulatory change in labeling or use limitations for pyrethroid pesticides. This support will include participation in the CASQA Pesticides Subcommittee and the Urban Pesticide Committee, and supporting the implementation of the Urban Pesticide Pollution Prevention (UP3) Project. Permittee staff will continue to provide staff time and resources necessary for the CASQA Pesticides Subcommittee to complete its negotiations with the California Department of Pesticide Regulation and USEPA regarding labeling and use limitations for pyrethroids.

Source control is generally a more cost-effective approach to pollution abatement than treatment control, as source controls do not involve the costly capital investments of treatment controls. As discussed previously, CASQA, EPA, and other agencies and experts

recommend a source control program as an essential component of a successful pollution reduction strategy.

The basis of source control involves preventing the entrance of the subject pollutant into the discharge stream. For pyrethroid pesticides, this means preventing the pesticide from entering the municipal storm drain system through urban runoff. This can take place by intervention at the various steps in the pest control process:

- Point of sale: reducing the purchase of pyrethroid products through education of PCOs and the public in consequences of pesticide use and alternative means of pest control, including integrated pest management (IPM)
- Application: reducing use of pyrethroids on site through education of PCOs and the public into the importance of proper application methods and the potential consequences of pesticide use, as well as pest control alternatives (IPM techniques)
- Off-site Transport: reducing movement of pyrethroids into municipal storm drain system via use of Green Gardener approaches, IPM, and LID building techniques to reduce irrigation water use, retain storm water runoff on-site, and provide on-site mitigation for runoff pollutants (via grassy swales, infiltration, etc.)

A five-year pyrethroid pollutant reduction program is proposed by the Permittees.

<u>Year 1</u>

- Continue to support state and federal efforts to improve pyrethroid pesticide regulation
- Continue to publicize/promote the services of IPM-certified PCOs, to encourage businesses and homeowners to choose their services
- Continue to implement local agency contracting rules to require contracting of IPM-certified PCOs for municipal pest control (through EcoWise Certified IPM Contracting Tool Kit, e.g.)
- Continue point-of-sale education effort providing instruction in pesticide alternatives and proper use/application (using materials available through Our Water Our World, UP3 Project, CASQA members, e.g.)
- Continue efforts to develop and implement LID guidance for planning and development

Year 2

- Coordinate with the University of California (UC) Extension Master Gardener Program to extend its services to the Temecula/Murrieta area to further promote and support the use of IPM by local residents
- Re-evaluate, enhance as needed, and continue measures implemented in Year 1

Year 3

- Conduct programmatic assessment as part of third-year annual report, evaluate successes and areas where additional efforts are needed and adjust program accordingly
- Re-evaluate, enhance as needed, and continue measures implemented in Years 1 and 2

Year 4

- Evaluate effectiveness of BMPs using water quality monitoring data as part of fourth year annual report
- Re-evaluate, enhance as needed, and continue implementation of revised program as defined in Year 3

Year 5

- Conduct programmatic assessment, evaluate successes and areas where additional efforts are needed as part of ROWD process
- Identify additional program elements, including source and/or treatment controls, as needed to effect required pollutant reductions; revise program accordingly
- Re-evaluate, enhance as needed, and continue implementation of revised program as defined in Year 3

Many of the source control materials and programs needed are readily available through existing programs such as EcoWise Certified, Green Gardener, Our Water Our World, the UP3 Project, and the Western IPM Center. The following websites provide further information on these and other programs:

Urban Pesticide Pollution Prevention (UP3) Project: www.up3project.org
Green Gardener Program: www.green-gardener.org/about
Western Integrated Pest Management Center: www.wripmc.org
EcoWise Certified Integrated Pest Management: www.ecowisecertified.com
Our Water Our World: www.ourwaterourworld.org
Green California: www.green.ca.gov/EPP/building/structipm.htm

City of San Francisco: http://www.sfenvironment.org/our_programs/topics.html?ti=1
DPR: http://www.cdpr.ca.gov/docs/registration/reevaluation/chemicals/pyrethroids.htm

As a practical measure, it will be necessary to evaluate individual Permittee capabilities and resources, and develop a specific work plan for implementation of the pyrethroid pollutant reduction program.

It is also essential to develop and implement the pyrethroid pollutant reduction program in coordination with other regulatory requirements, especially other pollutant reduction programs mandated under the storm water NPDES Permit and/or load allocations required by TMDLs within the SMR watershed.

7.0 References

Amweg, Erin L., Donald P. Weston, Jing You, and Michael J. Lydy. *Pyrethroid Insecticides and Sediment Toxicity in Urban Creeks from California and Tennessee, 40(5) 1700-1706.* 2006.

Anderson, Brian S. et al. *Causes of Sediment Toxicity in San Diego Bay, California, USA.* (in press) 2008.

Budd, R., S. Bondarenko, D. Haver, J. Kabashima, and J. Gan. *Occurrence and Bioavailability of Pyrethroids in a Mixed Land Use Watershed, Journal of Environmental Quality 36: 1006-1012*. 2007.

California Association of Stormwater Quality Agencies (CASQA). *California Stormwater BMP Handbook*. January 2003.

California Department of Pesticide Regulation (CDPR). *Pending Legislation*. www.cdpr.ca.gov/docs/legbills/pending.htm. Accessed December 2008.

California Regional Water Quality Control Board San Diego Region (CRWQCBSD). *Fiscal Year 2007-2008 Watershed Annual Report For the Riverside County Municipal Co-Permittees*. Fiscal Year 2007-2008.

Carlsen, Stacey K., Agricultural Commissioner, Director of Weights and Measures. *Draft Integrated Pest Management (IPM) Program Report by IPM Coordinator*. November 2008.

City of Palo Alto. *Storm Water Protection*. http://www.cityofpaloalto.org/depts/pwd/news/details.asp?NewsID=336&TargetID=153, accessed December 2008.

County of Los Angeles Department of Public Works. (LADPW). *Storm Water/Urban Runoff Public Education Model Program.* Fiscal Year 2002.

County of San Diego. *Low Impact Development Handbook: Stormwater Management Strategies. December 2007.*

County of Santa Barbara. *Green Gardener Program– How it Works.* http://www.greengardener.org/how_it_works.htm. November 2008. Accessed December 2008.

Dominguez Channel Watershed Management Area Committee (DCWMAC). *Annual Assessment*. Permit Year 2006-2007. http://ladpw.org/wmd/npdesrsa/annualreport/2007%5CAppendix%20F%20-%20Dominguez%20Channel%20&%20LA%20Harbor%20WMA%5CWatershed%20Assess

ment%5C%5CDC-Watershed%20Assessment%20Annual%20Report%20Summary.pdf , accessed December 2008.

Ecology Action. *The Monterey Bay Green Gardener Program "Sample Curriculum".* www.green-gardener.org/about. 2007. Accessed December 2008.

EOA, Inc. *Santa Clara Valley Urban Runoff Pollution Prevention Program's Urban Runoff Management Plan.* September 2004.

Haver, D., J. Kabashina, L. Oki, S. Bondarenko, J. Gan. *Presentation: Detection of pyrethroid insecticides in surface runoff from residential homes*, SETAC Conference, Milwaukee. 2007.

Institute for Wildlife Studies (IWS). *Restoration and Management of Bald Eagles on Santa Catalina Island, California*. January 2007.

Jamescourie, Rebecca. *Students Learn of Pollution's Effects.* http://www.nctimes.com/articles/2004/04/28/special_reports/science_technology/20_40_404_27_04.txt. North County Times, Tuesday April 27, 2004. Accessed December 2008.

Library of Congress, Thomas Online. *Search Bill Text for the 110th Congress (2007-2008).* http://thomas.loc.gov/home/c110query.html, keyword = pyrethroid. Accessed December 2008.

Matteson, Patricia, Wilhoit, and Robertson, Mark. *Environmental Justice Pilot Project Pest Management Assessment: Soil Fumigant and Organophosphate Insecticide Use and Alternatives – Parlier, Fresno County, California.* October 2007.

NAHB Research Center. *Municipal Guide to Low Impact Development.* http://www.lowimpactdevelopment.org/lid%20articles/Municipal_LID.pdf. Accessed December 2008.

National Institute of Health (NIH). *BMBL Appendix G: Integrated Pest Management*. http://bmbl.od.nih.gov/appendg.htm. June 1999. Accessed December 2008.

National Pesticide Telecommunications Network (NTPN). *Fact Sheet: Permethrin*. September 1997.

Oki, Loren, UC Davis, *personal communication with Armand Ruby*, Dec. 22, 2008

Our Water, Our World. *Less Toxic Product List.* http://www.ourwaterourworld.org/Portals/0/documents/pdf/products_by_pests.pdf . May 2007, accessed December 2008.

Prince Georges County, Maryland, Department of Environmental Resources (PG County). *Low-Impact Development Design Strategies: An Integrated Approach.* June 1999.

Quarles, William, Brandenburg, Bart, and Drlik, Tanya. *Pest Control Operator IPM Program Evaluation*. September 2002.

Raphael, Debbie. Johnson, Brian. *City of Santa Monica Toxics Use Reduction Program Integrated Pest Management*. June 1997.

Riverside County Flood Control and Water Conservation District. *Drainage Area Management Plan - Santa Ana and Santa Margarita Regions.* July 2005.

Riverside County Flood Control and Water Conservation District. *Riverside County – Santa Margarita Region Pyrethroid Source Identification Toxicity Reduction Evaluation Status Report*. October 2008.

Ruby, Armand. *Pyrethroids Monitoring Data Compilation, Memorandum to CASQA Board of Directors, Executive Program Committee, and Pesticides Subcommittee (and attachments)*. July 2008.

Santa Clara Valley Urban Runoff Pollution Prevention Program. *Commercial Site Design Examples.* February 2007.

San Francisco Estuary Project. www.sfestuary.com, 2007. Accessed December 2008.

State of California. *Best Practices Manual: Building Maintenance – Structural Integrated Pest Management* http://www.green.ca.gov/EPP/building/structipm.htm. Accessed December 2008.

State of California. *Official California Legislative Information.* http://www.leginfo.ca.gov/bilinfo.html, keyword = pyrethroid. Accessed December 2008.

TDC Environmental, LLC. *Diazinon & Chlorpyrifos Products: Screening for Water Quality Implications*. May 2001.

TDC Environmental, LLC. *Improving Urban Pesticide Regulatory Activities to Protect Water Quality – Annual Update 2007.* November 2007.

United States Environmental Protection Agency (EPA*). National Pollutant Discharge Elimination System (NPDES) Phase II BMP & Measurable Goal Examples: Public Education and Outreach on Stormwater Impacts Minimum Measure*. February, 2008.

United States Environmental Protection Agency (EPA). *Stormwater Management at EPA Headquarters.* May 2007.

University of California, Davis (UC Davis). *UC IPM Online – How to Manage Pests - Ants.* http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7411.html#MANAGEMENT. February, 2007. Accessed December 2008.

UP3 Project. *Draft Proposed Early Risk Mitigation Labeling for Pyrethroid Non-Agricultural End Use Products.* www.up3project.org/documents/LabelTable11-18-08.pdf. November 2008. Accessed December 2008.

Ventura Countywide Stormwater Quality Management Program (VCSQMP). *Technical Guidance Manual for Stormwater Quality Control Measures*. July 2002.

Weston, D.P., R. W. Holmes, J. You, and M. J. Lydy. *Aquatic Toxicity Due to Residential Use of Pyrethroid Pesticides, ES&T 39 (24), 9778 -9784.* 2005.

Wilen, Cheryl A, Ph.D. *Survey of Residential Pesticide Use and Sales in the San Diego Creek Watershed of Orange County, California*. October 2001.

Wilen, Cheryl A, Ph.D. *Tracking Non-residential pesticide use in Urban Areas of California*. June 2005.

Appendix C
Effectiveness Assessments for the Watershed Workplan

Watershed Workplan

Measureable Metrics Collected *(Data Compiled Annually)*	**Highest Potential CASQA Outcome Level** *1 - Documenting Activities* *2 - Raising Awareness* *3 - Changing Behavior* *4 - Reducing Loads* *5 - Improving Runoff Quality* *6 - Protecting Receiving Water Quality*	**Assessment Interval** *(how frequently the annually collected data will be assessed for meeting potential CASQA Outcome Levels)*	**Outcome Timeframe** *(time at which program will be reassessed if desired outcome has not been achieved)*
Annual Public Review Meeting conducted	1	Annual	Annual
Updated Characterization of Receiving Water Quality	1	Annual	Annual
Updated prioritization of water quality problems	1	Annual	Annual
Descriptions of likely sources updated	1	Annual	Annual
Updated BMP Implementation Strategy	1	Annual	Annual
BMPs implemented according to schedule	1	Annual	Annual
Number of Collaborative Meetings Attended	1	Annual	Annual
Numeric Nutrient Endpoints Study	6	ROWD	5+ Years
Brake Pad Legislation	3	ROWD	5+ years
Pyrethroid Toxicity Reduction Evaluation plan implemented	3	ROWD	5+ Years