Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Creek Status Monitoring Report

Water Year 2018 (October 2017 – September 2018)

Submitted in compliance with Provision C.8.h.iii of NPDES Permit No. CAS612008, Order No. R2-2015-049

March 31, 2019

PREFACE

In early 2010, several members of the Bay Area Stormwater Agencies Association (BASMAA) joined together to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by the Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (in this document the permit is referred to as the MRP).[1] The RMC includes the following participants:

- Alameda Countywide Clean Water Program (ACCWP)
- Contra Costa Clean Water Program (CCCWP)
- San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)
- Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)
- Fairfield-Suisun Urban Runoff Management Program (FSURMP)
- City of Vallejo and Vallejo Flood and Wastewater District (Vallejo)

This Creek Status Monitoring Report complies with provision C.8.h.iii of the MRP for reporting of all data in Water Year 2018 (October 1, 2017 through September 30, 2018). Data were collected pursuant to provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) of the MRP. Data presented in this report were produced under the direction of the RMC and the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) using probabilistic and targeted monitoring designs as described herein.

Consistent with the Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), monitoring data were collected in accordance with the most recent versions of the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2016a) and the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2016b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP)[2]. Data presented in this report were submitted in electronic SWAMP-comparable formats by SCVURPPP to the San Francisco Bay Regional Water Quality Control Board on behalf of SCVURPPP Co-permittees and pursuant to provision C.8.h.ii of the MRP.

[1] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) issued the MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). On November 19, 2015, the Regional Water Board updated and reissued the MRP (SFRWQCB 2015). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

[2] The current SWAMP QAPrP is available at: https://www.waterboards.ca.gov/water_issues/programs/swamp/qapp/swamp_QAPrP_2017_Final.pdf

LIST OF ACRONYMS

ACCWP	Alameda Countywide Clean Water Program
AFDM	Ash Free Dry Mass
AFS	American Fisheries Society
ASCI	Algae Stream Condition Index
BASMAA	Bay Area Stormwater Management Agency Association
BMI	Benthic Macroinvertebrate
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
COLD	Cold Freshwater Habitat
CSCI	California Stream Condition Index
DF	Detection Frequency
DO	Dissolved Oxygen
DPR	Department of Pesticide Regulation
DPS	Distinct Population Segment
EPA	Environmental Protection Agency
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information Systems
GRTS	Generalized Random Tessellation Stratified
IBI	Indices of Biotic Integrity
IMR	Integrated Monitoring Report
IPI	Index Physical Habitat Integrity
IWRMP	Integrated Water Resources Management Plan
LID	Low Impact Development
MDL	Method Detection Limit
MIGR	Fish Migration
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MUN	Municipal and Domestic Water Supply
MWAT	Maximum Weekly Average Temperature
NMFS	National Marine and Fisheries Services
NPDES	National Pollution Discharge Elimination System
O/E	Observed to Expected
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEC	Probable Effects Concentrations
PHAB	Physical Habitat Assessment
pMMI	Predictive Multimetric Index
PSA	Perennial Streams Assessment
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
RARE	Preservation of Rare and Endangered Species
RM	Reporting Module
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWB	Reachwide Benthos

SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water District
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SMC	Southern California Monitoring Coalition
SMCWPPP	San Mateo County Water Pollution Prevention Program
SPoT	Stream Pollution Trends
SPWN	Fish Spawning
SOP	Standard Operating Protocol
SSID	Stressor/Source Identification
STV	Statistical Threshold Value
SURF	Surface Water Database
SWAMP	Surface Water Ambient Monitoring Program
SWPP	Surface Water Protection Program
TEC	Threshold Effects Concentrations
TMDL	Total Maximum Daily Load
TNS	Target Non-Sampleable
TOC	Total Organic Carbon
TS	Target Sampleable
TST	Test of Significant Toxicity
TU	Toxicity Unit
UCMR	Urban Creeks Monitoring Report
WARM	Warm Freshwater Habitat
USEPA	Environmental Protection Agency
WQ	Water Quality
WQO	Water Quality Objective
WY	Water Year

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1.0 INTRODUCTION

This Creek Status Monitoring Report was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water District), which are subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009; referred to as MRP 1.0). On November 19, 2015, the SFRWQCB updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015; referred to as MRP 2.0). This report fulfills the requirements of provision C.8.h.iii of the MRP for comprehensively interpreting and reporting all Creek Status and Pesticides & Toxicity monitoring data collected during the foregoing October 1 – September 30 (i.e., Water Year 2018).[3] Data were collected pursuant to water quality monitoring requirements in provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) of the MRP. Monitoring data presented in this report were submitted electronically to the SFRWQCB by SCVURPPP and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN).[4]

Sections of this report are organized according to the following topics:

- **Section 1.0** – Introduction including overview of the Program goals, background, monitoring approach, and statement of data quality
- **Section 2.0** – Biological condition assessment and stressor analysis at probabilistic sites
- **Section 3.0** – Continuous water quality monitoring (temperature, general water quality)
- **Section 4.0** – Pathogen indicators
- **Section 5.0** – Chlorine monitoring
- **Section 6.0** – Pesticides & Toxicity monitoring
- **Section 7.0** – Conclusions and recommendations

[3] Monitoring data collected pursuant to other C.8 provisions (e.g., Pollutants of Concern Monitoring, Stressor/Source Identification Monitoring Projects) are reported in the SCVURPPP Urban Creeks Monitoring Report (UCMR) for WY 2018 to which this Creek Status Monitoring Report is appended.

[4] (http://water100.waterboards.ca.gov/ceden/sfei.shtml)

1.1 Monitoring Goals

Provision C.8.d of the MRP requires Permittees to conduct creek status monitoring that is intended to answer the following management questions:

1. ***Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers, and tributaries?***
2. ***Are conditions in local receiving water supportive of or likely supportive of beneficial uses?***

The first management question is addressed primarily through the evaluation of probabilistic and targeted monitoring data with respect to the triggers defined in the MRP. (A summary of trigger exceedances observed for each site is presented in Table 7.1.) Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses and are considered for future evaluation of Stressor/Source identification (SSID) projects.

The second management question is addressed by assessing indicators of beneficial uses. For example, the indices of biological integrity based on benthic macroinvertebrate and algae data are direct measures of aquatic life beneficial uses. Continuous monitoring data (temperature, dissolved oxygen, pH, and specific conductance) are evaluated with respect to COLD and WARM Beneficial Uses. Pathogen indicator data are used to assess REC-1 (water contact recreation) Beneficial Uses.

Creek Status and Pesticides & Toxicity monitoring parameters, methods, occurrences, durations and minimum number of sampling sites are described in provisions C.8.d and C.8.g of the MRP, respectively. The monitoring requirements in the 2015 MRP are similar to the 2009 MRP requirements (which began implementation on October 1, 2011) and build upon earlier monitoring conducted by SCVURPPP between 2002 and 2009. Creek Status and Pesticides & Toxicity monitoring is coordinated through the Regional Monitoring Coalition (RMC). Monitoring results are evaluated to determine whether triggers are met and further investigation is warranted as a potential Stressor/Source Identification (SSID) Project, as described in provision C.8.e of the MRP. Results of Creek Status Monitoring conducted in Water Years 2012 through 2017 were submitted in prior reports (SCVURPPP 2018, SCVURPPP 2017, SCVURPPP 2016, SCVURPPP 2015, SCVURPPP 2014, SCVURPPP 2013).

1.2 Regional Monitoring Coalition

Provision C.8.a (Compliance Options) of the MRP allows Permitees to address monitoring requirements through a regional collaborative effort, their Stormwater Program, and/or individually. The RMC was formed in early 2010 as a collaboration among a number of the Bay Area Stormwater Management Agencies Association (BASMAA) members and MRP Permittees (Table 1.1) to develop and implement a regionally coordinated water quality monitoring program to improve stormwater management in the region and address water quality monitoring required by the MRP.[5] Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012) allows Permittees and the Regional Water Board to improve their ability to collectively answer core management questions in a cost-effective and scientifically rigorous

[5] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) issued the first five-year MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

way. Participation in the RMC is facilitated through the BASMAA Monitoring and Pollutants of Concern (MPC) Committee.

Table 1.1. Regional Monitoring Coalition (RMC) participants.

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San José, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo County Wide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Flood and Wastewater District

The goals of the RMC are to:

1. Assist Permittees in complying with requirements in provision C.8 (Water Quality Monitoring) of the MRP;
2. Develop and implement regionally consistent creek monitoring approaches and designs in the Bay Area, through the improved coordination among RMC participants and other agencies (e.g., Regional Water Board) that share common goals; and
3. Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining reporting.

The RMC's monitoring strategy for complying with Creek Status monitoring is described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). The strategy includes regional ambient/probabilistic monitoring and local "targeted" monitoring. The combination of these two components allows each individual RMC participating program to assess the status of beneficial uses in local creeks within its jurisdictional area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks). The current MRP, updated and reissued in 2015, specifically prescribes the probabilistic/targeted approach and most of the other details of the RMC Creek Status and Long-Term Trends Monitoring Plan. Table 1.2 provides a list of which parameters are included in the probabilistic and targeted programs in the 2015 MRP. This report includes data collected in Santa Clara County under both monitoring components. Data are organized into report Sections that reflect the format of monitoring requirements in the MRP.

Table 1.2. Creek Status Monitoring parameters in compliance with MRP provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) and associated monitoring component.

Monitoring Elements	Monitoring Component		Report Section
	Regional Ambient (Probabilistic)	Local (Targeted)	
Creek Status Monitoring (C.8.d)			
Bioassessment & Physical Habitat Assessment	X	X[1]	2.0
Nutrients	X	X[1]	2.0
General Water Quality (Continuous)		X	3.0
Temperature (Continuous)		X	3.0
Pathogen Indicators		X	4.0
Chlorine	X	X[2]	5.0
Pesticides & Toxicity Monitoring (C.8.g)			
Water Toxicity		X	6.0
Sediment Toxicity		X	6.0
Sediment Chemistry		X	6.0

Notes:
[1] Provision C.8.d.i.(6) allows for up to 20% of sample locations to be selected on a targeted basis.
[2] Provision C.8.d.ii.(2) provides options for probabilistic or targeted site selection. In WY 2018, chlorine was measured at probabilistic sites.

1.3 Monitoring and Data Assessment Methods

1.3.1 Monitoring Methods

Water quality data were collected in accordance with California Surface Water Ambient Monitoring Program (SWAMP) comparable methods and procedures described in the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA 2016a) and the associated Quality Assurance Project Plan (QAPP; BASMAA 2016b). These documents are updated as needed to maintain their currency and optimal applicability. Where applicable, monitoring data were collected using methods comparable to those specified by the SWAMP Quality Assurance Program Plan (QAPrP)[6], and were submitted in SWAMP-compatible format to the SFRWQCB. The SOPs were developed using a standard format that describes health and safety cautions and considerations, relevant training, site selection, and sampling methods/procedures, including pre-fieldwork mobilization activities to prepare equipment, sample collection, and de-mobilization activities to preserve and transport samples.

[6] The current SWAMP QAPrP is available at: https://www.waterboards.ca.gov/water_issues/programs/swamp/qapp/swamp_QAPrP_2017_Final.pdf

1.3.2 Laboratory Analysis Methods

RMC participants, including SCVURPPP, agreed to use the same laboratories for individual parameters (except pathogen indicators), developed standards for contracting with the labs, and coordinated quality assurance samples. All samples collected by RMC participants that were sent to laboratories for analysis were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2016b). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also described in BASMAA (2016a). Analytical laboratory contractors included:

- BioAssessment Services, Inc. – Benthic macroinvertebrate (BMI) identification
- EcoAnalysts, Inc. – Algae identification
- CalTest, Inc. – Sediment chemistry, nutrients, chlorophyll a, ash free dry mass
- Pacific EcoRisk, Inc. - Water and sediment toxicity
- Alpha Analytical – Pathogen indicators

1.3.3 Data Analysis Methods

Monitoring data generated during WY 2018 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of water quality objectives (WQOs). Creek Status Monitoring and Pesticides & Toxicity Monitoring data must be evaluated with respect to numeric thresholds (i.e., triggers), specified in the “Followup” sections in provision C.8.d and C.8.g of the MRP (SFRWQCB 2015) that, if not met, require consideration for further evaluation as part of a Stressor/Source Identification project. SSID projects are intended to be oriented toward taking action(s) to alleviate stressors and reduce sources of pollutants. A stepwise process for conducting SSID projects is described in provision C.8.e.iii.

In compliance with provision C.8.e.i of the MRP, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Followup SSID projects are selected from this list.

1.4 Setting

1.4.1 Watersheds Monitored by SCVURPPP

There are 13 major watersheds within the SCVURPPP jurisdictional boundaries and these watersheds comprise most of the Santa Clara Basin. The watersheds are mapped in Figure 1.1 and their major characteristics are listed in Table 1.3. The Santa Clara Basin, San Francisco Bay south of the Dumbarton Bridge, and the 840 square miles that drain to it, are bounded by the Diablo Mountains on the east and the Santa Cruz Mountains on the west and south. Elevations range from sea level at the Bay to almost 4,000 feet in the Santa Cruz Mountains. There is a distinct transition in geography and land use at elevations of 600 to 800 feet. Areas above this elevation generally have steeper slopes and are largely forest, rangeland, or open space; below this threshold, an urbanized landscape dominates. Most watersheds have their headwaters in the undeveloped mountains and drain north through urbanized areas to the Bay. Flows in the lower reaches of most watersheds are controlled by the presence of water supply reservoirs that are managed by the Santa Clara Valley Water District (SCVWD) and other agencies. Many of the reservoirs are constructed at the transition between the Santa Clara Valley and the surrounding foothills. Water is captured during the winter rainy season and released in the spring at managed rates to allow for percolation through the stream bed and to protect fish habitat downstream of the reservoirs. To varying degrees, portions of all watersheds within the urban zone have been engineered or placed within underground culverts. The Sunnyvale East and West Channel watersheds contain no natural creek bed at all; they were constructed in the 1960s to manage flooding.

Table 1.3. Characteristics of major watersheds within SCVURPPP boundary.

Watershed	Area (square miles)	Number of Tributary Creeks	Natural Creek Bed (Miles)	Engineered Channel (Miles)	Underground Culvert or Stormdrain (Miles)	Impervious Area	Land Use				
							Residential	Industrial/ Commercial	Forest	Rangeland	Other
Adobe	11.0	7	18.8	2.3	12.0	44.7%	46.5%	11.8%	36.3%	2.7%	2.7%
Barron	15.6	5	15.1	7.9	28.6	60.3%	60.5%	20.1%	7.3%	7.0%	5.1%
Calabazas	20.3	6	12.9	14.1	55.5	NA	54.5%	29.4%	8.8%	5.2%	2.1%
Coyote	321	53	670	36.4	146	11.1%	8.6%	3.7%	49.9%	29.6%	8.2%
Guadalupe	171	50	207	45.5	265	37.1%	29.6%	13.6%	34.7%	15.5%	6.6%
Lower Penitencia	28.6	13	29.2	20.8	61.6	42.9%	30.7%	19.0%	1.1%	38.7%	10.5%
Matadero	14.0	3	18	NA	NA	60.3%	57.1%	5.8%	8.9%	8.2%	20%
Permanente	17.3	7	NA	NA	NA	43.9%	46.3%	13.1%	35.0%	2.8%	2.8%
San Francisquito	42.8	25	90.6	4.8	15.3	20.8%	29.6%	5.2%	44.7%	15.0%	5.5%
San Tomas Aquino	44.8	15	50.5	15.5	79.3	60.1%	53.9%	18.8%	23.7%	0.8%	2.8%
Stevens	29.2	12	54.2	1.1	30.0	28.6%	24.5%	9.0%	49.2%	12.5%	4.8%
Sunnyvale East	7.1	0	0	6.2	26.6	82.2%	65.3%	31.8%	0%	0%	2.9%
Sunnyvale West	7.6	0	0	6.7	18.7	72.4%	20.9%	65.2%	0%	0%	13.9%

Source: http://www.scvurppp-w2k.com/watersheds.shtml
NA – not available

WY 2018 Creek Status and Pesticides and Toxicity Monitoring Stations

The complete list of probabilistic and targeted monitoring sites sampled by SCVURPPP in WY 2018 in compliance with provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides and Toxicity Monitoring) is presented in Table 1.4. Monitoring locations with monitoring parameter(s) are mapped in Figure 1.2. Probabilistic station numbers, generated from the RMC Sample Frame, are provided for all bioassessment locations. Targeted stations numbers, based on SWAMP station numbering methods (BASMAA 2016a), are provided for all targeted monitoring sites.

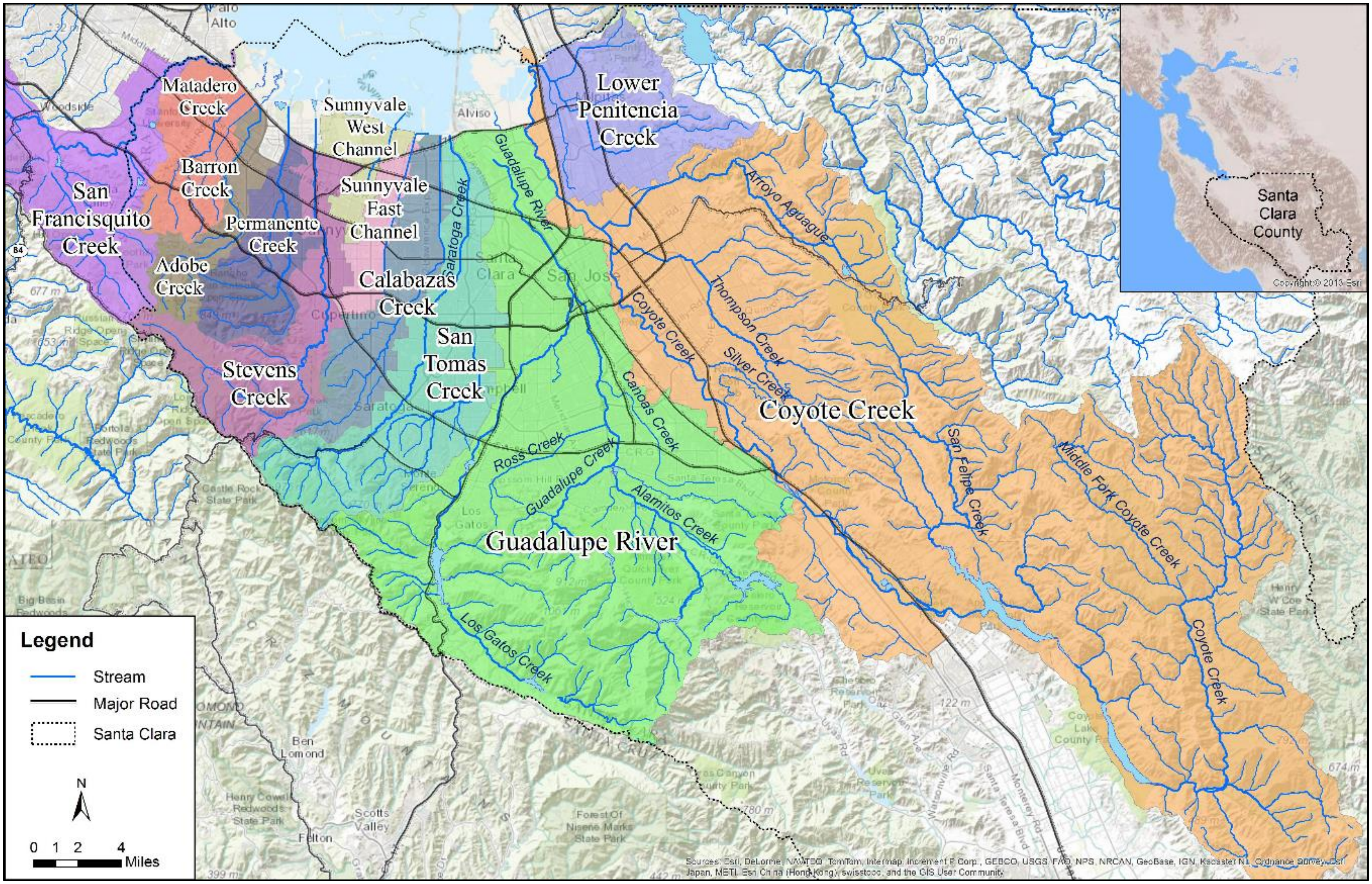

Figure 1.1. Watersheds within SCVURPPP jurisdictional boundaries.

Table 1.4. Sites and parameters monitored in WY 2018 in Santa Clara County.

Map ID [1]	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassessment, Nutrients, General WQ	Chlorine	Pesticides & Toxicity	Temp [2]	Cont WQ [3]	Pathogen Indicators
749	204R00749	Alameda Creek	Smith Creek	NU	37.31672	-121.65057	X	X				
746	205R00746	San Tomas Aquino	Saratoga Creek	NU	37.25201	-122.06016	X	X				
769	205R00769	Coyote Creek	MF Coyote Creek	NU	37.21998	-121.54206	X	X				
3498	205R03498	San Tomas Aquino	Saratoga Creek	U	37.25747	-122.03631	X	X				
3562	205R03562	San Tomas Aquino	Saratoga Creek	U	37.25258	-122.04500	X	X				
3591	205R03591	San Francisquito Cr	Los Trancos Creek	U	37.35238	-122.19713	X	X				
3619	205R03619	San Tomas Aquino	Saratoga Creek	U	37.30297	-121.99653	X	X				
3683	205R03683	Permanente Creek	Permanente Creek	U	37.33985	-122.09228	X	X				
3699	205R03699	Permanente Creek	Hale Creek	U	37.36703	-121.69869	X	X				
3738	205R03738	Coyote Creek	Upper Silver Creek	U	37.28625	-121.77795	X	X				
3754	205R03754	San Tomas Aquino	San Tomas Aquino	U	37.25954	-121.99221	X	X				
3795	205R03795	Coyote Creek	Lower Silver Creek	U	37.35770	-121.85820	X	X				
3825	205R03825	Coyote Creek	Thompson Creek	U	37.28066	-121.75541	X	X				
3843	205R03843	San Tomas Aquino	San Tomas Aquino	U	37.38186	-121.96843	X	X				
3847	205R03847	San Francisquito Cr	Los Trancos Creek	U	37.38068	-122.19441	X	X				
3875	205R03875	Calabazas Creek	Calabazas Creek	U	37.31483	-122.01634	X	X				
3907	205R03907	Lower Penitencia	Lower Penitencia	U	37.43624	-121.91424	X	X				
4190	205R04190	Guadalupe River	Guadalupe Creek	U	37.23516	-121.89116	X	X				
4217	205R04217	Coyote Creek	Upper Penitencia	U	37.40062	-121.74910	X	X				
4266	205R04266	Calabazas Creek	Calabazas Creek	U	37.29627	-122.02921	X	X				
400	205LGA400	Guadalupe River	Los Gatos Creek	U	37.31830	-122.06197						X
30	205MAT030	Matadero Creek	Matadero Creek	U	37.41001	-122.13823						X
64	205STE064	Stevens Creek	Stevens Creek	U	37.25764	-122.03561						X
225	205GUA225	Guadalupe River	Arroyo Calero	U	37.23878	-121.97094						X
75	205SAR075	San Tomas Aquino	Saratoga Creek	U	37.21416	-121.83447						X
190	205GUA190	Guadalupe River	Guadalupe Creek	U	37.24373	-121.87561				X		
202	205GUA202	Guadalupe River	Guadalupe Creek	U	37.23291	-121.89795				X		
210	205GUA210	Guadalupe River	Guadalupe Creek	U	37.21746	-121.91039				X		
218	205GUA218	Guadalupe River	Guadalupe Creek	U	37.2028	-121.88845				X		
250	205GUA250	Guadalupe River	Alamitos Creek	U	37.23363	-121.87058				X		
255	205GUA255	Guadalupe River	Alamitos Creek	U	37.22607	-121.85842				X		
262	205GUA262	Guadalupe River	Alamitos Creek	U	37.22041	-121.84516				X		
270	205GUA270	Guadalupe River	Alamitos Creek	U	37.20129	-121.82891				X		

Map ID [1]	Station ID	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
							Bioassessment, Nutrients, General WQ	Chlorine	Pesticides & Toxicity	Temp [2]	Cont WQ [3]	Pathogen Indicators
279	205GUA279	Guadalupe River	Alamitos Creek	U	37.17409	-121.82409				X		
235	205COY235	Coyote Creek	Coyote Creek	U	37.3536	-121.87417					X	
236	205COY236	Coyote Creek	Coyote Creek	U	37.35098	-121.87378					X	
239	205COY239	Coyote Creek	Coyote Creek	U	37.33722	-121.86953					X	
18	205CAL018	Calabazas Creek	Calabazas Creek	U	37.38760	-121.98690			X			
21	205STE021	Stevens Creek	Stevens Creek	U	37.40985	-122.06906			X			
10	205STQ010	San Tomas Aquino	San Tomas Aquino	U	37.38843	-121.96865			X			

U = urban, NU = non-urban

[1] Map ID applies to Figure 1.2.

[2] Temperature monitoring was conducted continuously (i.e., hourly) April through September.

[3] Continuous water quality monitoring (temperature, dissolved oxygen, pH, specific conductivity) was conducted during two 2-week periods (spring and late summer).

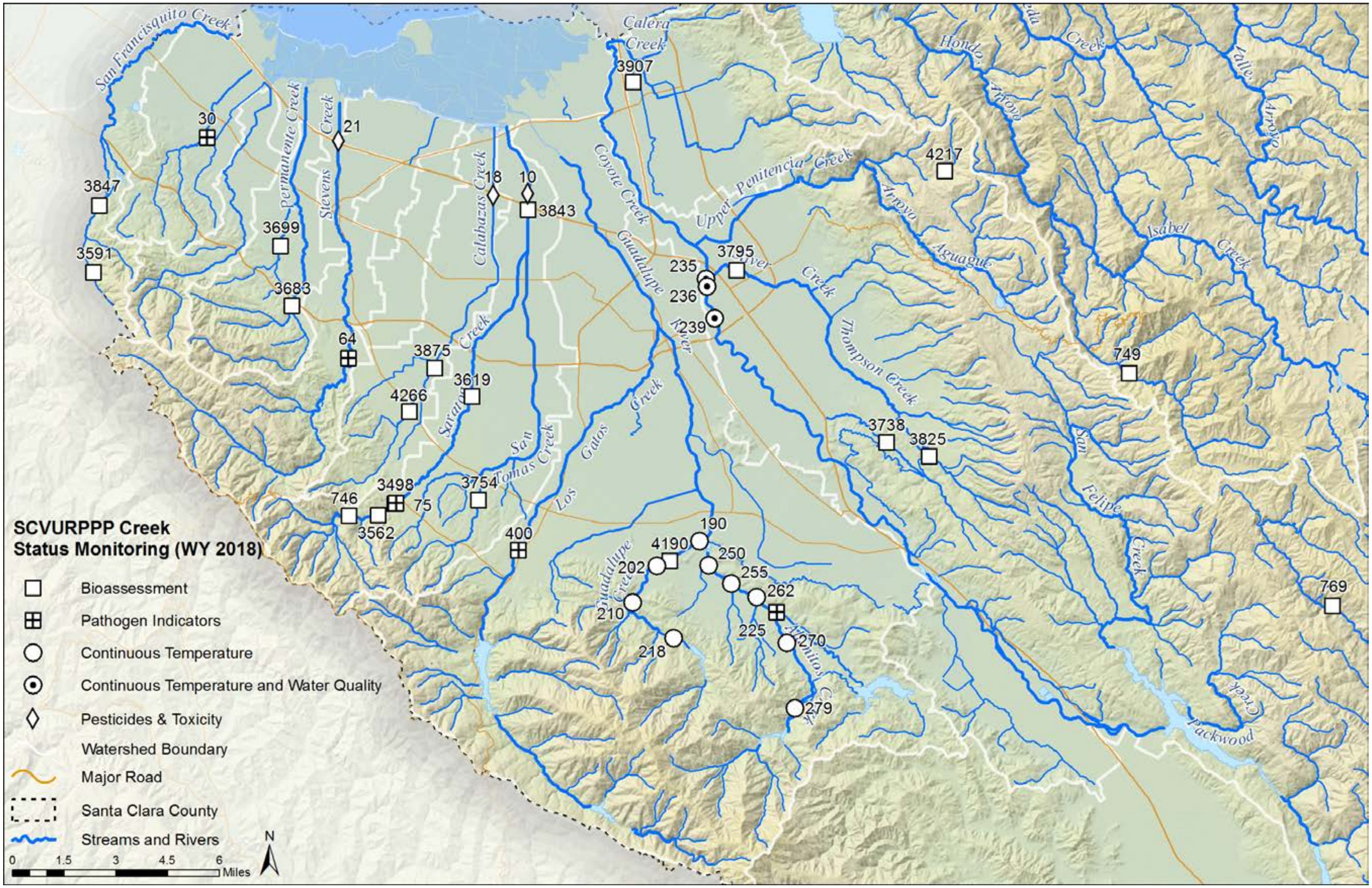

Figure 1.2. Map of SCVURPPP Program Area, major creeks, and sites monitored in WY 2018.

1.4.2 Designated Beneficial Uses

Beneficial Uses in Santa Clara Valley creeks are designated by the SFRWQCB for specific water bodies and generally apply to all its tributaries. Uses include aquatic life habitat, recreation, agriculture, groundwater recharge, and municipal and commercial supply. Table 1.5 lists Beneficial Uses designated by the SFRWQCB (2017) for water bodies monitored by SCVURPPP in WY 2018.

Table 1.5. Creeks monitored by SCVURPPP in WY 2018 and their Beneficial Uses (SFRWQCB 2017).

Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
Alamitos Creek			E	E					E			E	E	E	E	E	E	E	
Arroyo Calero			E						E			E	E	E	E	E	E	E	
Calabazas Creek	E			E					E						E	E	E	E	
Guadalupe Creek			E	E					E			E	E	E	E	E	E	E	
Hale Creek									E						E	E	E	E	
Los Gatos Creek		E	E	E					E			P	E	P	E	E	E	P	
Los Trancos Creek									E			E	E	E	E	E	E	E	
Lower Penitencia															E	E	E	E	
Lower Silver Creek															E	E	E	E	
Matadero Creek									E			E	E	E	E	E	E	E	
MF Coyote Creek[1]				E			E		E			E	E	E	E	E	E	E	
Permanente Creek				E					E				E	E	E	E	E	E	
San Tomas Aquino									E				E		E	E	E	E	
Saratoga Creek	E		E	E					E						E	E	E	E	
Smith Creek		E	E						E						E	E	E	E	
Stevens Creek			E	E					E			E	E	E	E	E	E	E	
Thompson Creek															E	E	E	E	
Upper Penitencia			E	E					E			E	E	E	E	E	E	E	
Upper Silver Creek													E		E	E	E	E	

Notes:
[1] No Beneficial Uses listed specifically for waterbody, beneficial uses listed are for main stem Coyote Creek (non-tidal).
E = Existing Use, P = Potential Use, L = Limited Use

AGR = Agricultural Supply
COLD = Cold Fresh Water Habitat
FRSH = Freshwater Replenishment
GWR - Groundwater Recharge
MIGR = Fish Migration
MUN = Municipal and Domestic Water
SHELL = Shellfish Harvesting
IND = Industrial Service Supply
EST = Estuarine
NAV = Navigation
RARE= Preservation of Rare and Endangered Species
REC-1 = Water Contact Recreation
SPWN = Fish Spawning
COMM = Commercial, and Sport Fishing
REC-2 = Non-contact Recreation
WARM = Warm Freshwater Habitat
WILD = Wildlife Habitat
PROC = Industrial Process Supply
MAR = Marine Habitat

1.4.3 Climate

The Santa Clara Valley experiences a Mediterranean-type climate with cool, wet winters and hot, dry summers. The area is characterized by microclimates created by topography, ocean currents, fog exposure, and onshore winds. The wet season typically extends from October through April with local long-term, mean annual precipitation ranging from 15 inches near the Bay to over 55 inches along the highest ridges in the Santa Cruz Mountains (PRISM Climate Group 30-year normals, 1981-2010[7]). Figure 1.3 illustrates the geographic variability of mean annual precipitation in the area. It is important to understand that mean annual precipitation depths are statistically calculated or modeled; actual measured precipitation in a given year rarely equals the statistical average. Figure 1.4 illustrates the temporal variability in annual precipitation measured at the Mineta San José International Airport from WY 1946 to WY 2018. Creek Status Monitoring in compliance with the MRP began in WY 2012 which was the first year of a severe statewide drought that persisted through WY 2016. In WY 2018, rainfall was below average but was preceded by a relatively wet year in WY 2017.

The overall Bay Area climate and the specific conditions within any given year are influenced by global climate change. The Climate Change Assessment report for the Bay Area highlights several impacts of climate change that are already being felt: the Bay Area's average annual maximum temperature increased by nearly 1°C from 1950 – 2005, coastal fog along the coast may be less frequent, sea level in the Bay Area has risen over 8 inches (Ackerly et al. 2018). These changes are projected to increase significantly in the coming decades. As a consequence, heat extremes, high year-to-year variability in precipitation, droughts, intense storms, and other events will also increase.

Climate patterns (e.g., extended droughts) and individual weather events (e.g., extreme storms, hot summers) influence biological communities (i.e., vegetation, wildlife) and their surrounding physical habitat and water quality. They should therefore be considered when evaluating the type of data collected by the Creek Status Monitoring Program. For example, periods of drought (rather than individual dry years) can result in changes in riparian and upland vegetation communities. Long drought periods are associated with increased streambed sedimentation which can persist directly or indirectly for many years, depending on the occurrence and magnitude of flushing flow events. Furthermore, in response to prolonged drought, the relative proportion of pool habitat can increase at the expense of riffle habitat. In addition, during severe droughts, water management agencies (such as the SCVWD) may also decrease the magnitude and duration of reservoir releases.

It is uncertain what effect these factors have on indices of biotic integrity (IBIs) that are calculated using data collected by the Creek Status Monitoring Program, such as benthic macroinvertebrates or algae. A study evaluating 20 years of bioassessment data collected in northern California showed that, although benthic macroinvertebrate taxa with certain traits may be affected by dry (and wet) years and/or warm (and cool) years, IBIs based on these organisms appear to be resilient (Mazor et al. 2009, Lawrence et al. 2010). However, this study did not specifically examine the impact of longer *periods* of extended drought or heat on IBIs, which would require analysis of a dataset with a much longer period of record. The Herbst Lab at the Sierra Nevada Aquatic Research Laboratory, University of California Santa Barbara is currently exploring how changing climate affects Sierra Nevada stream ecosystems.

[7] http://www.prism.oregonstate.edu/normals/

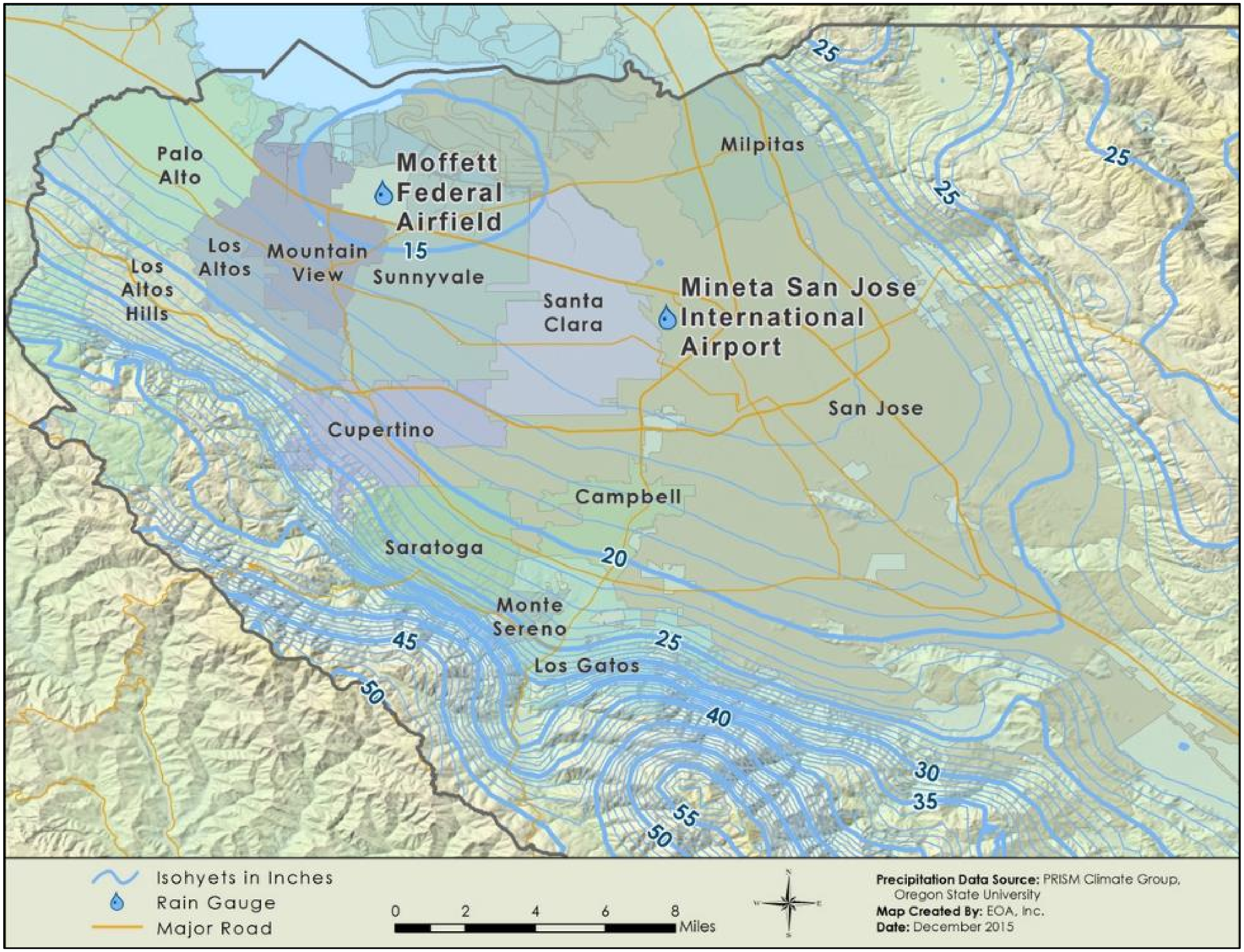

Figure 1.3. Average annual precipitation in Santa Clara Valley, as modeled by the PRISM Climate Group for the period of 1981-2010.

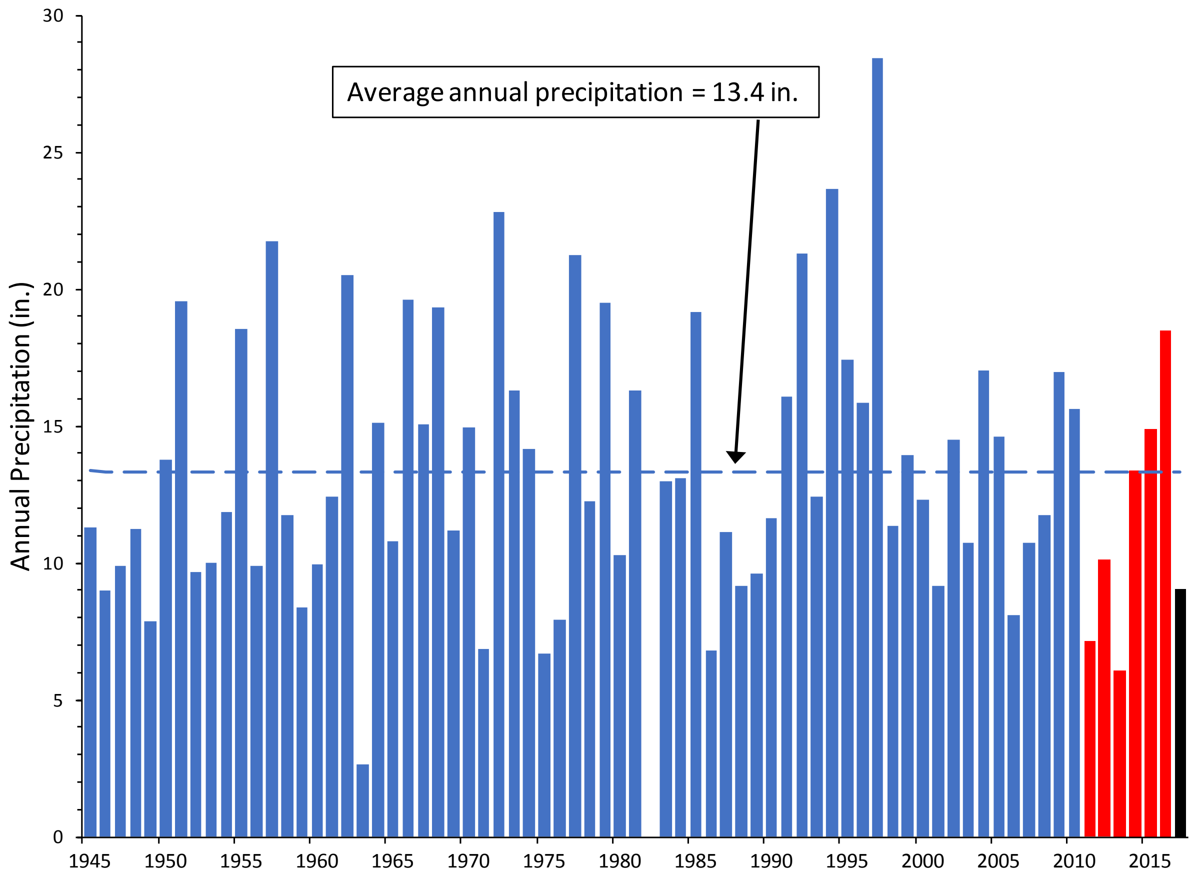

Figure 1.4. Annual rainfall recorded at the San José Airport, WY 1946 – WY 2018.

1.5 Statement of Data Quality

A comprehensive Quality Assurance/Quality Control (QA/QC) program was implemented by SCVURPPP covering all aspects of the probabilistic and targeted monitoring. In general, QA/QC procedures were implemented as specified in the BASMAA RMC QAPP (BASMAA, 2016a), and monitoring was performed according to protocols specified in the BASMAA RMC SOPs (BASMAA, 2016b), and in conformity with methods specified by the SWAMP QAPrP[8]. A detailed QA/QC report is included as Attachment 1.

Based on the QA/QC review, some WY 2018 data were flagged and/or rejected. However, overall, WY 2018 data met QA/QC objectives.

[8] The current SWAMP QAPrP is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf

2.0 BIOLOGICAL CONDITION ASSESSMENT

2.1 Introduction

In compliance with Creek Status Monitoring provision C.8.d.i, SCVURPPP conducted bioassessment monitoring in WY 2018. All bioassessment monitoring was performed at sites selected randomly using the probabilistic monitoring design[9]. The probabilistic monitoring design allows each individual RMC participating program to objectively assess overall stream ecosystem conditions within its program area (e.g., County boundary) while contributing data to answer regional management questions about water quality and beneficial use condition in San Francisco Bay Area creeks. The survey design provides an unbiased framework for data evaluation that will allow a condition assessment of ambient aquatic life uses within known estimates of precision. The monitoring design was developed to address the management questions for both RMC participating county and overall RMC area described below:

1. *What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are beneficial uses supported?*
    - i. *What is the condition of aquatic life in the urbanized portion of the RMC area; are water quality objectives met and are beneficial uses supported?*
    - ii. *What is the condition of aquatic life in RMC participant counties; are water quality objectives met and are beneficial uses supported?*
    - iii. *To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?*
    - iv. *To what extent does the condition of aquatic life in urban and non-urban creeks differ in each of the RMC participating counties?*
2. *What are major stressors to aquatic life in the RMC area?*
    - i. *What are major stressors to aquatic life in the urbanized portion of the RMC area?*
3. *What are the long-term trends in water quality in creeks over time?*

The first question (i.e., *What is the condition of aquatic life in creeks in the RMC area?*) is addressed by assessing indicators of aquatic biological health at probabilistic sampling locations. Once a sufficient number of samples have been collected, ambient biological condition can be estimated for streams at a regional scale. Over the past seven years (WY 2012 through WY 2018), the SCVURPPP and Regional Water Board have sampled 152 probabilistic sites in Santa Clara County, providing a sufficient sample size to estimate ambient biological condition for both urban and non-urban streams countywide.[10]

The second question (i.e., *What are major stressors to aquatic life in the RMC area?*) is addressed by the collection and evaluation of physical habitat and water chemistry data collected at the probabilistic sites, as potential stressors to biological health. The stressor levels can be compared to biological indicator data through correlation and relative risk analyses. Assessing the extent and relative risk of stressors can help prioritize stressors at a regional scale and inform local management decisions.

[9] The option to conduct 20% of bioassessment surveys at targeted sites was not exercised in WY 2018.

[10] For each of the strata, it is necessary to obtain a sample size of at least 30 in order to evaluate the condition of aquatic life within known estimates of precision. This estimate is defined by a power curve from a binomial distribution (BASMAA 2012).

The third question (i.e., *What are the long-term trends in water quality in creeks over time?*) is addressed by assessing the change in biological condition over several years. Changes in biological condition over time can help evaluate the effectiveness of management actions. Although, long-term trend analysis for the RMC probabilistic survey will require more than seven years of data collection, preliminary trend analysis of biological condition may be possible for some stream reaches using a combination of historical targeted data with the probabilistic data.

This report presents biological indicator data and potential stressor data collected at twenty sites in WY 2018. Data are compared to triggers and water quality objectives identified in the MRP.

A more comprehensive evaluation of regional bioassessment data is presented in the BASMAA RMC 5-Year Bioassessment Report (WY 2012 – WY 2016) (Attachment 2). Summary findings from the report are included in Section 7.1.

2.2 Methods

2.2.1 Probabilistic Survey Design

The RMC probabilistic design was created using the Generalized Random Tessellation Stratified (GRTS) approach developed by the United States Environmental Protection Agency (USEPA) and Oregon State University (Stevens and Olson 2004). GRTS offers multiple benefits for coordinating among monitoring entities, including the ability to develop a spatially balanced design that produces statistically representative data with known confidence intervals. The GRTS approach has been implemented in California by several agencies including the statewide Perennial Streams Assessment (PSA) conducted by Surface Water Ambient Monitoring Program (Ode et al. 2011) and the Southern California Stormwater Monitoring Coalition's (SMC) regional monitoring program conducted by municipal stormwater programs in Southern California (SCCWRP 2007).

Sample sites were selected using the GRTS approach from a sample frame consisting of a creek network geographic information system (GIS) data set within the 3,407-square mile RMC area (BASMAA 2012). The sample frame includes non-tidally influenced perennial and non-perennial creeks within five management units representing areas managed by the stormwater programs associated with the RMC (listed in Table 1.1). There is approximately one site for every stream kilometer in the sample frame. The National Hydrography Plus Dataset (1:100,000) was selected as the creek network data layer to provide consistency with both the Statewide PSA and the SMC, and the opportunity for data coordination with these programs.

Once the master draw was performed, the list of sites was classified by county and land use (i.e., urban and non-urban) to allow for comparisons between these strata. Urban areas were delineated by combining urban area boundaries and city boundaries defined by the U.S. Census (2000). Non-urban areas were defined as the remainder of the RMC area. Some sites classified as urban fall near the non-urban edge of the city boundaries and have little upstream development. For the purposes of consistency, these urban sites were not re-classified. Therefore, data values within the urban classification represent a wide range of conditions.

The RMC participants decided to partition their annual sampling efforts so that approximately 80% are in urban areas and 20% in non-urban areas. In addition, between WY 2012 and WY

2015, the SFRWQCB SWAMP conducted 34 bioassessments throughout the RMC region at non-urban sites selected from the sample frame, including 12 sites in Santa Clara County.[11]

2.2.2 Site Evaluations

Sites identified in the regional sample draw are evaluated by each RMC participant in chronological order using a two-step process described in RMC Standard Operating Procedure FS-12 (BASMAA 2016a), consistent with the procedure described by Southern California Coastal Water Research Project (SCCWRP 2012). Each site is evaluated to determine if it meets the following RMC sampling location criteria:

1. The location (latitude/longitude) provided for a site is located on or is within 300 meters of a non-impounded receiving water body;[12]
2. Site is not tidally influenced;
3. Site is wadeable during the sampling index period;
4. Site has sufficient flow during the sampling index period to support standard operation procedures for biological and nutrient sampling.
5. Site is physically accessible and can be entered safely at the time of sampling;
6. Site may be physically accessed and sampled within a single day;
7. Landowner(s) grant permission to access the site.[13]

In the first step, these criteria were evaluated to the extent possible using a “desktop analysis.” Site evaluations were completed during the second step via field reconnaissance visits. Based on the outcome of site evaluations, sites were classified into one of three categories:

- **Target** – Target sites were grouped into two subcategories:
    - **Target Sampleable (TS)** - Sites that met all seven criteria and were successfully sampled.
    - **Target Non-Sampleable (TNS)** - Sites that met criteria 1 through 4, but did not meet at least one of criteria 5 through 7 were classified as TNS.
- **Non-Target (NT)** - Sites that did not meet at least one of criteria 1 through 4 were classified as non-target status.
- **Unknown (U)** - Sites were classified with unknown status when it could be reasonably inferred either via desktop analysis or a field visit that the site was a valid receiving water body and information for any of the seven criteria was unconfirmed.

All site evaluation information was documented on field forms and entered into a standardized database. The overall percent of sites classified into the three categories can be evaluated to determine the statistical significance of local and regional average ambient conditions calculated from the multi-year dataset.

[11] As of WY 2016, the SFRWQCB SWAMP is no longer conducting RMC-related bioassessment monitoring at probabilistic sites.

[12] The evaluation procedure permits certain adjustments of actual site coordinates within a maximum of 300 meters.

[13] If landowners did not respond to at least two attempts to contact them either by written letter, email, or phone call, permission to access the respective site was effectively considered to be denied.

2.2.3 Field Sampling Methods

Bioassessment survey methods were consistent with the BASMAA RMC QAPP (BASMAA 2016b) and SOPs (BASMAA 2016a). In accordance with the RMC QAPP (BASMAA 2016b) bioassessments were planned during the spring index period (approximately April 15 – July 15) with the goal to sample a minimum of 30 days after any significant storm (defined as at least 0.5-inch of rainfall within a 24-hour period). The 30-day grace period allows diatom and soft algae communities to recover from peak flows that may scour benthic algae from the bottom of the stream channel.[14] During WY 2018, there was a small, but significant storm on April 8 (0.51 inches in 24-hour period[15]). Field sampling was conducted over a period of one month, between April 30 and May 30, 2018. Several sites exhibiting low flow conditions were sampled during the first week of May (i.e., just prior to 30-day grace period after the storm event on April 8). Algae data collected at these sites were flagged.

Each bioassessment sampling site consisted of an approximately 150-meter stream reach that was divided into 11 equidistant transects placed perpendicular to the direction of flow. Benthic macroinvertebrate (BMI) and algae samples were collected at 11 evenly spaced transects using the Reachwide Benthos (RWB) method described in the SWAMP SOP (Ode et al. 2016). The most recent SWAMP SOP (i.e., Ode et al. 2016) combines the BMI and algae methods that are referenced in the MRP (Ode 2007, Fetscher et al. 2009), provides additional guidance, and adds two new physical habitat analytes (assess scour and engineered channels). The full suite of physical habitat data was collected within the sample reach using methods described in Ode et al. (2016).

Immediately prior to biological and physical habitat data collection, water samples were collected at for nutrients, conventional analytes, ash free dry mass, and chlorophyll a analysis using the Standard Grab Sample Collection Method as described in SOP FS-2 (BASMAA 2016a). Water samples were also collected and analyzed in the field for free chlorine and total chlorine residual using a Pocket Colorimeter™ II and DPD Powder Pillows according to SOP FS-3 (BASMAA 2016a) (see Section 5.0 for chlorine monitoring results). In addition, general water quality parameters (dissolved oxygen, pH, specific conductance and temperature) were measured at or near the centroid of the stream flow using a pre-calibrated multi-parameter probe.

Biological and water samples were sent to laboratories for analysis. The laboratory analytical methods for BMIs followed Woodward et al. (2012), using the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Level 1 Standard Taxonomic Level of Effort, with the additional effort of identifying chironomids (midges) to subfamily/tribe instead of family (Chironomidae). Soft algae and diatom samples were analyzed following SWAMP protocols (Stancheva et al. 2015). The taxonomic resolution for all data was compared to the SWAMP master taxonomic list. All taxa identified in samples collected were on the SWAMP Master List and are included in the data submittal for WY 2018.

[14] The BASMAA 30-day grace period is more conservative than the 21-day grace period described in the SWAMP SOP (Ode et al. 2016).

[15] SCVWD rain gage (Alert ID 1453) at Office of Emergency Services, City of San Jose (www.alert.valleywater.org)

2.2.4 Data Analysis

BMI and algae data were analyzed to assess the biological condition (i.e., aquatic life Beneficial Uses) of the sampled reaches using condition index scores. Physical habitat data were used to characterize physical habitat conditions using a newly developed multimetric index scoring tool. Physical habitat and water chemistry data were also evaluated as potential stressors to biological health using triggers and water quality objectives identified in the MRP (see Stressor Variable section below). Data analysis methods are described below.

Biological Indicators

Benthic Macroinvertebrates

The benthic (i.e., bottom-dwelling) macroinvertebrates collected through this monitoring program are organisms that live on, under, and around the rocks and sediment in the stream bed. Examples include dragonfly and stonefly larvae, snails, worms, and beetles (Figure 2.1). Each BMI species has a unique response to water chemistry and physical habitat condition. Some are relatively sensitive to poor habitat and pollution; others are more tolerant. Therefore, the abundance and variety of BMIs in a stream indicates the biological condition of the stream.

The California Stream Condition Index (CSCI) is an assessment tool that was developed by the State Water Resources Control Board (State Water Board) to support the development of California's statewide Biological Integrity Plan[16]. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI was developed using a large reference data set that represents the full range of natural conditions in California and site-specific models for predicting biological communities. The CSCI combines two types of indices: 1) taxonomic completeness, as measured by the ratio of observed-to-expected taxa (O/E); and 2) ecological structure and function, measured as a predictive multimetric index (pMMI) that is based on reference conditions. The CSCI score is computed as the average of the sum of the O/E and pMMI.

CSCI scores for each station are calculated using a combination of biological and environmental data following methods described in Rehn et al. (2015). Biological data consist of the BMI data collected and analyzed using the protocols described in the previous section. Environmental predictor data are generated in GIS using drainage areas upstream of each BMI sampling location. The environmental predictors and BMI data were formatted into comma delimited files and used as input for the RStudio statistical package and the necessary CSCI program scripts, developed by Southern California Coastal Water Research Project (SCCWRP) staff (Mazor et al. 2016).

The State Water Board is continuing to evaluate the performance of CSCI in a regulatory context. In the current MRP, the Regional Water Board defined a CSCI score of 0.795 as a threshold for identifying sites with potentially degraded biological condition that may be considered as candidates for a Stressor/Source Identification project.

[16] The Biological Integrity Assessment Implementation Plan has been combined with the Biostimulatory Substances Amendment project. The State Water Board is proposing to adopt a statewide water quality objective for biostimulatory substances (e.g., nitrate) along with a program of implementation. A draft policy document for public review is anticipated in late 2019.

Figure 2.1. Examples of benthic macroinvertebrates.

Benthic Algae

Similar to BMI's, the abundance and type of benthic algae species living on a streambed can indicate stream health. When evaluated with the CSCI, biological indices based on benthic algae can provide a more complete picture of the streams biological condition because algae respond more directly to nutrients and water chemistry. In contrast, BMIs are more responsive to physical habitat. Figure 2.2 shows examples of benthic algae common in Bay Area streams.

The State Water Board and SCCWRP recently developed the draft Algae Stream Condition Index (ASCI) which uses benthic algae data as a measure of biological condition for streams in California (Theroux et al. in prep.). The ASCI is a non-predictive[17] scoring tool that consists of three multimetric indices (MMI) comprised of single-assemblage metrics associated with either diatoms or soft algae, or combinations of metrics representing both assemblages (i.e, "hybrid"). The individual metrics associated with hybrid MMI include five of the six metrics used for the diatom MMI. The soft algae metrics used in the hybrid MMI are different than metrics used in the soft algae MMI.

The ASCI is very similar to the algae Indices of Biological Integrity (IBIs) developed in Southern California (Fetscher et al. 2014), with the exception that metric development and testing was conducted using data collected throughout California. Analysis of the three ASCI tools (i.e., diatom, soft algae, hybrid) conducted by SCCWRP suggests that the hybrid ASCI index is the

[17] Predictive indices (e.g., CSCI) utilize environmental variables that characterize immutable natural gradients as predictors for biological conditions. A predictive O/E and MMI algae model was developed and tested, but ultimately not recommended due to low precision and accuracy.

most responsive algae index, especially for nutrient stressor gradients (Theroux et al. in prep.). Additional study is needed however, to determine the best approach to apply the ASCI tools to evaluate bioassessment data. For example, it is not clear if the ASCI should be used as a second line of evidence to understand CSCI scoring results, or if it would be more effective as an independent indicator to evaluate different types of stressors (e.g., nutrients) to which BMIs are not very responsive. The ASCI is currently under review by the Biostimulatory-Biointegrity Policy Science Advisory Panel and the State Water Board.

The algae data collected at twenty sites in Santa Clara County during 2018 were evaluated using the diatom ASCI, soft algae ASCI, and hybrid ASCI. ASCI scores were generated using the beta version reporting module developed by SCCWRP. These scores are considered provisional until the ASCI has been fully evaluated and finalized.

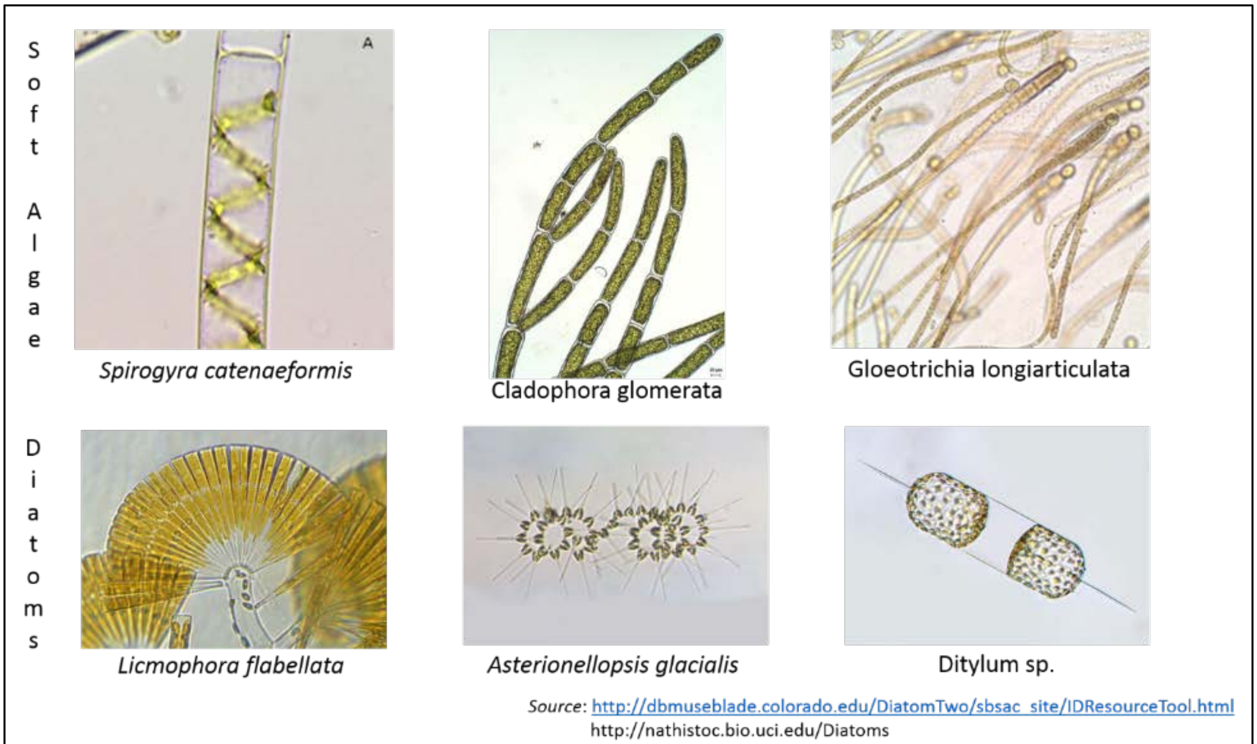

Figure 2.2. Examples of soft algae and diatoms.

Physical Habitat Indicators

The condition of physical habitat is a major contributor to stream ecosystem health. Physical habitat components such as streambed substrate, channel morphology, microhabitat complexity, in-stream cover-type complexity, and riparian vegetation cover contribute to the overall physical and biological integrity of a stream. The physical characteristics of a stream reach are affected by both natural factors (e.g., climate, slope, geology) and human disturbance (e.g., channelization, development, stream crossings, hydromodification).

Physical habitat conditions are generally evaluated using endpoint variables, or metrics, which are calculated using reach-scale averages of transect-based measurements and observations. The State Water Board has developed a SWAMP Bioassessment Reporting Module (SWAMP

RM), a custom Microsoft Access™ application, that produces approximately 170 different metrics that are based on physical habitat measurements collected using both EPA's Environmental Monitoring and Assessment Program (EMAP) for freshwater wadeable streams (Kaufmann et al. 1999) and the SWAMP "Full" habitat protocol (Ode 2007) that was implemented by SCVURPPP at bioassessment stations. The metrics are classified into five thematic groups representing different physical attributes: substrate, riparian vegetation (including structure and shading), flow habitat variability, in-channel cover, and channel morphology.

The State Water Board recently developed the Index of Physical Habitat Integrity (IPI) as an overall measure of physical habitat condition. Similar to the CSCI, the IPI is calculated using a combination of physical habitat data collected in the field and environmental data generated in GIS following the methods described in Rehn et al. (2018). The IPI is based on five of the metrics generated by the SWAMP RM. The metrics were selected for their ability to discriminate between reference and stressed sites and provide unbiased representation of waterbodies across the different ecoregions of California. Scoring for these metrics were then calibrated using environmental variables that were associated with drainage areas for each sampling location.

Biological and Physical Habitat Condition Thresholds

Existing thresholds for CSCI scores (Mazor 2015) and ASCI scores (Mazor et al. in review) were used to evaluate the BMI and algae data collected in Santa Clara County and analyzed in this report (Table 2.1). Provisional thresholds for IPI scores (Rehn et al 2018) were used to evaluate physical habitat conditions. The thresholds for all three indices were based on the distribution of scores for data collected at reference calibration sites located throughout California. Four condition categories are defined by these thresholds: "likely intact" (greater than 30th percentile of reference site scores); "possibly intact" (between the 10th and the 30th percentiles); "likely altered" (between the 1st and 10th percentiles); and "very likely altered" (less than the 1st percentile).

Table 2.1. Condition categories used to evaluate CSCI, ASCI, and IPI scores.

Biological Indicator	Tool	Likely Intact	Possibly Intact	Likely Altered	Very Likely Altered
BMI	CSCI	≥ 0.92	≥ 0.79 to < 0.92	≥ 0.63 to < 0.79	< 0.63
Diatoms	ASCI	≥ 0.92	≥ 0.80 to < 0.92	≥ 0.63 to < 0.80	< 0.63
Soft Algae		≥ 0.93	≥ 0.82 to < 0.93	≥ 0.68 to < 0.82	< 0.68
Hybrid		≥ 0.93	≥ 0.83 to < 0.93	≥ 0.70 to < 0.83	< 0.70
Physical Habitat	IPI	≥ 0.94	≥ 0.84 to < 0.94	≥ 0.71 to < 0.83	< 0.70

A CSCI score below 0.795 is referenced in the MRP as a threshold indicating a potentially degraded biological community, and thus should be considered for a SSID Project. The MRP threshold is the division between the "possibly intact" and "likely altered" condition categories described in Mazor (2015). Further investigation is needed to evaluate the applicability of this threshold to sites in highly urban watersheds and/or modified channels that are frequent throughout the SCVURPPP study area.

Stressor Variables

Physical habitat, landscape characteristics, general water quality, and water chemistry data collected during the bioassessment surveys were compiled and evaluated as potential stressor variables affecting biological condition.

Physical habitat stressor variables include 11 of the metrics developed by the SWAMP RM (described above) that were selected based on their ability to discriminate between reference and stressed sites and also showed little bias among ecoregions (Andy Rehn, personal communication, 2017) (Table 2.2). Additional physical habitat variables include the reachwide qualitative assessment (PHAB) that consists of three separate attributes: channel alteration, epifaunal substrate, and sediment deposition. Each attribute is individually scored on a scale of 0 to 20, with a score of 20 representing good condition. The total PHAB score is the sum of three individual attribute scores with a score of 60 representing the highest possible score.

Table 2.2. Physical habitat metrics used to assess physical habitat data collected at bioassessment sites in WY 2018. The five metrics used to calculate IPI scores are also shown.

Type	Variable Name	Variables used for IPI Score
Channel Morphology	Evenness of Flow Habitat Types	x
	Percent Fast Water of Reach	
Habitat Complexity and Cover	Mean Filamentous Algae Cover	
	Natural Shelter cover - SWAMP	
	Shannon Diversity (H) of Aquatic Habitat Types	x
	Riparian Cover Sum of Three Layers	x
Human Disturbance	Combined Riparian Human Disturbance Index - SWAMP	
Substrate Size and Composition	Evenness of Natural Substrate Types	
	Percent Gravel - coarse	
	Percent Substrate Smaller than Sand (<2 mm)	x
	Shannon Diversity (H) of Natural Substrate Types	x

Landscape variables were generated in GIS using three different scales of drainage area upstream of each sampling location: 1 km, 5 km, and entire watershed. Land use and transportation data layers were overlayed with the drainage areas to calculate landscape variables, including percent urban area, percent impervious area, total number of road crossings, and road density.

Water quality stressor variables include the general parameters measured in the field with sondes (i.e., dissolved oxygen, pH, temperature and specific conductivity), free chlorine and total chlorine residual, and water chemistry analyzed at laboratories (nutrients and anions). Additional water quality variables included chlorophyll a and ash free dry mass, both measured from filtration of the benthic algae composite samples.

Some of the water quality stressor variables used in the analysis were calculated or converted from other analytes or units of measurement:

- Conversion of measured total ammonia to the more toxic form of unionized ammonia was calculated to compare with the 0.025 mg/L annual median standard provided in the San Francisco Basin Water Quality Control Plan (Basin Plan) (SFRWQCB 2017). The conversion was based on a formula provided by the American Fisheries Society (AFS; https://fisheries.org/wp-content/uploads/2016/03/Copy-of-pub_ammonia_fwc.xls). The calculation requires total ammonia and field-measured values of pH, temperature, and specific conductance.
- Total nitrogen concentration was calculated by summing nitrate, nitrite, and Total Kjeldahl Nitrogen concentrations.
- The volumetric concentrations (mass/volume) for ash free dry mass and chlorophyll a (as measured by the laboratory) were converted to an area concentration (mass/area). Calculations required using both algae sampling grab size and composite volume.

Another potential stressor is climate. During the first five years of probabilistic sampling (WY 2012 – WY 2016), average precipitation was lower than average. During the drought, low base flow conditions were further impacted by minimal or complete absence of water releases from upstream reservoirs and diversion pipes bringing imported water from other parts of the State. Drought conditions changed with an above average wet season in WY 2017, followed by average season in WY 2018. Comparison of sampling results from recent wet years will provide useful information to evaluate the impacts of drought on biological integrity of the streams.

Stressor Thresholds

In compliance with provision C.8.h.iii.(4), water chemistry data collected at the bioassessment sites during WY 2018 were compared to stressor thresholds and applicable water quality standards (Table 2.3). Thresholds for pH, specific conductance, dissolved oxygen (DO), and temperature (for waters with COLD Beneficial Use only) are listed in provision C.8.d.iv of the MRP. With the exception of temperature and specific conductance, these conform to Water Quality Objectives in the Basin Plan (SFRWQCB 2017). Of the eleven nutrients analyzed synoptically with bioassessments, WQOs only exist for three: ammonia (unionized form), and chloride and nitrate (for waters with MUN Beneficial Use only). Smith Creek (tributary to Alameda Creek) is the only creek sampled in WY 2018 with MUN designated (see Table 1.4).

Table 2.3. Thresholds for nutrient and general water quality variables.

	Units	Threshold	Direction	Source
Nutrients and Ions				
Nitrate as N [a]	mg/L	10	Increase	Basin Plan
Un-ionized Ammonia [b]	mg/L	0.025	Increase	Basin Plan
Chloride [a]	mg/L	250	Increase	Basin Plan
General Water Quality				
Oxygen, Dissolved	mg/L	5.0 or 7.0	Decrease	Basin Plan
pH		6.5 to 8.5		Basin Plan
Temperature, instantaneous maximum [c]	°C	24	Increase	MRP
Specific Conductance [c]	µS/cm	2000	Increase	MRP

[a] Nitrate and chloride WQOs only apply to waters with MUN designated Beneficial Use

[b] This threshold is an annual median value and is not typically applied to individual samples.

[c] The MRP thresholds (or triggers) for temperature and specific conductance apply when 20 percent of instantaneous results are in exceedance. Application to individual samples is provisional.

Stressor Assessment

The association of stressors with biological indicator scores was evaluated using simple regression models. Linear regressions were run between variables within each of the stressor data types (e.g., landscape, physical habitat and water chemistry) and biological conditions indicators (i.e., CSCI and ASCI scores). Scatter plots showing trend lines are presented for some of the variables that had the greatest positive or negative correlation. However, the correlations were not expected to be very strong or significant due to the small WY 2018 sample size (n=20). More sophisticated statistical analyses using non-parametric measures of correlation (e.g., random forest models) are applied to the regional WY 2012 – WY 2016 dataset in the RMC 5-Year Report, summarized in Section 7.1 and included as Attachment 2.

2.3 Results and Discussion

The section below summarizes results from bioassessment sampling conducted during WY 2018. Conclusions and recommendations for this section are presented in Section 7.0.

A comprehensive analysis of bioassessment data collected by the Program over a five-year period is presented in the RMC Five-Year Bioassessment Report (5-Year Report) (BASMAA 2019) (Attachment 2). This BASMAA-funded project evaluated bioassessment data collected at all RMC (n=312) and Water Board (n=45) probabilistic monitoring sites sampled between WY 2012 and WY 2016. The data were evaluated to assess overall biological condition of streams within the RMC, as well as the extent and influence of stressor data on biological condition scores. In addition, the 5-Year Report evaluated the RMC Sample Frame and provided potential recommendations for revising the monitoring design in the future. Additional analysis of the full SCVURPPP MRP bioassessment dataset will be conducted for the Integrated Monitoring Report which will be developed following WY 2019 and submitted by March 31, 2020 (the fifth year of the Permit term) in lieu of an annual UCMR.

2.3.1 Site Evaluations

During WY 2018, SCVURPPP conducted site evaluations at a total of 75 potential probabilistic sites in Santa Clara County drawn from the Sample Frame. Of these sites, twenty were sampled in WY 2018 (rejection rate of 73%). Approximately 45 of the evaluated sites (60%) were rejected due to an inability to sample the site (e.g., low/no flow conditions, not wadeable). Ten sites (about 13%) were rejected due to access issues. Three of the twenty sampled sites (15%) were classified as non-urban land use. Land use classification, sampling location, and date for each site sampled during WY 2018 are listed in Table 2.4. Sites are mapped in Figure 1.2.

Table 2.4. Bioassessment sampling dates and locations in Santa Clara County in WY 2018.

Station Code	Creek	Sample Date	Land Use	Elevation (m)	Latitude	Longitude
204R00749	Smith Creek	5/9/2018	NU	704	37.31672	-121.65057
205R00746	Saratoga Creek	5/24/2018	NU	214	37.25201	-122.06016
205R00769	MF Coyote Creek	5/10/2018	NU	510	37.21998	-121.54206
205R03498	Saratoga Creek	5/23/2018	U	146	37.25747	-122.03631
205R03562	Saratoga Creek	5/23/2018	U	172	37.25258	-122.04500
205R03591	Los Trancos Creek	5/7/2018	U	218	37.35238	-122.19713
205R03619	Saratoga Creek	5/8/2018	U	67	37.30297	-121.99653
205R03683	Permanente Creek	4/30/2018	U	94	37.33985	-122.09228
205R03699	Hale Creek	4/30/2018	U	54	37.36703	-121.69869
205R03738	Upper Silver Creek	5/1/2018	U	106	37.28625	-121.77795
205R03754	San Tomas Aquino	5/8/2018	U	97	37.25954	-121.99221
205R03795	Lower Silver Creek	5/30/2018	U	25	37.35770	-121.85820
205R03825	Thompson Creek	5/1/2018	U	157	37.28066	-121.75541
205R03843	San Tomas Aquino	5/29/2018	U	8	37.38186	-121.96843
205R03847	Los Trancos Creek	5/7/2018	U	120	37.38068	-122.19441
205R03875	Calabazas Creek	5/2/2018	U	65	37.31483	-122.01634
205R03907	Lower Penitencia	5/30/2018	U	4	37.43624	-121.91424
205R04190	Guadalupe Creek	5/29/2018	U	72	37.23516	-121.89116
205R04217	Upper Penitencia	5/3/2018	U	519	37.40062	-121.74910
205R04266	Calabazas Creek	5/2/2018	U	89	37.29627	-122.02921

NU = non-urban, U = urban

Since WY 2012, a total of 152 probabilistic sites were sampled by SCVURPPP (n=140) and SWAMP (n=12) in Santa Clara County. During the seven-year sampling period, SCVURPPP sampled 121 urban and 19 non-urban sites and SWAMP sampled 12 non-urban sites.

2.3.2 Biological Condition Assessment

2.3.2.1 Bioassessment Data

A total of 141 unique BMI taxa were identified in samples collected at the 20 bioassessment sites in Santa Clara County during WY 2018. A total of 227 benthic algae taxa were identified in samples collected at the sites, including 164 diatom taxa and 63 soft algae taxa. The total number of BMI, diatom, and soft algae taxa identified at each bioassessment location is presented in Table 2.5. BMIs and diatoms were relatively well represented across all sites, with BMIs ranging from 9 to 53 taxa and diatoms ranging from 18 to 55 taxa. Soft algae taxa were less common across sites, ranging from 1 to 26 taxa. Nine of the sites (45%) had three or less soft algae taxa. Low numbers of soft algae taxa are common in Bay Area streams.

Table 2.5. The total number of unique BMI, diatom and soft algae taxa identified in samples collected at 20 bioassessment sites in Santa Clara County during WY 2018.

RMC Station	Creek Name	Elevation (m)	Land Use	BMI	Diatoms	Soft Algae
204R00749	Smith Creek	704	NU	53	18	6
205R00746	Saratoga Creek	214	NU	51	38	10
205R00769	MF Coyote Creek	510	NU	37	31	26
205R03498	Saratoga Creek	146	U	49	34	4
205R03562	Saratoga Creek	172	U	48	34	1
205R03591	Los Trancos Creek	218	U	40	31	2
205R03619	Saratoga Creek	67	U	26	25	3
205R03683	Permanente Creek	94	U	31	21	3
205R03699	Hale Creek	54	U	15	55	2
205R03738	Upper Silver Creek	106	U	15	46	4
205R03754	San Tomas Aquino	97	U	32	28	3
205R03795	Lower Silver Creek	25	U	11	43	15
205R03825	Thompson Creek	157	U	22	35	10
205R03843	San Tomas Aquino	8	U	13	37	16
205R03847	Los Trancos Creek	120	U	52	30	1
205R03875	Calabazas Creek	65	U	15	32	3
205R03907	Lower Penitencia	4	U	9	54	5
205R04190	Guadalupe Creek	72	U	40	41	4
205R04217	Upper Penitencia	519	U	39	28	5
205R04266	Calabazas Creek	89	U	24	46	3

NU = non-urban, U = urban

The total number of BMI taxa (i.e., BMI richness) was moderately positively correlated with site elevation (r^2=0.32, p-value = 0.009) (Figure 2.3).[18] In contrast, total taxa for diatoms generally decreased with increasing site elevation (r^2=0.29, p-value = 0.015). BMI richness was not correlated with diatom or soft algae richness across the 20 bioassessment sites sampled in WY 2018. Similarly, diatom richness did not appear to have a correlation with soft algae richness.

[18] R-squared represents the amount of variance in the dependent variable. The higher the R-square the better the model. The p-value represents the statistical significance of the result. A small p-value (≤ 0.05) indicates strong evidence; a large p-value (> 0.05) indicates weak evidence.

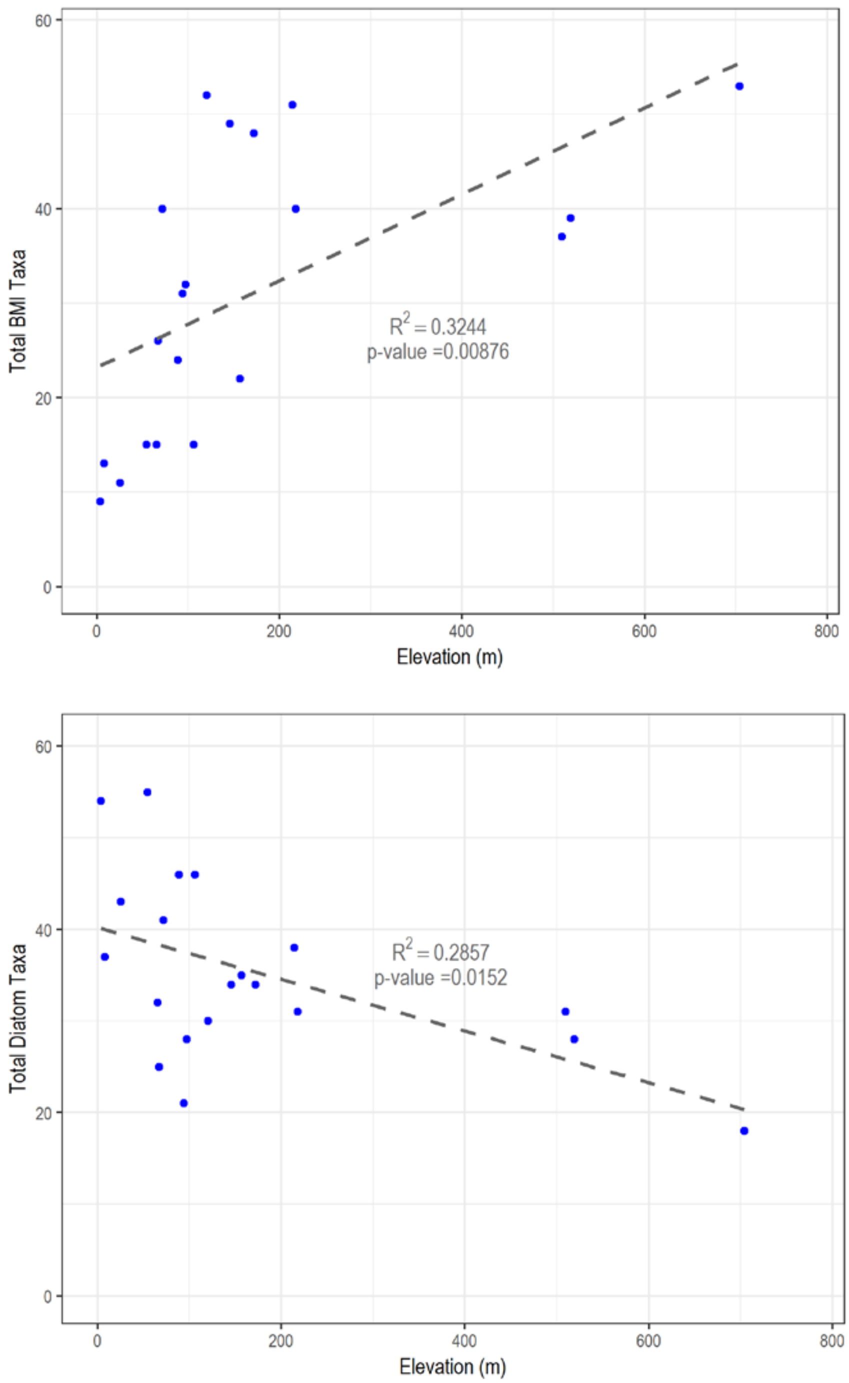

Figure 2.3. Total BMI (top) and diatom (bottom) taxa compared to elevation of the bioassessment sites, SCVURPPP, WY 2018.

Biological condition, as represented by CSCI and ASCI (diatom, soft algae, and hybrid) scores, for the 20 probabilistic sites sampled by SCVURPPP in WY 2018 are listed in Table 2.6 and mapped in Figure 2.6. Scores in the two higher condition categories (i.e., above the 10th percentile of reference sites) for each indicator are highlighted and bold.

Table 2.6. Biological condition scores, presented as CSCI and ASCI (diatom, soft algae and hybrid) for 20 probabilistic sites sampled in Santa Clara during WY 2018. Site characteristics related to percent impervious watershed area, channel modification and flow condition are also presented. Bold highlighted values indicate scores in the two higher condition categories.

Station Code	Creek	Land Use	Imperv. Area	Modified Channel [1]	Flow [2]	CSCI Score	ASCI Score		
							Diatom	Soft Algae	Hybrid
204R00749	Smith Creek	NU	1%	N	P	1.23	**1.21**	0.78	**1.10**
205R00746	Saratoga Creek	NU	2%	N	P	1.12	**0.96**	**0.94**	0.82
205R00769	MF Coyote Creek	NU	1%	N	P	0.74	**1.22**	**1.01**	**1.14**
205R03498	Saratoga Creek	U	3%	N	P	1.14	**1.04**	0.71	**0.91**
205R03562	Saratoga Creek	U	2%	Y	P	1.08	**1.04**	0.47	**0.91**
205R03591	Los Trancos Creek	U	5%	N	NP	1.06	**0.87**	**1.02**	**0.87**
205R03619	Saratoga Creek	U	16%	Y	NP	0.63	0.63	0.54	0.47
205R03683	Permanente Creek	U	11%	N	P	0.91	0.69	**0.83**	0.74
205R03699	Hale Creek	U	26%	N	P	0.46	**0.91**	**0.94**	0.81
205R03738	Upper Silver Creek	U	9%	N	P	0.47	0.72	0.58	0.61
205R03754	San Tomas Aquino	U	11%	N	P	0.92	0.77	**1.02**	0.76
205R03795	Lower Silver Creek	U	25%	Y	P	0.4	0.58	0.73	0.61
205R03825	Thompson Creek	U	6%	N	P	0.43	0.70	0.46	0.64
205R03843	San Tomas Aquino	U	37%	Y	P	0.39	**0.81**	0.33	0.62
205R03847	Los Trancos Creek	U	6%	N	NP	1.2	**0.82**	0.47	0.71
205R03875	Calabazas Creek	U	27%	N	NP	0.46	0.58	0.47	0.47
205R03907	Lower Penitencia	U	69%	Y	P	0.19	0.59	**0.88**	0.61
205R04190	Guadalupe Creek	U	4%	N	P	0.88	**1.03**	**0.94**	**0.89**
205R04217	Upper Penitencia	U	1%	N	NP	1.04	**0.82**	**1.03**	**0.90**
205R04266	Calabazas Creek	U	12%	N	NP	0.51	**0.89**	**1.02**	0.79

NU = non-urban, U = urban

[1] Highly modified channel is defined as having armored bed and banks (e.g., concrete, gabion, rip rap) for majority of the reach or characterized as highly channelized earthen levee.

[2] Flow status (P = perennial, NP = non-perennial) was based on visual observations at each site made during fall or spring seasons.

CSCI Scores

The CSCI scores ranged from 0.19 to 1.23 across the 20 bioassessment sites sampled in WY 2018 (Table 2.6). A total often of the 20 bioassessment sites (50%) had CSCI scores in the two higher condition categories - “possibly intact” and “likely intact” condition. These combined classifications are above the MRP trigger threshold value of 0.795. Seven of the 20 sites had scores greater than 1.0, which are considered scores representing reference type conditions. These higher scoring sites were relatively undeveloped, with impervious area ranging between

1% and 6% (Table 2.6). Five of these sites occurred in two creeks: Saratoga Creek (3) and Los Trancos Creek (2).

One site (205R00769) had a CSCI score that ranked as “likely altered” (0.63 - 0.79). This site is located in a remote location of Middle Fork Coyote Creek in Henry Coe State Park. Nine sites (45%) were ranked as “very likely altered” (CSCI < 0.63), indicating highly degraded conditions. Seven of these sites were predominantly urban (impervious area > 10%) and four had modified channels.

Sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.

ASCI Scores

The benthic algae taxa identified in the samples collected in Santa Clara County were used to calculate scores for the provisional statewide ASCI. Scores for three ASCI indices (diatoms, soft algae and hybrid) are shown in Table 2.6.

- **Diatoms.** Twelve of the twenty bioassessment sites had diatom ASCI scores that were classified as “possibly intact” or “likely intact” condition. The higher scoring sites occurred over a wide gradient of urbanization, ranging from 1% to 37% impervious area. Seven of the twelve sites also received CSCI scores that were in two higher condition categories (Table 2.6).

- **Soft Algae**. Ten of the twenty bioassessment sites had soft algae ASCI scores that were classified as “possibly intact” or “likely intact” condition. The higher scoring sites occurred over a wide gradient of urbanization, ranging from 1% to 69% impervious area in the upstream watersheds. Six of the ten sites also received CSCI scores that were in the two higher condition categories (Table 2.6).

- **Hybrid**. Seven of the twenty bioassessment sites had hybrid ASCI scores that were classified as “possibly intact” or “likely intact” condition. The higher scoring sites occurred in drainages with relatively low levels of urbanization, ranging from 1% to 5% impervious area. Six of the seven sites also received CSCI scores that were in two higher condition categories (Table 2.6).

The diatom and hybrid ASCI scores showed moderately positive correlation with the CSCI scores for the twenty bioassessment sites sampled during WY 2018 (Figure 2.4). Soft algae ASCI scores were not correlated with CSCI scores or diatom index scores.

A statewide bioassessment data analysis evaluated the CSCI and the three ASCI indices and concluded that the hybrid ASCI index was the most responsive index[19], especially for nutrient stressor gradients (Theroux et al. in prep.). Additional guidance is needed, however, to determine the best application of the ASCI tool in evaluating bioassessment data. For example, it is not clear if one or more of the ASCI indices should be used to assess biological condition. Furthermore, it is not clear if ASCI should be used as a second line of evidence to the CSCI scoring results, or if it would be more effective as an independent indicator to evaluate different types of stressors (e.g., nutrients).

[19] For the remainder of this report, the hybrid ASCI will be used to evaluate stressor association with biological condition.

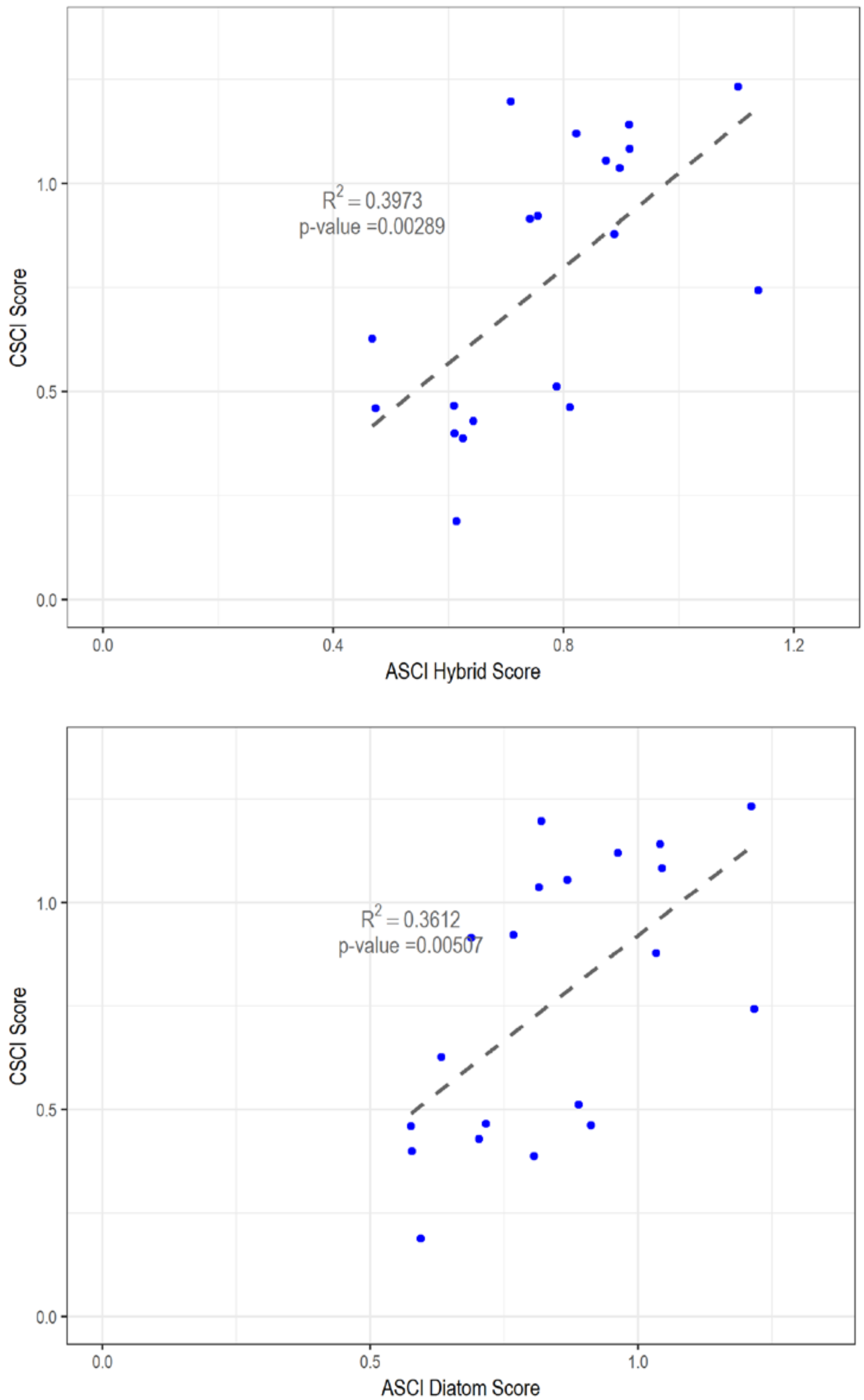

Figure 2.4. CSCI Scores compared to hybrid ASCI (top) and diatom ASCI (bottom) scores for 20 bioassessment sites sampled in Santa Clara County in WY 2018.

IPI Scores

Physical habitat conditions, as represented by IPI scores, are listed in Table 2.7. The qualitative habitat (PHAB) scores, including individual scores for channelization, epifaunal substrate and sedimentation attributes, and total PHAB (sum of the three attributes scores) are also presented in the table. Biological condition scores for CSCI and the hybrid ASCI are included in the table for comparison. The two higher condition categories for all three indices (i.e., above the 10th percentile of reference sites) are shown in shaded cells with bold text.

Table 2.7. IPI scores for twenty probabilistic sites in Santa Clara County sampled in WY 2018. Qualitative PHAB scores are also listed. CSCI and hybrid ASCI scores are provided for comparison.

Station Code	Creek Name	CSCI Score	ASCI Hybrid Score	IPI Score	Channel Alteration	Epifaunal Substrate	Sediment Deposition	Total PHAB Score
204R00749	Smith Creek	1.23	1.10	1.14	20	18	16	54
205R00746	Saratoga Creek	1.12	0.82	1.05	19	15	13	47
205R00769	MF Coyote Creek	0.74	1.14	1.15	20	18	18	56
205R03498	Saratoga Creek	1.14	0.91	1.19	15	12	9	36
205R03562	Saratoga Creek	1.08	0.91	1.14	7	16	10	33
205R03591	Los Trancos Creek	1.06	0.87	1.08	16	16	13	45
205R03619	Saratoga Creek	0.63	0.47	0.99	9	9	10	28
205R03683	Permanente Creek	0.91	0.74	1.08	9	14	11	34
205R03699	Hale Creek	0.46	0.81	1.0	13	9	9	31
205R03738	Upper Silver Creek	0.47	0.61	1.15	17	14	12	43
205R03754	San Tomas Aquino	0.92	0.76	1.06	11	9	10	30
205R03795	Lower Silver Creek	0.40	0.61	0.8	4	7	4	15
205R03825	Thompson Creek	0.43	0.64	1.03	18	10	13	41
205R03843	San Tomas Aquino	0.39	0.62	0.93	3	7	6	16
205R03847	Los Trancos Creek	1.20	0.71	1.12	12	12	8	32
205R03875	Calabazas Creek	0.46	0.47	0.65	12	5	5	22
205R03907	Lower Penitencia	0.19	0.61	0.34	3	2	1	6
205R04190	Guadalupe Creek	0.88	0.89	1.2	17	12	8	37
205R04217	Upper Penitencia	1.04	0.90	0.97	19	17	16	52
205R04266	Calabazas Creek	0.51	0.79	1.04	14	6	10	30

IPI scores, composed of metrics that are primarily based on physical habitat measurements, were positively correlated with the qualitative habitat assessment PHAB scores ($r^2 = 0.50$, p-value = 0.0005) (Figure 2.5). IPI scores were also positively correlated with CSCI scores, and slightly less so with hybrid ASCI scores (Figure 2.5).

Individual physical habitat variables are evaluated as stressors in the next section of the report.

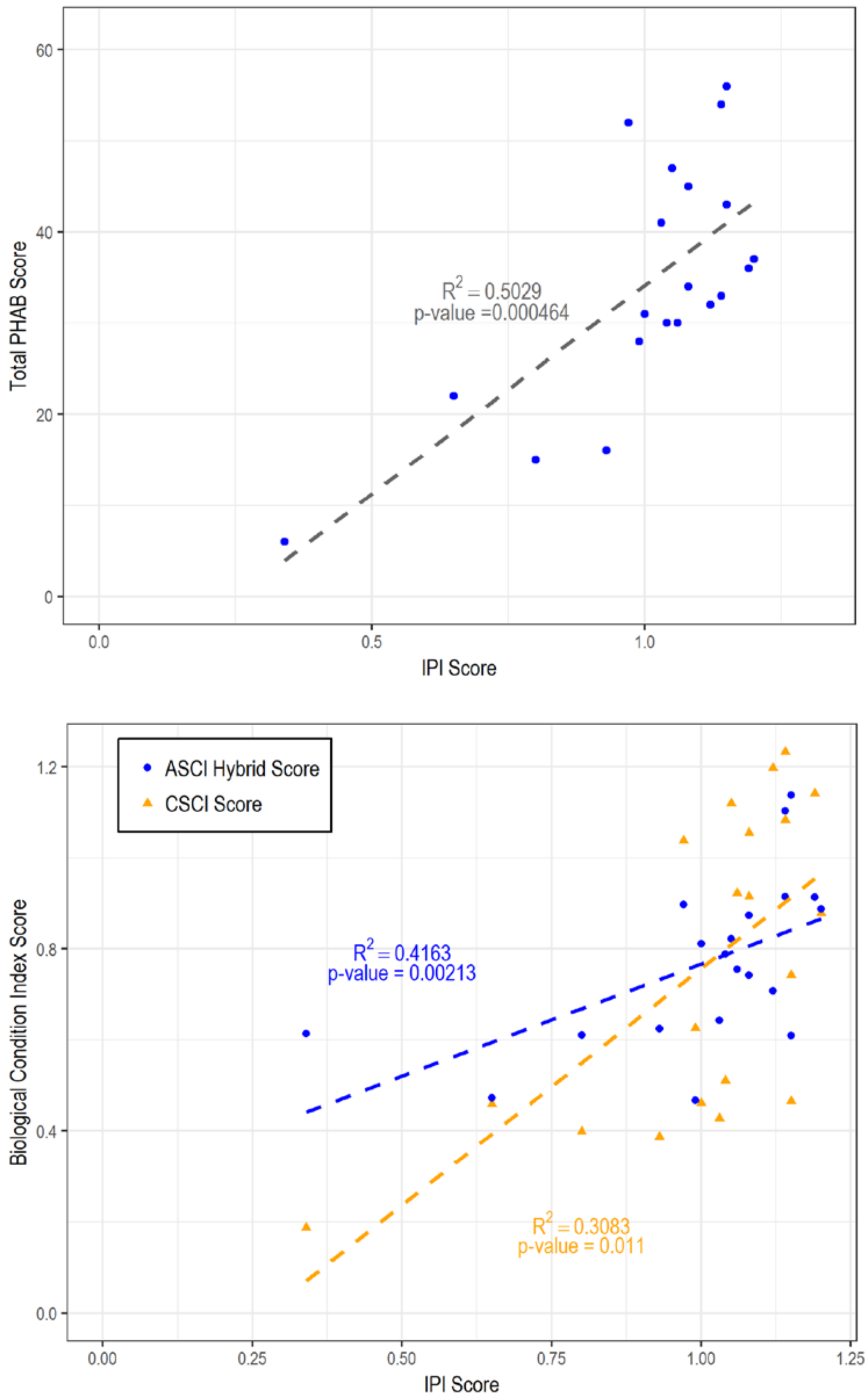

Figure 2.5. Total PHAB scores compared with IPI scores (top) and biological condition scores (CSCI and hybrid ASCI) plotted with IPI scores (bottom) for twenty bioassessment sites sampled In Santa Clara County during WY 2018.

Overall Condition

The condition categories for each site based on two of the biological indicators (CSCI and hybrid ASCI) and the IPI, as presented in Table 2.1, are mapped in Figure 2.6. There were six sites with scores in the two higher condition categories for all three indices (green and yellow symbols in Figure 2.6). Two of the sites are located in upper reaches of Saratoga Creek (sites 205R03562 and 205R03498). The remaining four high-scoring sites are located in Los Trancos Creek at Foothill Park (site 205R03591), Guadalupe Creek at the percolation ponds (site 205R04190), Upper Penitencia Creek upstream of Cherry Flat Reservoir (site 205R04217), and Smith Creek in Joseph Grant County Park (site 204R00749). All six sites were relatively undeveloped (less than < 5% impervious area in the upstream watershed).

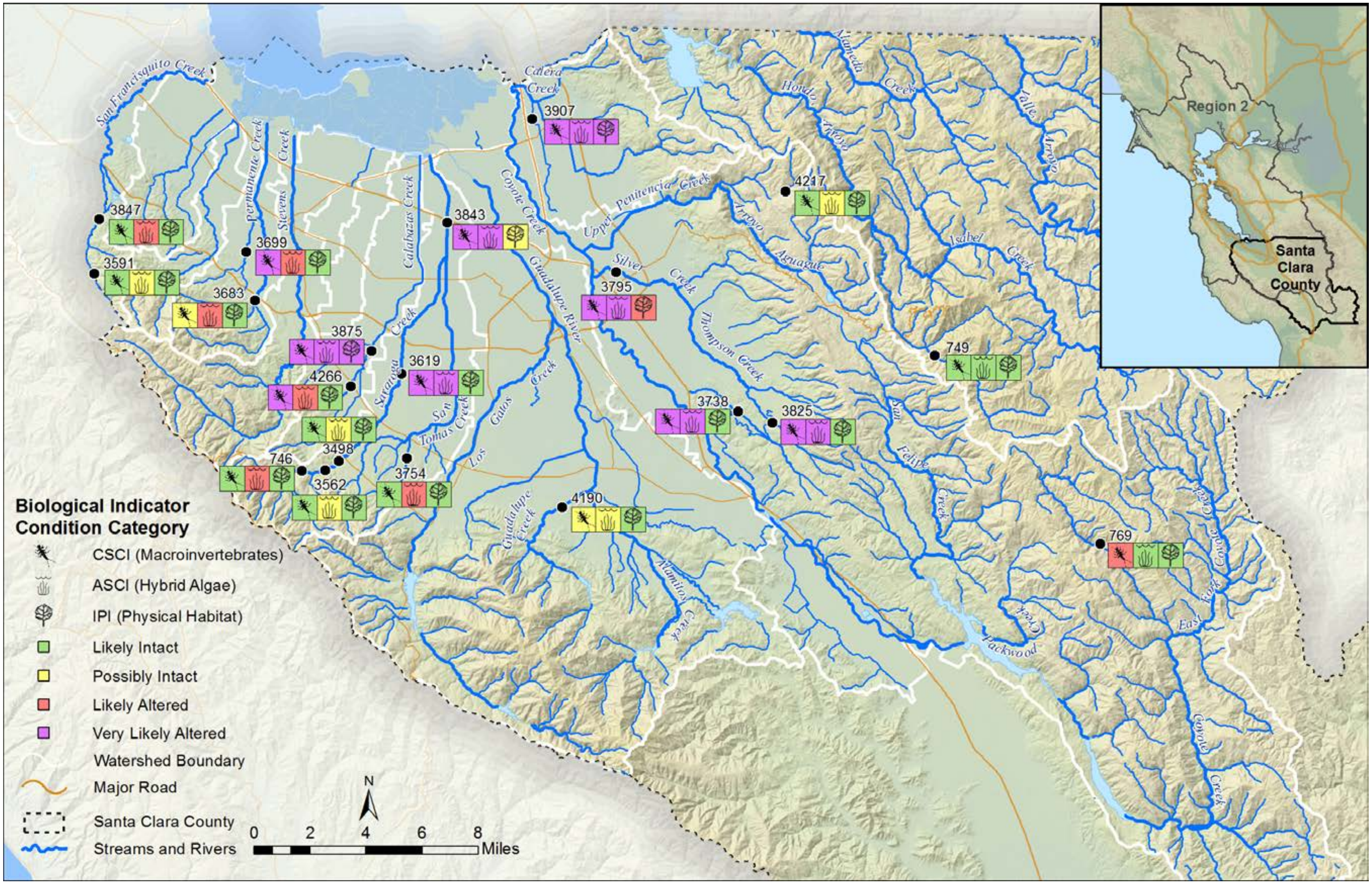

Figure 2.6. Condition category as represented by CSCI, ASCI Hybrid, and IPI scores for 20 probabilistic sites sampled in Santa Clara County during WY 2018.

2.3.3 Stressor Assessment

This section summarizes results for stressor data collected at 20 bioassessment sites during WY 2018. Stressors were evaluated using simple linear regressions between variables within each of the stressor data types (e.g., landscape, physical habitat and water chemistry) and biological conditions indicators (i.e., CSCI and ASCI scores). Scatter plots showing trend lines are presented for some of the variables that had the greatest positive or negative correlation. However, due to small number of samples (n=20), associations with biological condition are not expected to be strong.

General Water Chemistry

General water quality measurements sampled at the twenty bioassessment sites in WY 2018 are listed in Table 2.8. None of the water quality measurements exceeded water quality objectives or MRP trigger thresholds. Nor were any of the water quality measurements well correlated with CSCI or hybrid ASCI scores.

Table 2.8. General water quality measurements for twenty probabilistic sites in Santa Clara County sampled in WY 2018.

Station Code	Creek Name	Sample Date	Temp (C)	DO (mg/L)	pH	Specific Conductance (uS/cm)
204R00749	Smith Creek	5/9/2018	13.1	10.1	7.8	310
205R00746	Saratoga Creek	5/24/2018	12.2	11.4	8.0	462
205R00769	MF Coyote Creek	5/10/2018	12.9	9.0	7.6	328
205R03498	Saratoga Creek	5/23/2018	13.9	11.3	8.3	507
205R03562	Saratoga Creek	5/23/2018	12.7	11.9	8.0	502
205R03591	Los Trancos Creek	5/7/2018	11.0	11.1	7.8	515
205R03619	Saratoga Creek	5/8/2018	13.8	11.1	7.8	447
205R03683	Permanente Creek	4/30/2018	14.5	9.2	8	1143
205R03699	Hale Creek	4/30/2018	12.0	9.0	8.1	1959
205R03738	Upper Silver Creek	5/1/2018	13.9	8.4	8.1	1443
205R03754	San Tomas Aquino	5/8/2018	16.5	9.3	7.6	626
205R03795	Lower Silver Creek	5/30/2018	19.9	7.7	7.5	1540
205R03825	Thompson Creek	5/1/2018	14.0	8.5	8.1	746
205R03843	San Tomas Aquino	5/29/2018	19.7	7.2	7.8	1020
205R03847	Los Trancos Creek	5/7/2018	14.5	10.3	8.2	718
205R03875	Calabazas Creek	5/2/2018	19.9	9.4	8.3	335
205R03907	Lower Penitencia	5/30/2018	22.6	8.3	8.0	1342
205R04190	Guadalupe Creek	5/29/2018	17.6	11.7	7.2	750
205R04217	Upper Penitencia	5/3/2018	12.6	9.7	7.6	376
205R04266	Calabazas Creek	5/2/2018	16.5	9.5	7.9	321

Landscape Variables

Landscape variables associated with the drainage area for each bioassessment site sampled in WY 2018 are presented in Table 2.9. Landscape variables include: percent urban area, percent impervious area, total number of road crossings, and road density (road length/watershed area). The total drainage area and CSCI scores are presented for comparison. Based on the simple regression models, the strongest relationships between CSCI scores and landscape variables were for impervious area ($r^2 = 0.55$, $p < 0.0002$) and road density ($r^2 = 0.62$, $p < 4e-05$) (Figure 2.7). The same two landscape variables were not well correlated with the ASCI scores (not shown).

Table 2.9. Landscape variables for watershed areas of the 20 bioassessment sites sampling in WY 2018.

Station Code	Creek Name	CSCI	Drainage Area (km2)	Elevation (m)	Percent Urban Watershed	Percent Impervious Watershed	Road Crossings Watershed	Road Density (km/km^2)
204R00749	Smith Creek	1.23	30	704	0%	1%	7	0.4
205R00746	Saratoga Creek	1.12	19	214	2%	2%	16	1.1
205R00769	MF Coyote Creek	0.74	37	510	0%	1%	9	0.2
205R03498	Saratoga Creek	1.14	24	146	9%	3%	22	1.8
205R03562	Saratoga Creek	1.08	22	172	5%	2%	18	1.3
205R03591	Los Trancos Creek	1.06	5	218	13%	5%	0	1.6
205R03619	Saratoga Creek	0.63	34	67	32%	16%	38	4.6
205R03683	Permanente Creek	0.91	11	94	12%	11%	6	1.3
205R03699	Hale Creek	0.46	8	54	83%	26%	25	8.8
205R03738	Upper Silver Creek	0.47	10	106	18%	9%	27	3.4
205R03754	San Tomas Aquino	0.92	9	97	51%	11%	21	5.1
205R03795	Lower Silver Creek	0.4	97	25	49%	25%	130	7.1
205R03825	Thompson Creek	0.43	11	157	13%	6%	16	2.4
205R03843	San Tomas Aquino	0.39	107	8	71%	37%	188	9.1
205R03847	Los Trancos Creek	1.2	14	120	20%	6%	6	2.7
205R03875	Calabazas Creek	0.46	19	65	66%	27%	48	8.4
205R03907	Lower Penitencia	0.19	12	4	96%	69%	27	12.5
205R04190	Guadalupe Creek	0.88	37	72	8%	4%	13	2.3
205R04217	Upper Penitencia Cr	1.04	4	519	0%	1%	0	0
205R04266	Calabazas Creek	0.51	11	89	43%	12%	27	5

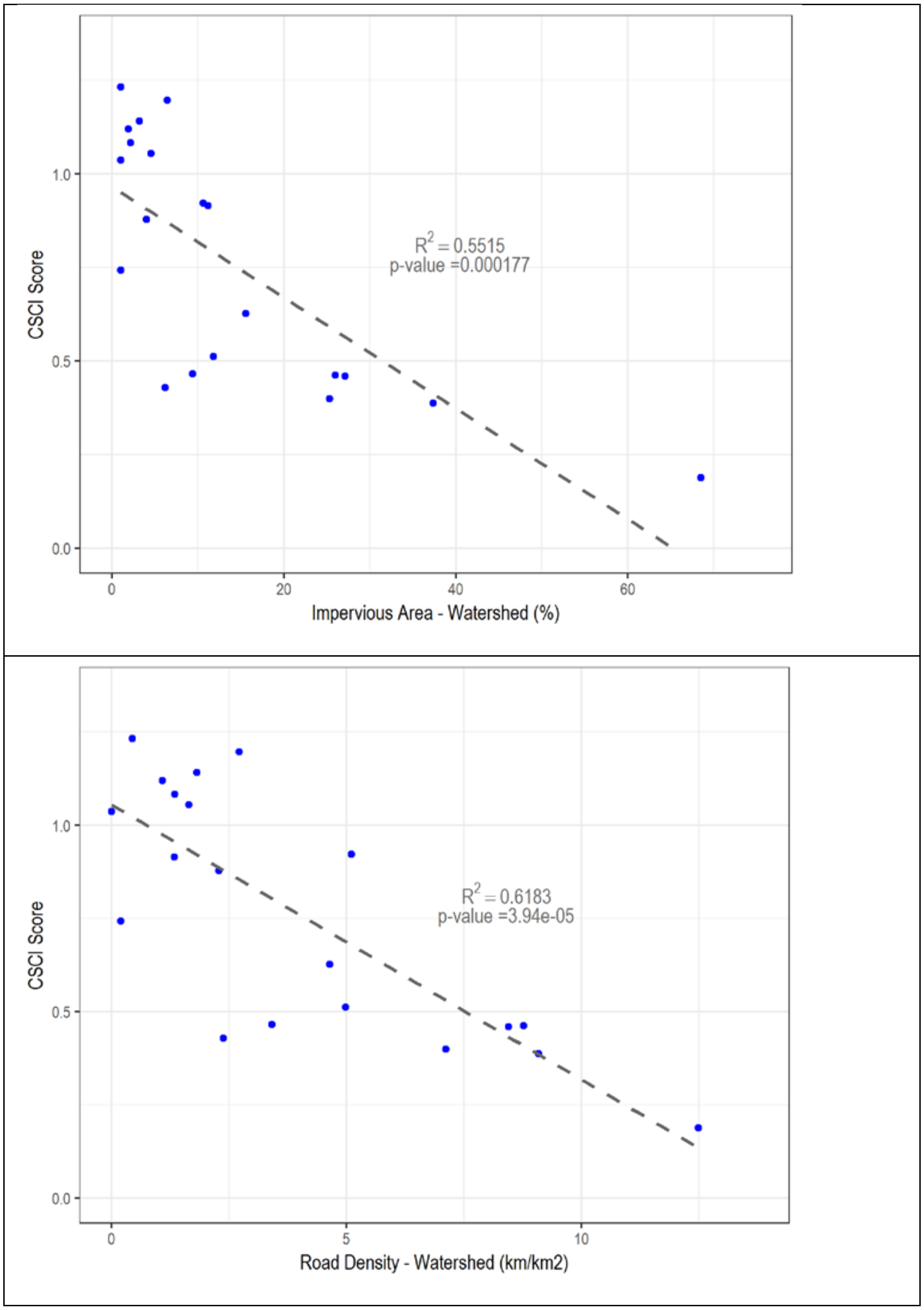

Figure 2.7. CSCI Scores compared to percent impervious (top) and road density (bottom) for 20 bioassessment sites sampled in Santa Clara County in WY 2018.

Physical Habitat

Scores for eleven physical habitat metrics that were generated from the physical habitat data collected at bioassessment sites in WY 2018 are listed in Table 2.10. Based on the simple regression models, the strongest relationships between CSCI scores and physical habitat were for *Smaller than Sand* metric (negatively correlated, $r^2 = 0.5$, $p < 0.0005$) and the *Substrate Diversity of Natural Substrate Types* metric (positively correlated $r^2 = 0.38$, $p < 0.004$) (Figure 2.8). The same two landscape variables were less correlated with the ASCI scores (not shown).

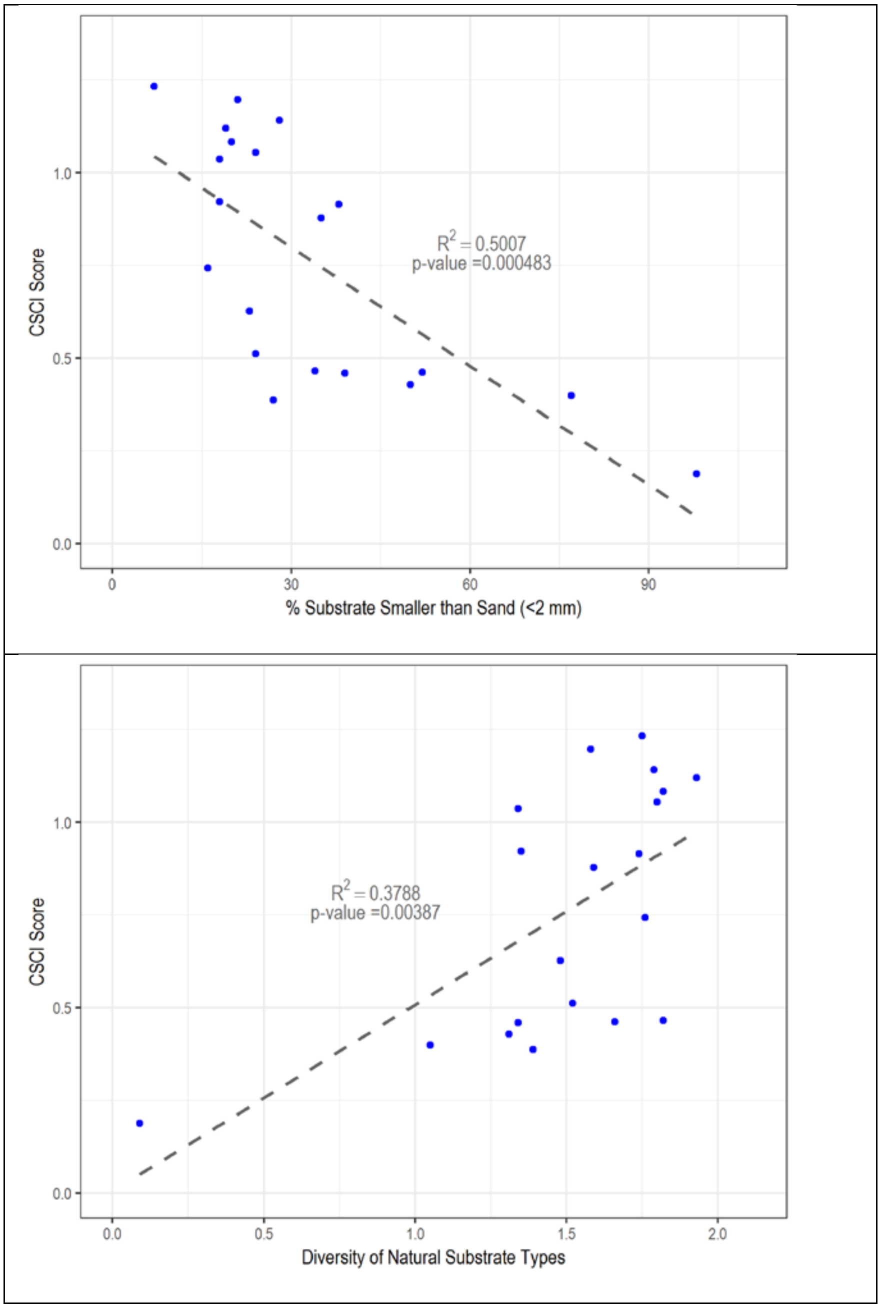

Figure 2.8. CSCI Scores compared to PHAB metrics associated with substrate size and composition (Substrate Smaller than Sand (top) and Diversity of Natural Substrate Types (bottom)) for 20 bioassessment sites sampled in Santa Clara County in WY 2018.

Water Chemistry (Nutrients)

Nutrient and conventional analyte concentrations measured in water samples collected at twenty bioassessment sites in Santa Clara County during WY 2018 are listed in Table 2.11. There were no water quality objective exceedances for water chemistry parameters.

Total nitrogen concentrations ranged from 0.12 to 8.1 mg/L. The two highest nitrogen concentrations were measured at site 205R03795 in Lower Silver Creek (8.1 mg/L) and site 205R03699 (3.1 mg/L) on Hale Creek. Total phosphorus concentrations ranged from <0.001 to 0.22 mg/L. The highest phosphorus concentration was measured at site 205R03699 on Hale Creek. Neither of the nutrient parameters were correlated with CSCI or hybrid ASCI scores.

In an effort to assess whether nutrient concentrations (measured during bioassessments) are affecting indicators of biomass (i.e., chlorophyll a, ash free dry mass, percent algae cover), simple regression models were run. There was slight positive correlation between total nitrogen concentration and percent macroalgal cover ($r^2 = 0.25$, $p = 0.024$) for the 20 sites sampled in WY 2018 (Figure 2.9). Chlorophyll a and algae cover were moderately positively correlated ($r^2 = 0.34$, $p = 0.007$). Additional analyses with larger number of samples should be conducted to assess whether percent algae cover provides an accurate estimate for algae biomass (as measured by chlorophyll a and ash free dry mass) at bioassessment sites.

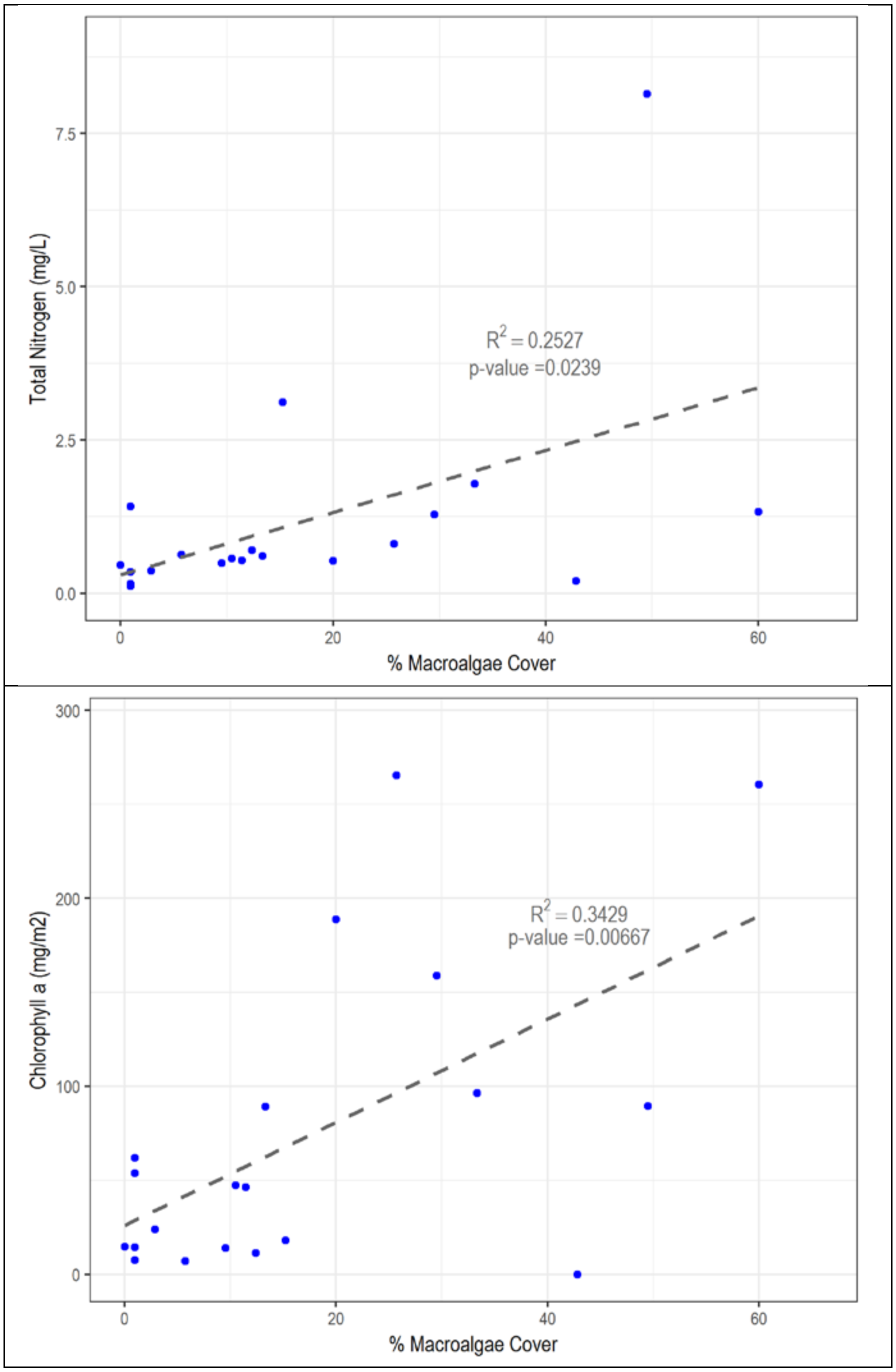

Figure 2.9. Total nitrogen concentrations compared with percent macroalgae cover (top) and chlorophyll a concentrations compared with percent macroalgae cover (bottom), for 20 bioassessment sites sampled in Santa Clara County in WY 2018.

Table 2.10. Scores for 11 PHAB metrics calculated from physical habitat data collected at twenty probabilistic sites in Santa Clara County during WY 2018.

Station Code	CSCI Score	Channel Morphology		Habitat Complexity and Cover				Substrate Size and Composition				Human Disturbance
		Evenness of Flow Habitat Types[1]	% Fast Water of Reach	Shannon Diversity - Aquatic Habitat Types[1]	Natural Shelter Cover	Mean Filamentous Algae Cover	Riparian Cover Sum of 3 Layers[1]	Evenness of Natural Substrate Types	Shannon Diversity - Natural Substrate Types[1]	% Gravel Coarse	% Substrate Smaller than Sand (<2 mm)[1]	Riparian Human Disturbance Index
204R00749	1.23	0.9	36	1.7	33	5	113	0.9	1.8	35	7	0.1
205R00746	1.12	0.6	46	1.6	28	5	119	0.9	1.9	19	19	1.6
205R00769	0.74	0.8	26	1.6	44	30	139	0.9	1.8	25	16	0.2
205R03498	1.14	1.0	50	1.9	22	4	142	0.9	1.8	30	28	3.1
205R03562	1.08	0.7	56	1.6	42	4	172	0.8	1.8	15	20	5.7
205R03591	1.06	0.7	56	1.6	31	0	150	0.9	1.8	20	24	1.3
205R03619	0.63	0.4	12	1.8	18	4	126	0.8	1.5	42	23	3.5
205R03683	0.91	0.6	68	1.9	45	17	157	0.8	1.7	21	38	2.2
205R03699	0.46	0.5	24	1.7	47	4	159	0.8	1.7	25	52	3.7
205R03738	0.47	0.9	33	1.9	44	20	153	0.9	1.8	20	34	1.5
205R03754	0.92	0.7	17	1.6	29	0	150	0.7	1.4	53	18	3.3
205R03795	0.4	0.9	0	1.4	29	28	118	0.7	1.1	11	77	4.5
205R03825	0.43	1.0	40	1.6	81	33	153	0.8	1.3	7	50	1.6
205R03843	0.39	0.8	22	1.1	22	35	100	0.8	1.4	38	27	3.3
205R03847	1.2	0.6	20	1.6	17	0	182	0.8	1.6	32	21	3.9
205R03875	0.46	0.1	0	1.7	17	2	70	0.8	1.3	30	39	3.4
205R03907	0.19	0.1	0	1.1	37	5	86	0.1	0.1	0	98	4.6
205R04190	0.88	0.9	41	1.9	51	5	169	0.8	1.6	38	35	2.9
205R04217	1.04	0.2	4	1.4	17	1	160	0.8	1.3	43	18	1.1
205R04266	0.51	0.8	45	1.8	18	0	125	0.9	1.5	40	24	3.1

[1] One of the five metrics used for development of the Index for Physical Habitat Integrity (IPI)

Table 2.11. Nutrient and conventional constituent concentrations in water samples collected at 20 sites in Santa Clara County during WY 2018. Physical habitat measurement percent macroalgae cover, is also shown for comparison.

Station Code	Creek	Ammonia as N	Unionized Ammonia (as N)	Chloride	AFDM	Chloro a	Nitrate as N	Nitrite as N	Total Kjeldahl as N	Total Nitrogen	Ortho-Phosphate as P	Phosphorus as P	Silica as SiO2	Macro Algae Cover
		mg/L	mg/L	mg/L	g/m2	mg/m2	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	%
Water Quality Objective:		NA	0.025 [b]	250 [a]	NA	NA	10 [a]	NA	NA	NA	NA	NA	NA	NA
204R00749	Smith Creek	0.044 J	0.001	6.6	11	54	0.06	< 0.001	0.088 J	0.15	0.007 J	0.007 J	13	1
205R00746	Saratoga Creek	< 0.04	< 0.001	16	38	89	0.21	< 0.001	0.4	0.61	0.072	0.06	23	13
205R00769	MF Coyote Cr	< 0.04	< 0.001	7.9	9	NR	0.07	< 0.001	0.13	0.20	< 0.006	< 0.007	13	43
205R03498	Saratoga Cr	< 0.04	< 0.001	22	106	46	0.14	< 0.001	0.4	0.54	0.06	0.064	20	11
205R03562	Saratoga Creek	< 0.04	< 0.001	21	61	47	0.17	< 0.001	0.4	0.57	0.066	0.046	20	10
205R03591	Los Trancos Cr	< 0.04	< 0.001	18	100	15	0.11	< 0.001	0.35	0.46	0.017	0.018	17	0
205R03619	Saratoga Creek	< 0.04	< 0.001	65	84	14	0.31	< 0.001	0.18	0.49	0.071	0.077	14	10
205R03683	Permanente Cr	< 0.04	< 0.001	30	81	189	0.13	< 0.001	0.4	0.53	0.19	0.035	16	20
205R03699	Hale Creek	0.099 J	0.002	200	74	18	2.00	0.012	1.1	3.11	0.21	0.22	32	15
205R03738	Upper Silver Cr	< 0.04	< 0.001	170	165	159	0.71	0.002 J	0.57	1.28	0.15	0.17	39	30
205R03754	San Tomas Aquino	< 0.04	< 0.001	59	13	7	0.32	< 0.001	0.31	0.63	0.019	0.02	28	6
205R03795	Lower Silver Cr	0.92	0.009	140	305	89	8.00	0.017	0.13	8.15	0.032	< 0.007	27	50
205R03825	Thompson Cr	< 0.04	< 0.001	100	135	96	1.30	< 0.001	0.48	1.78	0.056	0.053	27	33
205R03843	San Tomas Aquino	1.2	0.024	72	228	261	0.57	0.006	0.75	1.33	0.013	0.046	18	60
205R03847	Los Trancos Cr	< 0.04	< 0.001	45	61	14	0.08	< 0.001	< 0.07	0.12	0.029	0.03	24	1
205R03875	Calabazas Cr	0.055 J	0.004	43	23	8	0.22	< 0.001	0.13	0.35	< 0.006	0.062	8.6	1
205R03907	Lower Penitencia	1.1	0.046	120	533	62	0.77	0.027	0.62	1.42	0.028	0.043	20	1
205R04190	Guadalupe Cr	1.0	0.005	34	36	266	0.10	0.001 J	0.7	0.80	0.02	< 0.007	16	26
205R04217	Upper Penitencia	< 0.04	< 0.001	12	102	24	< 0.02	0.001 J	0.35	0.36	0.035	0.034	13	3
205R04266	Calabazas Cr	< 0.04	< 0.001	42	48	11	0.26	0.001 J	0.44	0.70	0.093	0.092	9.5	12

NA = Not Applicable, NR = Not Reported

J = The reported result is an estimate.

[a] Chloride and nitrate WQOs only apply to waters with MUN designated Beneficial Uses.

[b] This threshold is an annual median value and is not typically applied to individual samples.

3.0 CONTINUOUS WATER QUALITY MONITORING

3.1 Introduction

During WY 2018 water temperature and general water quality were monitored in compliance with Creek Status Monitoring Provisions C.8.d.iii – iv of the MRP. Monitoring was conducted at selected sites using a targeted design based on the directed principle[20] to address the following management questions:

1. *What is the spatial and temporal variability in water quality conditions during the spring and summer season?*
2. *Do general water quality measurements indicate potential impacts to aquatic life?*

The first management question is addressed primarily through evaluation of water quality results in the context of existing aquatic life uses. Temperature and general water quality data were evaluated for potential impacts to different life stages and overall population of fish community present within monitored reaches.

The second management question is addressed primarily through the evaluation of targeted data with respect to water quality objectives and thresholds from published literature. Sites where exceedances occur may indicate potential impacts to aquatic life or other beneficial uses and are considered as candidates for future Stressor/Source Identification projects.

3.2 Study Area

In compliance with MRP, temperature was monitored at a minimum of eight sites, and general water quality was monitored at three sites. The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns.

3.2.1 Temperature

Continuous (hourly) water temperature measurements were collected from April through September 2018, at nine locations[21] in two creeks of the Guadalupe River watershed: Alamitos Creek and Guadalupe Creek (Figure 3.1). Both creeks are impounded by large dams located at the base of the Santa Cruz Mountains. The temperature monitoring locations were downstream of the reservoirs in reaches flowing through the Santa Clara Valley. The upper watershed areas for these creeks include rangeland and forested land uses within Almaden Quicksilver County Park and the Sierra Azul Open Space Preserve. The lower watershed areas are primarily residential land uses within the City of San José.

The Almaden Reservoir (1,590 acre-feet) is located in upper Alamitos Creek and the Guadalupe Reservoir (3,415 acre-feet) is located in upper Guadalupe Creek. Both reservoirs are owned and operated by SCVWD. The reservoirs are primarily used for water supply, although they

[20] Directed Monitoring Design Principle: A deterministic approach in which points are selected deliberately based on knowledge of their attributes of interest as related to the environmental site being monitored. This principle is also known as "judgmental," "authoritative," "targeted," or "knowledge-based."

[21] SCVURPPP typically monitors water temperature at more stations than the MRP required minimum of eight to mitigate for potential equipment loss.

also provide some flood protection by containing runoff during the wet season. Releases during the late summer can also benefit the environment by maintaining flow in the creek.

Guadalupe Creek and Alamitos Creek support spawning and rearing habitat for steelhead, although fish are less abundant in the unshaded, warm section of Guadalupe Creek downstream of Camden Avenue (Smith 2013). Seven of the sites were also monitored for temperature as part of Creek Status Monitoring Project during WY 2017. Two temperature monitoring sites that are closer to the reservoirs were added in WY 2018: site 218 on Guadalupe Creek located about 1000 meters downstream of Guadalupe Reservoir, and site 279 on Alamitos Creek located about 1250 meters downstream of Calero Reservoir. These new sites were selected to evaluate water temperatures in reaches closer to the reservoirs.

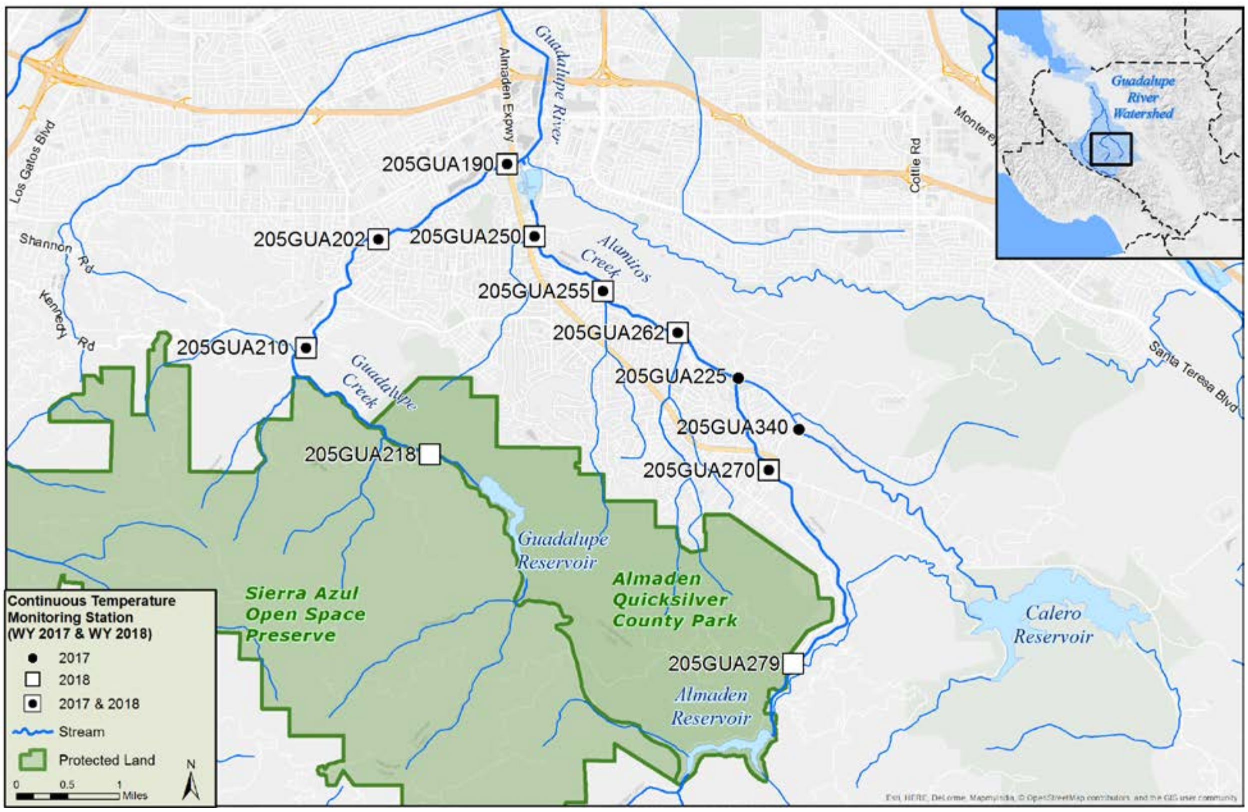

Figure 3.1. Continuous temperature stations in the Guadalupe River watershed, WY 2017 and 2018.

3.2.2 General Water Quality

Continuous (15-minute) general water quality measurements (DO, specific conductance, pH, and temperature) were recorded at three locations on the mainstem of Coyote Creek during two two-week sampling events in WY 2018 (Figure 3.2). The stations include site 205COY235 (Watson Park), site 205COY236 (Julian Street) and site 205COY239 (Williams). The first event was in late May through early June and the second event was in September.

The monitoring stations were previously sampled for continuous water quality in WY 2013 as part of the Coyote Creek Dissolved Oxygen Stressor/Source Identification (Coyote Creek SSID) Project (SCVURPPP 2014) and for MRP Provision C.8.d.iii compliance in WY 2017. The Coyote Creek SSID Project evaluated a range of potential stressors and sources that may cause low dissolved oxygen in the section of Coyote Creek between Watson Park and Williams Park. The Coyote Creek SSID Project measured continuous water quality at six locations between June and September 2013.

WY 2017 monitoring was conducted following an extremely wet winter that resulted in widespread flooding in the urban reaches of Coyote Creek. One of the objectives for sampling these locations was to determine if the high flow events in 2017 may have flushed out the fine sediment and organic matter that was identified as a potentially important factor causing reduced dissolved oxygen levels in the Coyote Creek SSID Project study area.

Creek Status Monitoring results from WY 2017 indicated that dissolved oxygen during the September sampling event was generally higher compared to levels measured in WY 2013. To evaluate inter-annual variability, the same sites were monitored in WY 2018. Data may help assess overall variability in water quality conditions between a year with high rainfall and flooding (WY 2017) and a year with average rainfall (WY 2018).

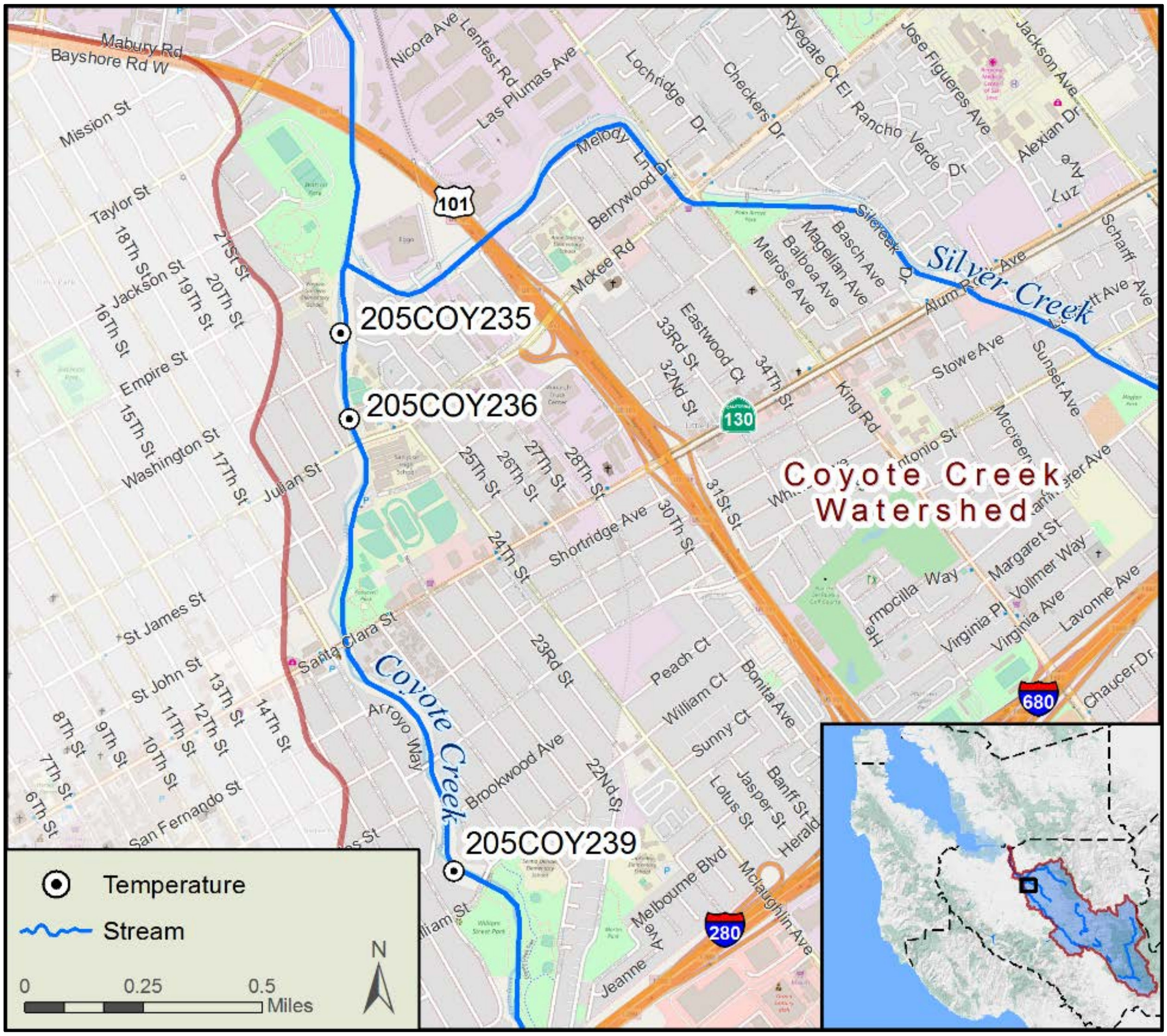

Figure 3.2. Continuous water quality stations in Coyote Creek, WY 2017 and 2018.

3.3 Methods

Water quality data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016a) and associated QAPP (BASMAA 2016b). Data were evaluated with respect to the MRP provision C.8.d "Follow-up" triggers for each parameter.

3.3.1 Continuous Temperature

Digital temperature loggers (Onset HOBO Water Temp Pro V2) were programmed to record data at 60-minute intervals. The loggers were deployed at targeted sites from April 5 through September 27, 2018. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-5 (BASMAA 2016a).

3.3.2 Continuous General Water Quality

Water quality monitoring equipment recording dissolved oxygen, temperature, conductivity, and pH (YSI 6600 data sondes) were programmed to record data at 15-minute intervals. The sondes were deployed at targeted sites for two 2-week periods: during spring season (Event 1) and during summer season (Event 2) in 2018. Procedures for calibrating, deploying, programming and downloading data are described in RMC SOP FS-4 (BASMAA 2016a).

3.3.3 Data Evaluation

Continuous temperature and water quality data generated during WY 2018 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of water quality objectives. Provision C.8.d of the MRP identifies trigger criteria as the principal means of evaluating the creek status monitoring data to identify sites where water quality impacts may have occurred. Sites with targeted monitoring results exceeding the trigger criteria are identified as candidate SSID projects. The relevant trigger criteria for continuous temperature and water quality data are listed in Table 3.1.

Table 3.1. Water Quality Objectives and thresholds used for trigger evaluation.

Monitoring Parameter	Objective/Trigger Threshold	Units	Source
Temperature	Two or more weekly average temperatures exceed the MWAT of 17.0°C for a Steelhead stream, or when 20% of the results at one sampling station exceed the instantaneous maximum of 24°C.	^oC	MRP provision C.8.d.iii.
General Water Quality Parameters	20% of results at each monitoring site exceed one or more established standard or threshold - applies individually to each parameter		
Conductivity	2000	µS/cm	MRP provision C.8.d.iii.
Dissolved Oxygen	WARM < 5.0, COLD < 7.0	mg/L	SF Bay Basin Plan Ch. 3, p. 3-4
pH	> 6.5, < 8.5 [1]	pH	SF Bay Basin Plan Ch. 3, p. 3-4
Temperature	Same as Temperature (See Above)		

[1]. Special consideration will be used at sites where imported water is naturally causing higher pH in receiving waters.

3.4 Results and Discussion

The section below summarizes results from continuous temperature and water quality monitoring conducted during WY 2018. Conclusion and recommendations for this section are presented in Section 7.0.

3.4.1 Continuous Temperature

Temperature loggers were deployed at nine sites in the Guadalupe River watershed on April 5, checked and downloaded on June 4, and removed on September 27, 2018 (26 weeks). During retrieval in September, the temperature logger at site 262 was not recovered, and as a result, only 12 weeks of data were recorded at that site.

Summary statistics for continuous water temperature data collected at the nine sites are listed in Table 3.2. The number and percent of measurements from each site that exceed the instantaneous maximum temperature trigger of 24°C is shown in the table. Temperatures greater than 24°C occurred at one site (218) during the month of August, but only for 1% of the total measurements recorded; therefore, the trigger threshold for instantaneous maximum temperature was not exceeded.

Maximum Weekly Average Temperature (MWAT) values were calculated for each of the nine monitoring sites (Table 3.3). Consistent with MRP requirements, the MWAT was calculated for non-overlapping, seven-day periods. The MWAT values across all the sites ranged from 11.0 °C to 16.1°C during the month of April to 19.0 °C to 22.7°C during the month of August. Time series plots of the MWAT values are shown for sites in Guadalupe Creek (Figure 3.3) and Alamitos Creek (Figure 3.4). Similar to the results from WY 2017, the MWAT trigger was exceeded on two or more weeks at all sampling locations in WY 2018. As a result, all nine sites will be added to the list of potential sites considered for SSID projects.

Water temperature data, calculated as a daily average, for monitoring sites in Guadalupe Creek and Alamitos Creek in WY 2018, are shown in Figures 3.5 and 3.6, respectively. Daily average temperatures collected during WY 2017 are also presented for comparison. Water temperatures generally increased throughout the summer months of June through August followed by a slow decline by mid/late September for both years. Water temperatures had similar seasonal patterns between the two years of monitoring, with the exception of higher temperatures observed during the months June and September during WY 2017. The higher water temperatures in September 2017 coincide with a heatwave that exhibited some of the highest air temperatures for that month on record.

Instantaneous water temperatures collected at monitoring sites in Guadalupe Creek and Alamitos Creek for both years, are presented as bean plots in Figures 3.7 and 3.8, respectively. In Guadalupe Creek, water temperatures were relatively consistent for both years, with the median temperature generally increasing with decreasing site elevation (Figure 3.7). However, site 218 (only sampled in 2018), located just below Guadalupe Reservoir, had a higher median temperature than adjacent downstream sites. This pattern suggests that water released from the reservoir (potentially warmed by solar radiation) is gradually cooled by the shaded riparian corridor at sites further downstream. Water temperature gradually increases at sites further downstream that have less shading and more influence from urban runoff and groundwater return flows. A similar pattern was observed in Alamitos Creek sites, with the median temperature lowest in the middle elevation site (262) and increasing at sites located further upstream and downstream of that site (Figure 3.8).

Table 3.2. Descriptive statistics for continuous water temperature measured between April 5 and September 27, 2018 at nine sites in the Guadalupe River watershed, Santa Clara County.

	Site ID	205GUA190	205GUA 202	205GUA 210	205GUA 218	205GUA 250	205GUA 255	205GUA 262	205GUA 270	205GUA 279
	Start Date	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018	4/5/2018
	End Date	9/27/2018	9/27/2018	9/27/2018	9/27/2018	9/27/2018	9/27/2018	6/25/2018	9/27/2018	9/27/2018
Temperature (ºC)	Min	12.3	9.7	8.7	9.6	12.7	11.9	12.0	10.7	11.6
	Median	19.0	17.8	17.1	19.1	19.1	18.6	16.6	17.9	18.2
	Mean	18.4	17.2	16.7	18.1	18.7	18.5	16.7	17.5	17.7
	Max	23.4	22.6	22.6	24.9	23.4	23.4	22.2	22.0	23.6
	Max 7-day mean	21.0	21.1	20.4	22.7	21.4	21.3	19.2	20.6	21.5
	N (# individual measurements)	4196	3451	4196	4197	4195	4194	1939	4195	4195
# Measurements > 24°C		0	0	0	52	0	0	0	0	0
		0%	0%	0%	1%	0%	0%	0%	0%	0%

Table 3.3. MWAT values for water temperature data collected at nine stations monitored in Guadalupe River watershed, WY 2018. MWAT values that exceed MRP trigger (17°C) are indicated in bold.

	Guadalupe Creek				Alamitos Creek				
Station	205GUA190	205GUA202	205GUA210	205GUA218	205GUA250	205GUA255	205GUA262	205GUA270	205GUA279
Date	Weekly Average Temperature (ºC)								
4/5/2018	14.6	13.6	12.7	11.5	15.2	15.1	14.9	13.9	12.9
4/12/2018	13.9	12.0	11.2	11.0	14.6	14.4	14.3	13.0	12.8
4/19/2018	15.0	13.8	12.7	11.9	16.1	16.0	15.9	14.6	13.7
4/26/2018	14.8	13.3	12.4	12.3	15.6	15.5	15.5	13.9	13.7
5/3/2018	15.6	14.8	13.8	13.5	16.7	16.5	16.4	15.1	14.4
5/10/2018	15.9	15.1	14.1	14.3	16.6	16.4	16.3	15.1	14.8
5/17/2018	16.1	15.3	14.7	15.1	17.0	16.9	16.8	15.7	15.3
5/24/2018	16.7	16.3	15.5	16.0	17.5	17.5	17.3	16.4	15.9
5/31/2018	17.1	16.7	15.7	16.6	17.9	17.9	17.7	16.7	16.2
6/7/2018	17.5	16.7	16.0	17.3	18.2	18.2	18.1	16.9	16.6
6/14/2018	18.0	17.5	16.8	18.1	18.8	18.7	18.5	17.5	17.0
6/21/2018	18.8	19.0	18.1	18.9	19.7	19.6	19.2	18.6	17.6
6/28/2018	19.0	18.9	18.1	19.3	19.9	19.7		18.6	17.9
7/5/2018	19.7	19.7	18.9	20.2	20.6	20.4		19.3	18.6
7/12/2018	20.2	20.6	19.9	21.1	21.1	20.9		20.1	19.2
7/19/2018	20.7	21.1	20.4	21.6	21.4	21.3		20.6	19.8
7/26/2018	20.6	20.1	19.6	21.4	19.8	20.6		19.9	19.9
8/2/2018	20.5	19.2	18.9	21.4	19.8	20.0		19.2	20.0
8/9/2018	20.9	19.8	19.7	22.3	20.2	20.5		19.9	20.7
8/16/2018	21.0	19.4	19.6	22.7	20.5	20.2		19.8	21.1
8/23/2018	20.9	19.5	19.1	22.5	20.6	19.8		19.3	21.2
8/30/2018	20.8		19.0	22.3	20.3	19.8		19.3	21.5
9/6/2018	21.0		18.0	21.6	19.8	19.1		18.4	21.0
9/13/2018	20.0		16.3	20.1	18.7	17.9		17.1	20.0
9/20/2018	19.9		16.9	20.0	19.2	18.5		17.7	19.9
9/27/2018	19.4		16.6	19.1	18.2	17.7		17.5	19.3
Total Weeks	26	21	26	26	26	26	12	26	26
MWAT >17°C	18	11	12	17	19	19	5	16	15
% Exceed	69%	52%	46%	65%	73%	73%	42%	62%	58%
> MRP Trigger	Y	Y	Y	Y	Y	Y	Y	Y	Y

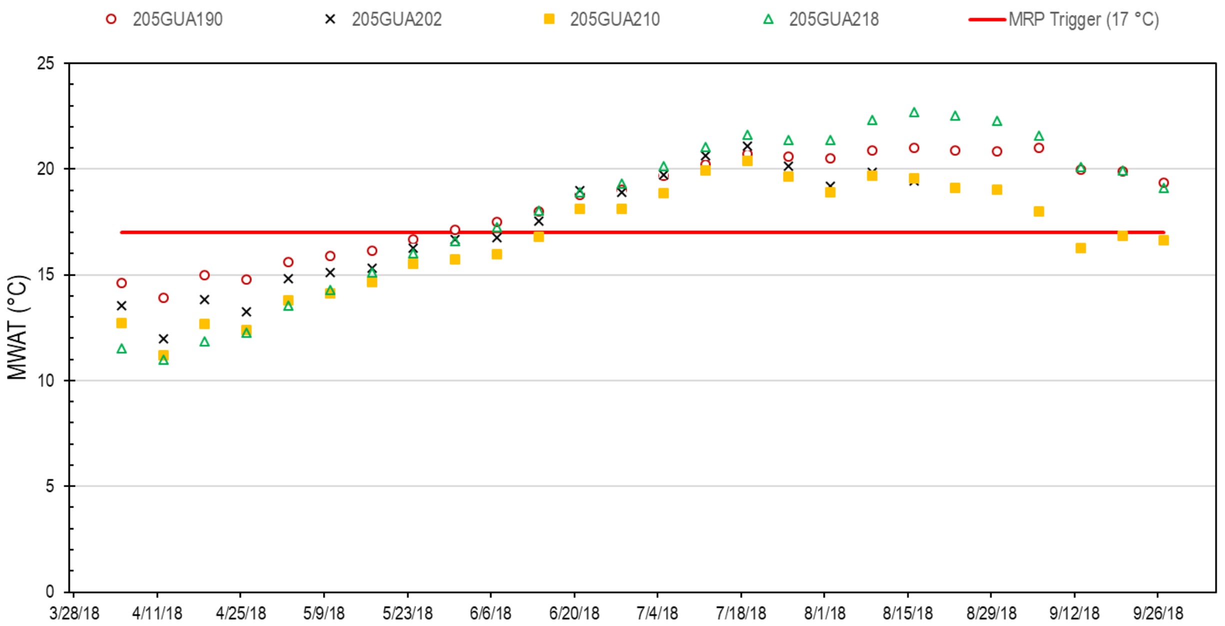

Figure 3.3. Maximum Weekly Average Temperature (MWAT) values calculated for water temperature collected at four sites in Guadalupe Creek over 26 weeks of monitoring in WY 2018. The MRP trigger (17°C) is shown for comparison.

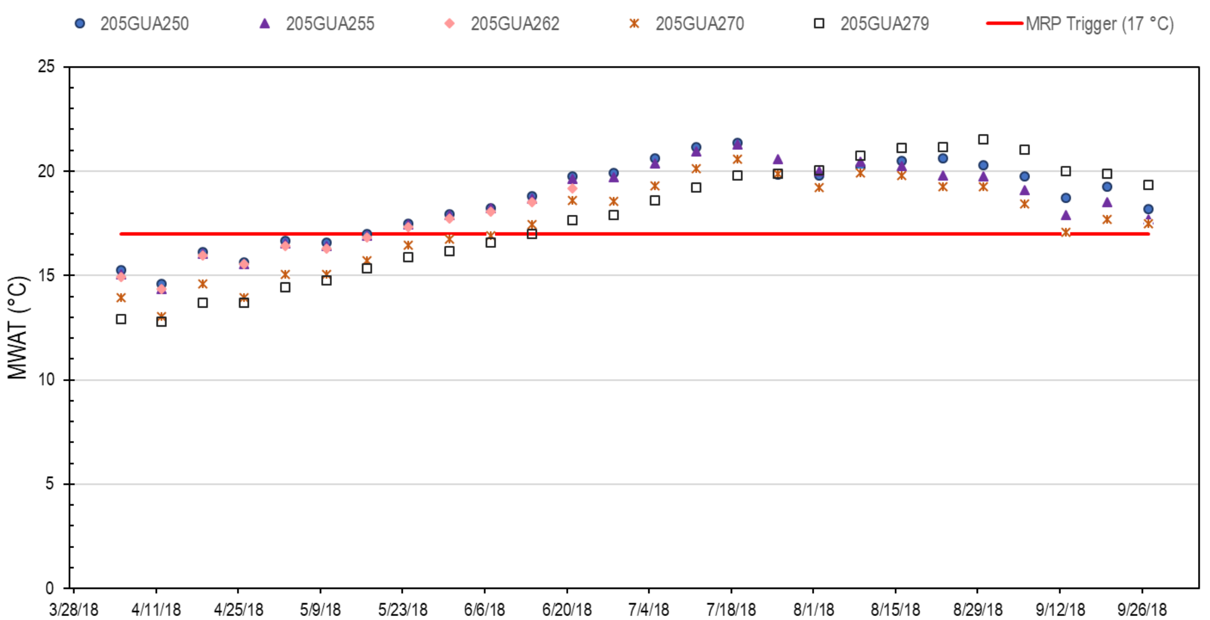

Figure 3.4. Maximum Weekly Average Temperature (MWAT) values calculated for water temperature collected at five sites in Alamitos Creek over 26 weeks of monitoring in WY 2018. The MRP trigger (17°C) is shown for comparison.

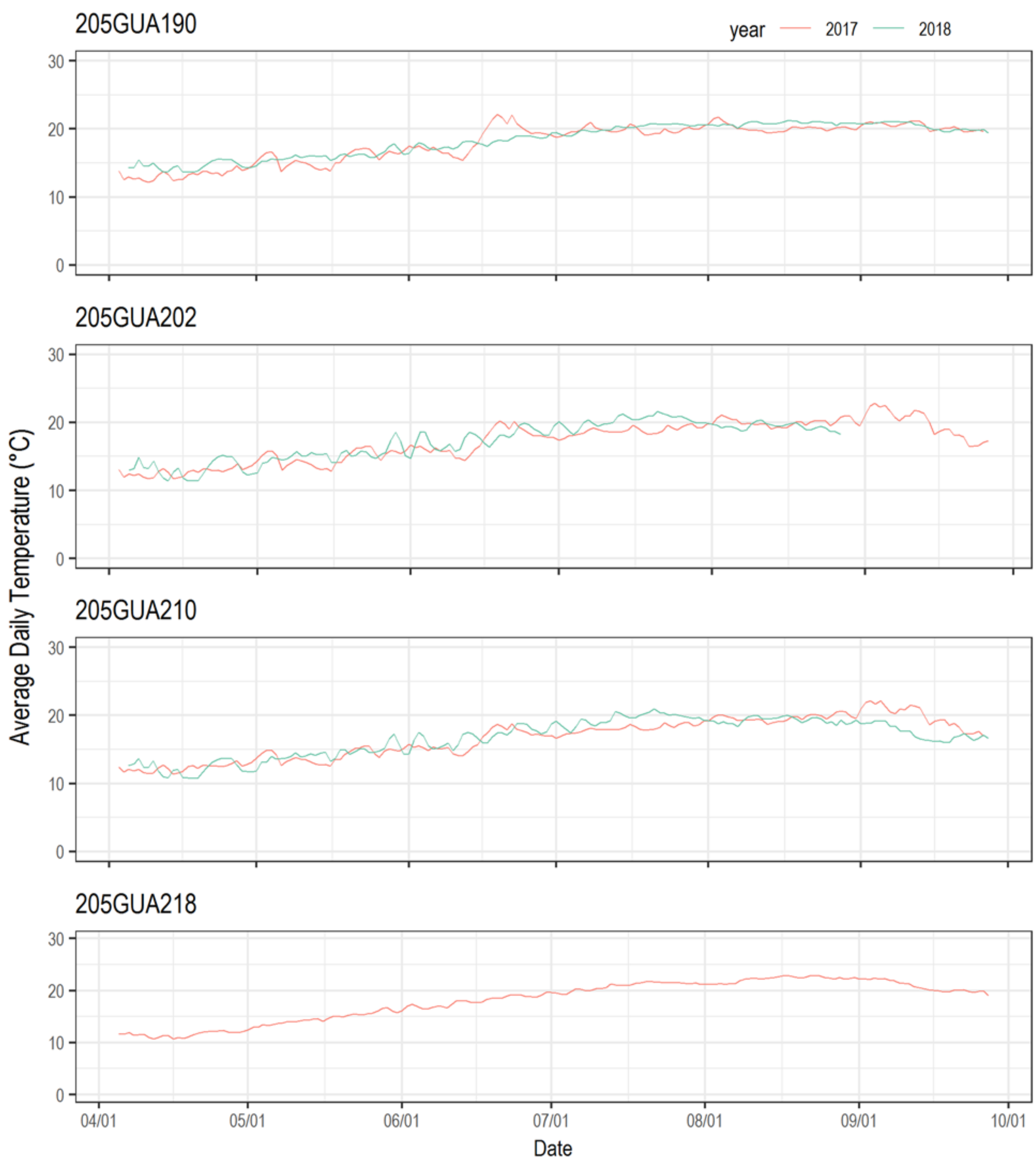

Figure 3.5. Water temperature, shown as daily average, collected between April and September at four sites in Guadalupe Creek during WY 2017 and WY 2018.[22]

[22] Datalogger at site 202 malfunctioned at the end of August with an abrupt jump in temperature from approximately 17 to 20°C with no diurnal variability; these records were excluded.

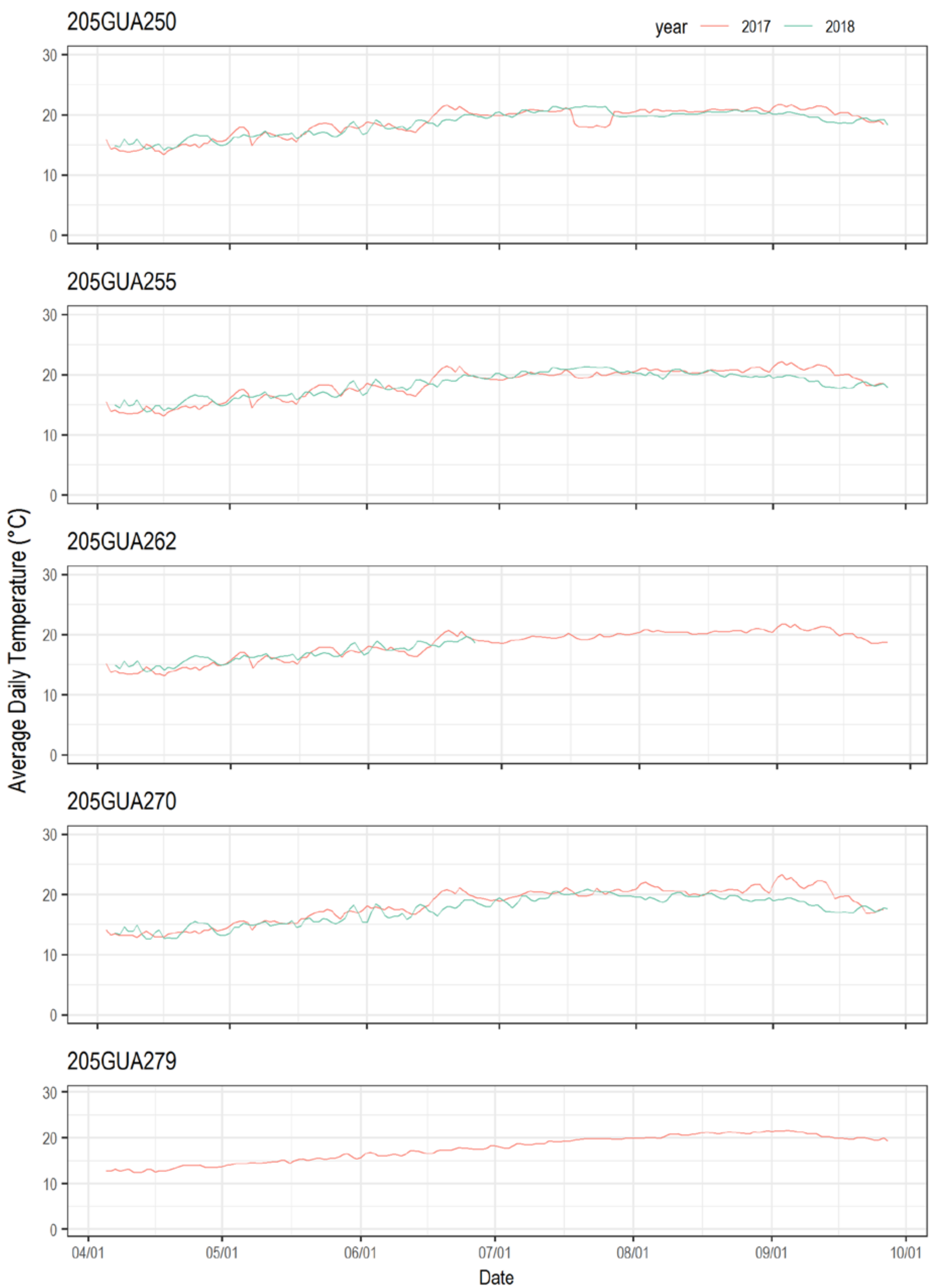

Figure 3.6. Water temperature, shown as daily average, collected between April and September at five sites in Alamitos Creek during WY 2017 and WY 2018.

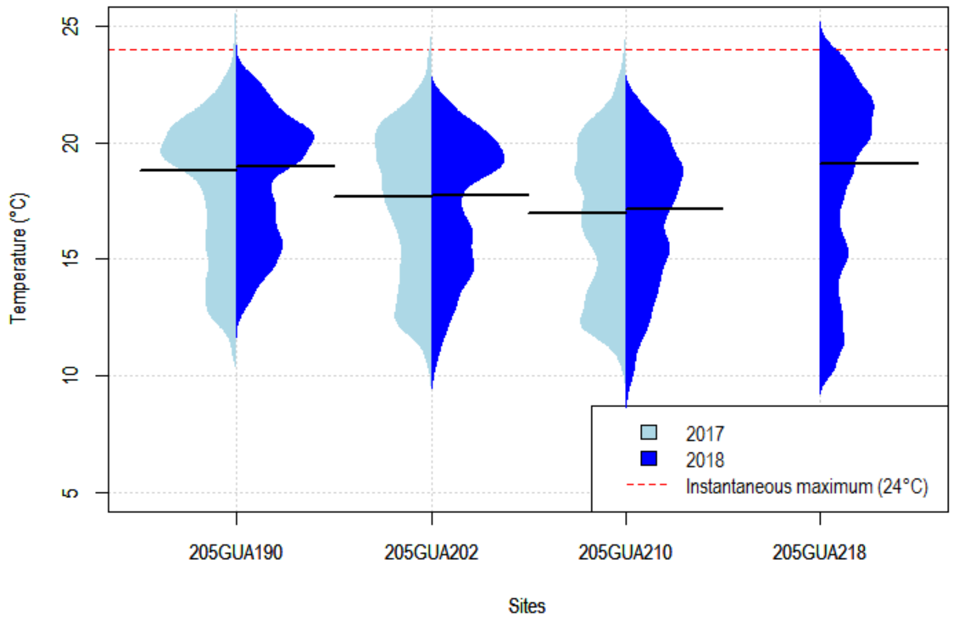

Figure 3.7. Water temperature data, presented as bean plots, collected between April and September, at four sites in Guadalupe Creek during WY 2017 and WY 2018. Solid black lines indicate median temperature.

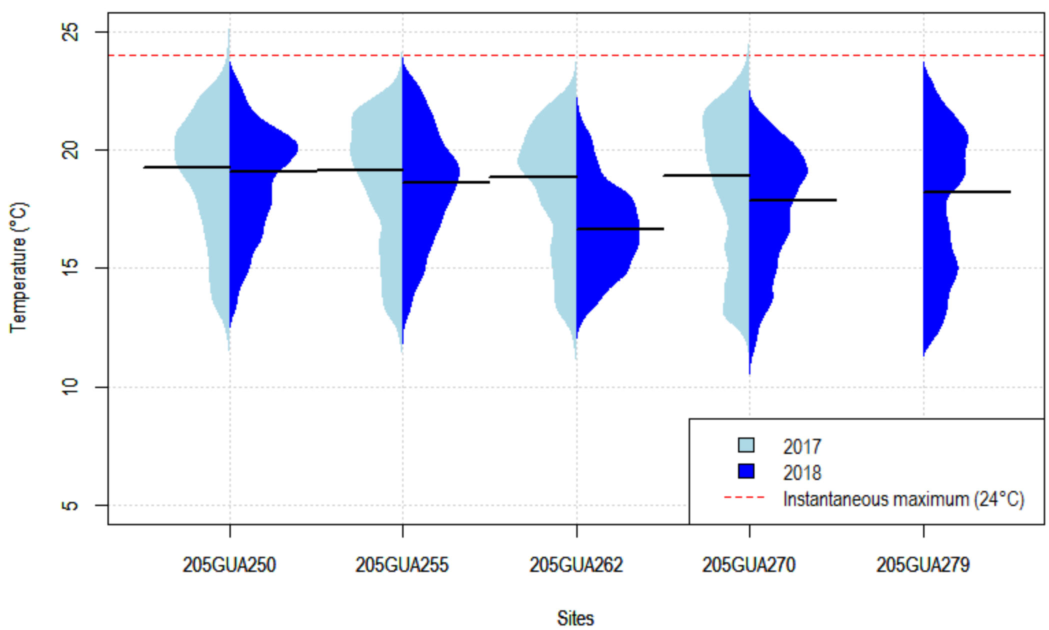

Figure 3.8. Water temperature data, presented as bean plots, collected between April and September, at five sites in Alamitos Creek during WY 2017 and WY 2018. Solid black lines indicate median temperature.

Temperature Trigger Considerations

The Basin Plan (SFRWQCB 2017) designates several Beneficial Uses associated with aquatic life uses, including COLD, WARM, MIGR, SPWN and RARE, for Guadalupe Creek and Alamitos Creek (Table 1.5). Spawning and rearing habitat for juvenile steelhead is present in the reaches of Guadalupe Creek and Alamitos Creek below the reservoirs (Becker et al. 2007). The extent and quality of steelhead rearing habitat is dependent on the amount and timing of releases from the reservoirs. Additional limiting factors to the steelhead population in these creeks include passage barriers, water temperature, riparian cover, sediment, mercury contamination, and predatory warm water fish species (FAHCE 2003).

Since WY 2004, the SCVWD conducted temperature and fisheries monitoring in Guadalupe Creek to meet mitigation monitoring requirements for the Downtown-Guadalupe River Flood Control Project. Most of the temperature monitoring was conducted at stations in the Guadalupe River. Limited data available for Guadalupe Creek showed cooler temperatures further upstream at stations closest to the dam, which is consistent with monitoring results presented in this report. Portions of Guadalupe Creek and Alamitos Creek presently support small population of steelhead/resident rainbow trout, although fish are generally less abundant in the unshaded, warm section of Guadalupe Creek downstream of Camden Avenue (Smith 2013).

Annual fall monitoring conducted by the SCVWD since 2004 indicates juvenile steelhead were typically present in Guadalupe Creek (SCVWD et al. 2016). Steelhead numbers dropped in 2015 due to low flow conditions caused by the drought. In 2016, only two steelhead individuals were documented at one site, which was the lowest count on record. However, a separate study in 2016 documented a total of 26 juvenile and adult steelhead further upstream below the dam for Guadalupe Reservoir (SCVWD et al. 2016). Additional monitoring in 2017 recorded 30 steelhead in a 2.5-mile reach downstream of the dam for Guadalupe Reservoir (SCVWD, personal communication, Clayton Leal). In general, the upper reaches of Guadalupe Creek provide summer refugia for steelhead.

Steelhead were historically found in Alamitos Creek (Leidy et al. 2005); however, no records were available to confirm current presence of steelhead populations in the creek. Smith (2013) reports portions of Alamitos Creek support populations of steelhead.

Providing continuous flow during the dry season would allow steelhead to migrate to more optimal habitat conditions, including reaches with cooler water temperatures. In addition, longitudinal connectivity to areas where food is available can allow juvenile steelhead to increase feeding behavior and maintain optimal body weight to survive periods of warmer temperatures (Smith 2013). Thus, flow in the lower reaches is critically important for sustaining steelhead populations, as well as other Aquatic Life Beneficial Uses.

Although the MRP trigger for temperature (i.e., MWAT >17°C for two or more weeks) was exceeded at all nine stations, it is important to keep in mind that different water temperature thresholds exist that may be more relevant to Santa Clara County streams. NOAA's National Marine Fisheries Service (NMFS) has developed recovery plans for Central Coast steelhead (which includes the Guadalupe River watershed) using the Maximum Weekly Maximum Temperature (MWMT) of 20 °C to evaluate water quality conditions potentially impacting steelhead. The MWMT is calculated using the maximum, not the average, weekly temperatures of nonoverlapping weeks. The MWMT is suggested to better reflect transient water temperature peaks and any acute effects of the single point maximum temperature. (http://krisweb.com/stream/temp_standards.htm)

3.4.2 General Water Quality

Summary statistics for general water quality measurements collected at the three sites in Coyote Creek during the two sampling events in WY 2018 are listed in Table 3.4. Monitoring was conducted from May 21 through June 24, 2018 (Event 1) and from September 10 through September 19, 2018 (Event 2). Sampling locations are mapped in Figure 3.2. Plots for all water quality parameters collected during Event 1 are shown in Figure 3.9 and for Event 2 in Figure 3.10.

Table 3.4. Descriptive statistics for continuous water temperature, dissolved oxygen, pH, and specific conductance measured at three Coyote Creek sites in Santa Clara County during WY 2018. Data were collected every 15 minutes over two 2-week time periods during May/June (Event 1) and September (Event 2).

Parameter	Data Type	205COY235		205COY236		205COY239	
		Event 1 WY18	Event 2 WY18	Event 1 WY18	Event 2 WY18	Event 1 WY18	Event 2 WY18
Temperature (°C)	Minimum	16.4	16.9	16.8	16.4	16.1	15.9
	Median	18.2	18.0	18.2	17.8	18.3	17.8
	Mean	18.4	18.1	18.3	17.9	18.6	17.8
	Maximum	21.3	19.8	21.1	19.4	22.5	20.1
	% > 24	0%	0%	0%	0%	0%	0%
Dissolved Oxygen (mg/L)	Minimum	2.7	4.1	0.3	4.5	4.5	6.6
	Median	4.2	4.9	4.6	5.2	6.3	7.2
	Mean	4.3	4.9	4.2	5.2	6.3	7.3
	Maximum	6.0	5.6	5.9	5.9	7.9	8.3
	% < 7	100%	100%	100%	100%	84%	14%
pH	Minimum	7.6	7.6	n/a	7.6	7.5	7.7
	Median	7.5	7.8	n/a	7.7	7.5	7.8
	Mean	7.6	7.8	n/a	7.7	7.6	7.8
	Maximum	7.7	7.8	n/a	7.8	7.9	7.8
	% < 6.5 or > 8.5	0%	0%	n/a	0%	0%	0%
Specific Conductivity (uS/cm)	Minimum	906	915	898	842	862	807
	Median	967	932	963	863	927	828
	Mean	966	938	968	867	931	831
	Maximum	1067	983	1167	901	1032	861
	% > 2000	0%	0%	0%	0%	0%	0%
Total number of data points (N)		1357	853	1358	853	1344	851

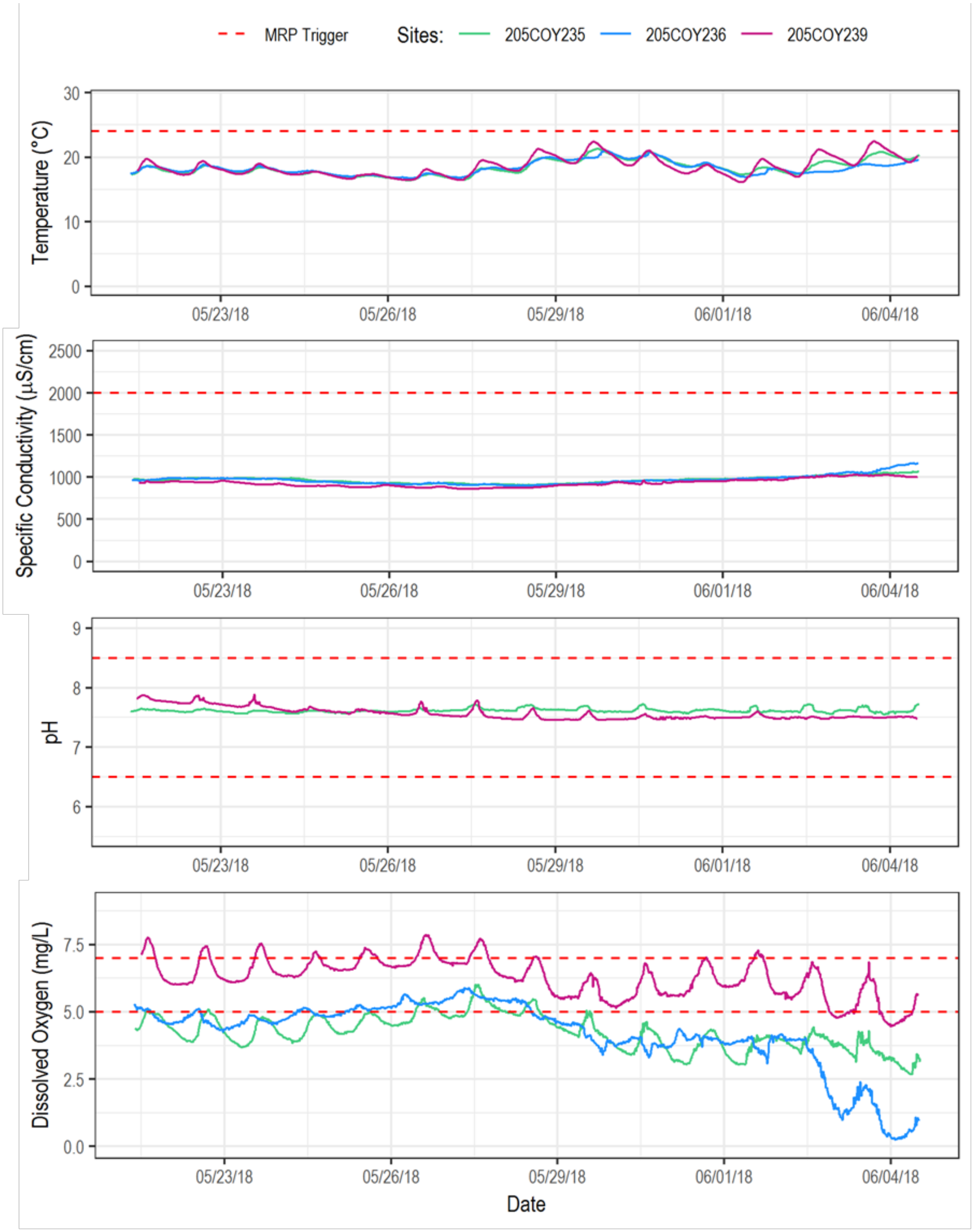

Figure 3.9 Continuous water quality data (temperature, specific conductance, pH[23], and dissolved oxygen) collected at three sites in Coyote Creek in May/June 2018 (Event 1).

23 pH sensor did not meet data quality objectives for pre- and post-calibration; data were not used for analyses.

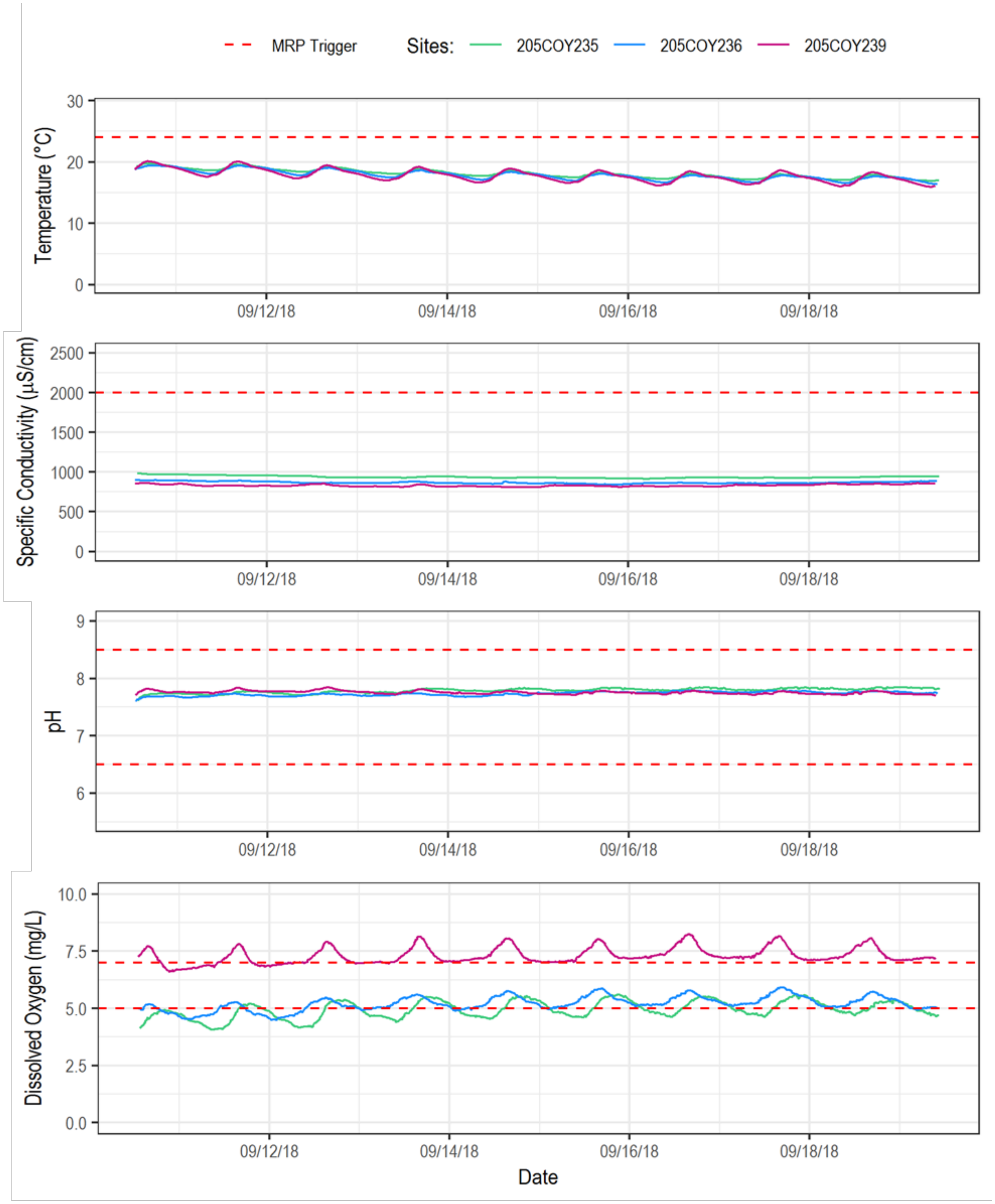

Figure 3.10. Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at three sites in Coyote Creek in September 2018 (Event 2).

Temperature

The water temperature data show a similar pattern for all three sites during both events. Daily patterns are evident in the record with cooler temperatures recorded at night and warmer temperatures in the afternoon. During the May-June sampling event (Event 1), water temperatures showed both cooling and warming trends over the two-week deployment (Figure 3.9). Water temperatures were much more stable (other than diurnal variation) during Event 2. In general, water temperatures showed little variability between sites during each event (Figures 3.9 and 3.10).

Water temperatures never exceeded 24°C, so the MRP trigger for instantaneous maximum temperature was not exceeded at any of the sites for either sampling event (Table 3.4). MWAT was calculated for both two-week events (Table 3.5). The MWAT threshold (17 °C) was exceeded at all three stations during both weeks of both events.

Table 3.5. MWAT values for water temperature data collected at three stations monitored in Coyote Creek, WY 2018.

Station		205COY235	205COY236	205COY239
Month	Week	Maximum Weekly Average Temperature (°C)		
May/June	Week 1	18.1	18.2	18.5
	Week 2	18.0	18.2	18.1
September	Week 1	19.3	19.1	19.2
	Week 2	19.1	18.8	18.8

During the September sample event, the Coyote Creek sites exhibited lower water temperatures in 2018 compared to 2017 and 2013 (Figure 3.10). Overall, the median value and range of water temperature measurements over the three years of monitoring was highly variable. Bean plots of temperature data collected during September events of WY 2013, 2017, and 2018 are shown in Figure 3.11.

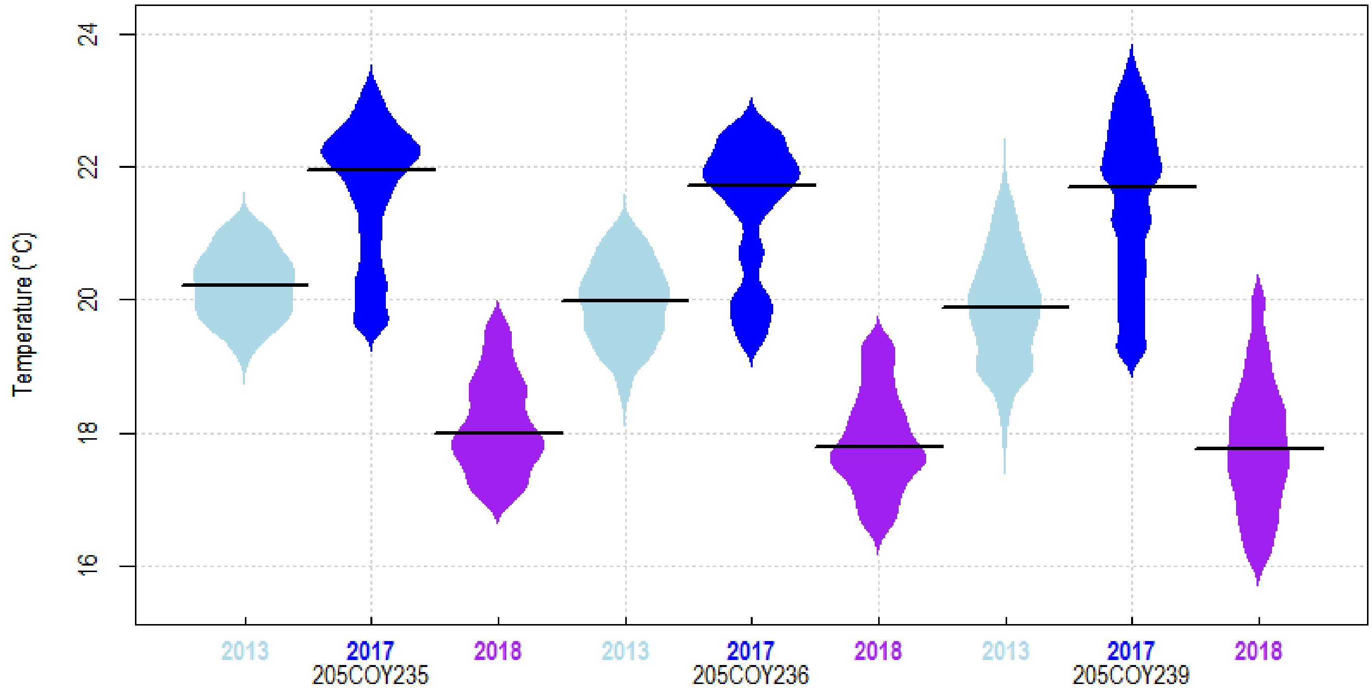

Figure 3.11. Comparison of temperature data collected in September 2017 and 2018 for Creek Status Monitoring with data collected in September 2013 for the Coyote Creek SSID Project.

Specific Conductance

Specific conductance was approximately 900 to 1000 µS /cm at all three sites during both sampling events, and thus, never exceeded the MRP trigger threshold (2000 µS/cm). Specific conductance levels followed a similar pattern at all three sites during both events, with very little variability in the record.

pH

The pH data was generally consistent between sites, ranging between 7.5 and 8.0 for both sampling events, and thus never exceeded the MRP trigger. Calibration checks of the sonde that was deployed at station 205COY236 during the spring sampling event showed a drift in the pH sensor of over 0.2 units, which was not consistent with Measurement Quality Objectives in the project QAPP (BASMAA 2016b). Thus, those pH data were rejected and not used in the analyses. The pH probe was replaced prior to the September sampling event.

Dissolved Oxygen

Dissolved oxygen concentrations decreased across all the sites during second week of Event 1 (Figure 3.9). The decrease may be associated with the observed increase in water temperatures that occurred during the same period. The dissolved oxygen data showed a consistent pattern for both sampling events, with median DO levels about 2.0 mg/L lower at the two downstream sites (235, 236) compared to the upstream site (239) (Figure 3.9 and Figure 3.10). In general, the two lowest elevation sites had less diurnal variability compared to the upstream site. The DO levels dropped dramatically at site 236 (Julian Street) (< 1.0 mg/L) during the last few days of deployment during Event 1 (Figure 3.8). The drop may have been associated with thermal stratification, which was observed in previous data collected for the Coyote Creek SSID Project (SCVURPPP 2014).

Dissolved oxygen data collected during Event 2 was compared to data collected at the same sites during the same time period in WY 2017 (Creek Status Monitoring) and WY 2013 (Coyote Creek Dissolved Oxygen SSID Project). Distribution of the data from all three years, presented as bean distribution plots, are shown in Figure 3.12. The median DO levels increased from 2013 to 2017 (by approximately 1.0 mg/L) and from 2017 to 2018 (by approximately 1.5 mg/L) at all three sites.

One hypothesis for the observed increase in DO levels between 2013 and 2017 may be associated with high stream flows that occurred in Coyote Creek during the winter season of WY 2017. These high flows may have caused an overall reduction in the amount of organic material and sediment at the sites. One of the conclusions of the Coyote Creek SSID project was that accumulated organic material and sediment coupled with slow velocity and low gradient of the channel are likely important factors in the low DO concentrations and the low potential for re-aeriation of the water column.

The dissolved oxygen concentrations in 2018 were below 7.0 mg\L (MRP trigger for cold water fishery stream) at all three sites (Table 3.4 and Figure 3.12). These data results should be interpreted cautiously. Although Coyote Creek is designated as COLD Habitat, Aquatic Life Beneficial Uses associated with cold water fishery, except migration, are generally not supported in the reach where water quality sampling was conducted. The sampling reach of Coyote Creek mainstem may support a WARM water fishery; however, existing habitat and water quality conditions currently do not support a cold water fishery.

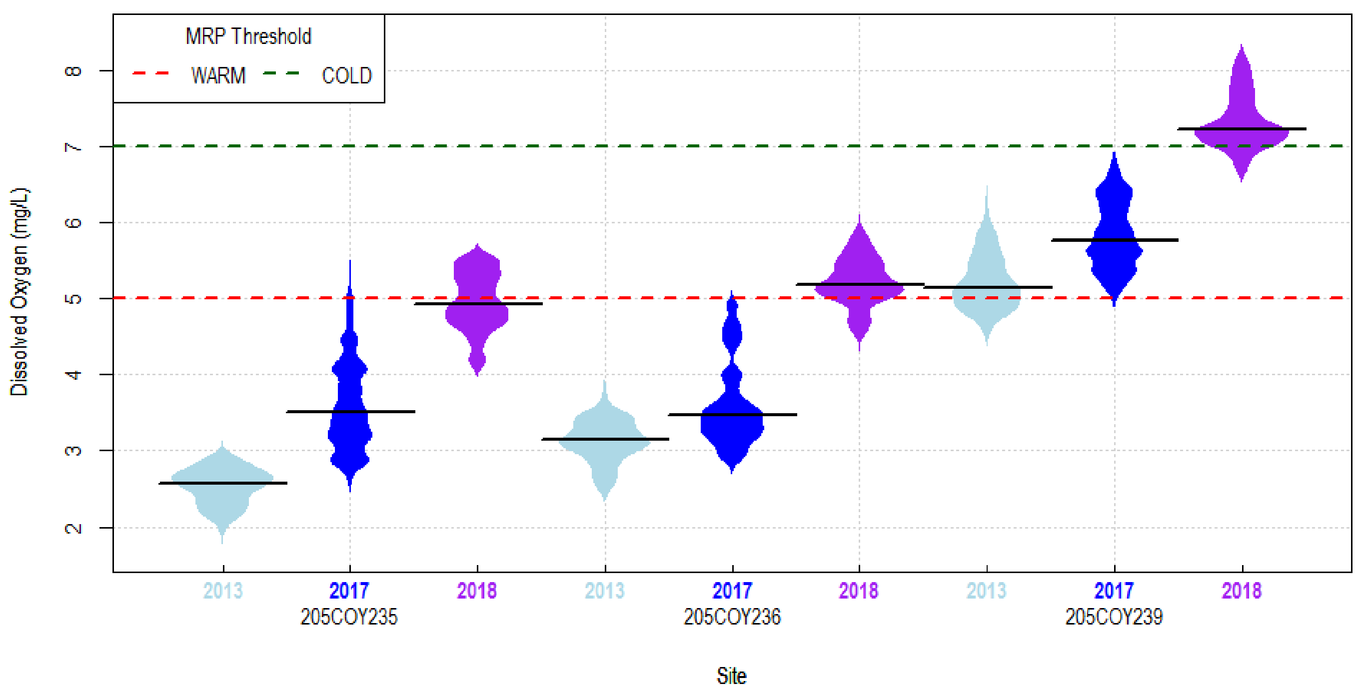

Figure 3.12. Comparison of dissolved oxygen data collected in September 2017 and 2018 for the Creek Status Monitoring Project (WY 2017 and 2018) with data collected in September 2013 for the Coyote Creek SSID Project.

Continuous Water Quality Trigger Summary

The MRP trigger summary for the continuous water quality data is shown in Table 3.6. All three sites exceeded triggers for MWAT and dissolved oxygen; however, decisions to initiate SSID studies will consider the discussions above.

Table 3.6. Exceedances of MRP triggers at three sites in Coyote Creek, Santa Clara County, WY 2018.

Data Type	MRP Trigger	205COY235	205COY236	205COY239	205COY235	205COY236	205COY239
		May/June WY 2018			September WY 2018		
Instantaneous Temperature	20% results > 24°C	No	No	No	No	No	No
MWAT	2 weeks > 17°C	Yes	Yes	Yes	Yes	Yes	Yes
Instantaneous Dissolved Oxygen	20% results < 7 mg/L	Yes	Yes	Yes	Yes	Yes	No
Instantaneous Specific Conductivity	20% results > 2000 µS/cm	No	No	No	No	No	No
Instantaneous pH	20% results > 6.5, < 8.5	No	No	No	No	No	No

4.0 PATHOGEN INDICATORS

4.1 Introduction

During WY 2018 pathogen indicators were monitored in compliance with Creek Status Monitoring Provision C.8.d.v of the MRP. Monitoring was conducted at sites selected using a targeted design based on the directed principle to address the following management question: *What are the pathogen indicator concentrations at creek sites where there is potential for water contact recreation to occur?*

This management question is addressed primarily through the evaluation of targeted data with respect to trigger thresholds identified in the MRP. Sites where exceedances occur may indicate potential impacts to aquatic life or other beneficial uses and are considered as candidates for future Stressor/Source Identification projects.

4.2 Study Area

In compliance with Provision C.8.d.v of the MRP, five pathogen indicator samples were collected. Samples were collected during one sampling event (July 27, 2018) at five sites located in municipal parks with good public access to creeks and the potential for recreational water contact (Figure 3.1). One site was located on Arroyo Calero at Singer Park (205GUA225), one was located on Los Gatos Creek at Vasona Park (205LGA400), one on Saratoga Creek at Wildwood Park (205SAR075), one on Stevens Creek at Blackberry Farm (205STE064), and one on Matadero Creek at Cornelis Bol Park (205MAT030). The sample stations for WY 2018 are the same sample stations that were monitored for pathogen indicators in WY 2017. Repeat sampling can provide information (albeit limited) on variability at the sites.

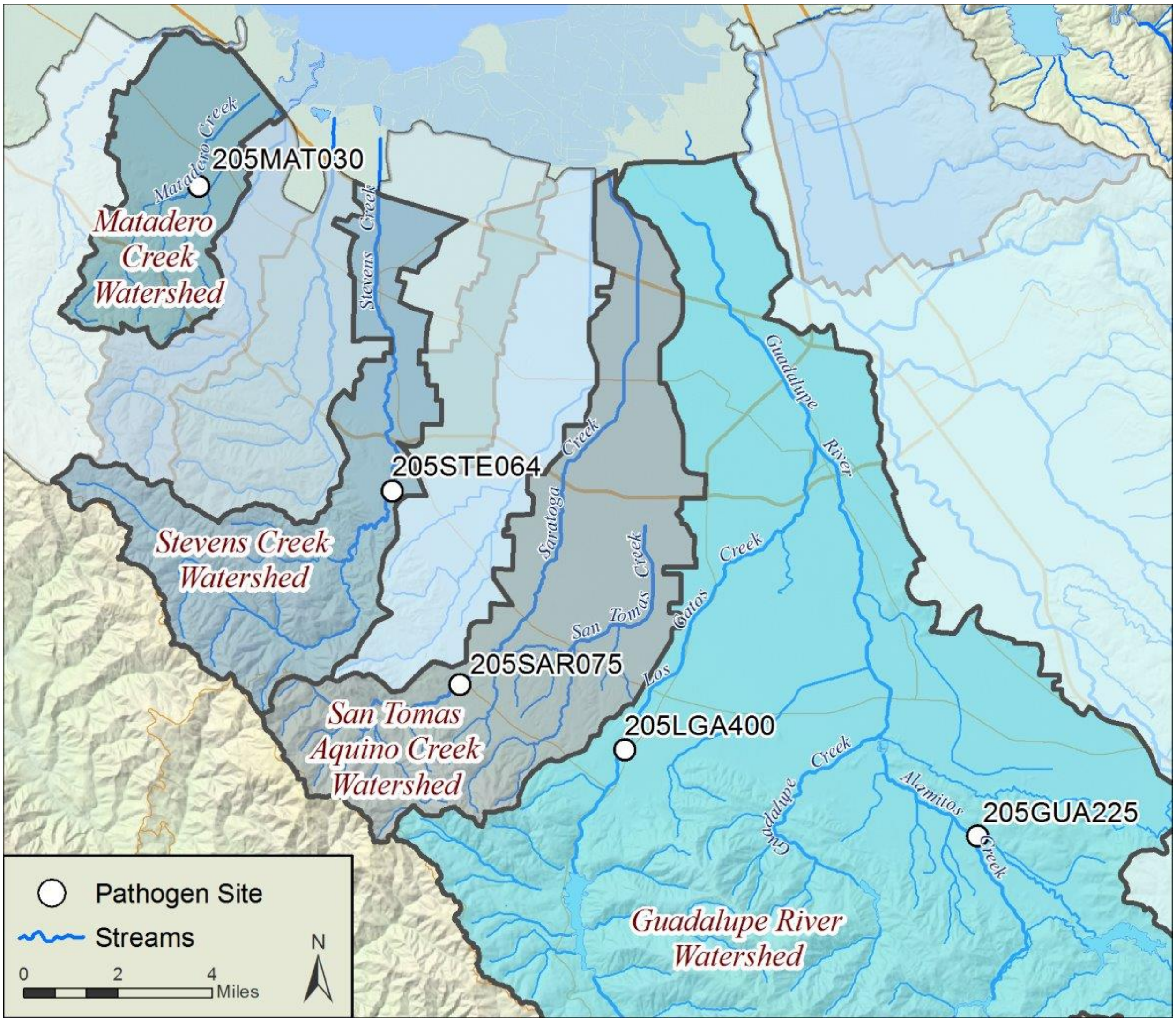

Figure 4.1. Pathogen indicator monitoring sites sampled in Santa Clara County during WY 2017 and WY 2018.

4.3 Methods

Pathogen indicator data were collected during the dry season in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016a) and associated QAPP (BASMAA 2016b). Sampling techniques for pathogen indicators (enterococci and *E. coli*) include direct filling of sterile containers and transfer of samples to the analytical laboratory within specified holding time requirements. Procedures for sampling and transporting samples are described in RMC SOP FS-2 (BASMAA 2016a).

Pathogen indicator data generated during WY 2018 were evaluated with respect to MRP Provision C.8.d.v “Follow-up” triggers to identify potential impacts to water contact recreation (REC-1). The relevant trigger criteria for pathogen indicator data is based on USEPA (2012) recommended statistical threshold value for an estimated illness rate of 36 per 1000 primary contact recreators. For *E. coli*, the trigger threshold is 410 cfu/100 mL. For enterococcus, the trigger threshold is 130 cfu/100 mL. Sites with monitoring results exceeding the trigger criteria are identified as candidate SSID projects.

4.4 Results and Discussion

The section below summarizes results from pathogen indicator monitoring conducted during WY 2018. Conclusion and recommendations for this section are presented in Section 7.0.

Pathogen indicator (*E. coli* and enterococci) densities measured in grab samples collected on July 27, 2017 and July 27, 2018 are listed in Table 4.1. Stations are mapped in Figure 4.1. In WY 2018, three samples exceeded the MRP trigger for enterococci (205SAR075, 205STE0064, and 205MAT030). There were no measurements that exceeded the MRP trigger for *E. Coli* in WY 2018.

Pathogen indicator densities were measured at the same site locations for WY 2017 and WY 2018. Although this two-year dataset is insufficient to identify trends, comparisons between both measurements are valuable. All three locations with exceedances of the MRP trigger for enterococci in WY 2018, also had exceedances in WY 2017. Site 205GUA225 had the highest enterococci and *E. coli* levels in WY 2017, but the lowest results in WY 2018. While there were three exceedances of the MRP trigger for *E. coli* in WY 2017, there were none in WY 2018. These results suggest that pathogen indicator densities at the monitoring stations are highly variable.

It is important to recognize that pathogen indicators do not directly represent actual pathogen concentrations and do not distinguish among sources of bacteria. Testing water samples for specific pathogens is generally not practical for a number of reasons (e.g., concentrations of pathogens from fecal contamination may be small and difficult to detect but still of concern, laboratory analysis is often difficult and expensive, and the number of possible pathogens to potentially test for is large). Therefore, the presence of pathogens is inferred by testing for “pathogen indicator” organisms. The USEPA recommends using *E. coli* and enterococci as indicators of fecal contamination based on historical and recent epidemiological studies (USEPA 2012). The USEPA pathogen indicator thresholds were derived based on human recreation at beaches receiving bacteriological contamination from human wastewater, and may not be applicable to conditions in urban creeks which do not receive wastewater treatment plant discharges. Furthermore, although animal fecal waste contributes to the pathogen indicator load, it is much less likely to contain pathogens of concern to human health than human sources. In most cases, it is the human sources that are associated with REC-1 health risks rather than wildlife or domestic animal sources (USEPA 2012). As a result, the comparison of pathogen indicator results to pathogen indicator thresholds may not be appropriate and should be interpreted cautiously.

The State Water Board recently (August 7, 2018) adopted new WQOs for *E. coli* and enterococci based on USEPA (2012) criteria. The new WQOs, which are based on an estimated illness rate of 32 per 1000 primary contact recreators, will become effective upon approval by the Office of Administrative Law and the USEPA. [24] For freshwaters (i.e., salinity is equal to or less than 1 part per thousand (ppth) 95 percent of the year), the six-week rolling geometric mean of *E. coli* must not exceed 100 cfu/100 mL; and the statistical threshold value (STV) of 320 cfu/100 mL must not be exceeded by more than 10 percent of samples collected in a calendar month. For marine and brackish waters (i.e., salinity is greater than 1 ppth more than 5 percent of the year), the six-week rolling geometric mean of enterococci must not exceed 30 cfu/100 mL; and the STV of 110 cfu/100 mL must not be exceeded by more than 10 percent of samples collected in a calendar month. These thresholds are included in Table 3.1 for reference.

Table 4.1. Enterococci and *E. coli* levels measured in Santa Clara County during WY2017 and WY 2018. Values in bold exceeded MRP trigger thresholds.

Site ID	Creek Name	Site Name	*Enterococci (cfu/100ml) (MPN/100ml)*[1]	*E. Coli (cfu/100ml) (MPN/100ml)* [1]	Sample Date
MRP Trigger Threshold (USEPA 2012; 36 per 1000 recreators)			*130*	*410*	
Newly Adopted WQO (based on 32 per 1000 recreeators)			*110*	*320*	
205GUA225	Arroyo Calero	Singer Park	30	31	7/27/2018
			1986	687	7/27/2017
205SAR075	Saratoga Creek	Wildwood Park	281	185	7/27/2018
			218	517	7/27/2017
205LGA400	Los Gatos Creek	Vasona Park	87	138	7/27/2018
			29	55	7/27/2017
205STE064	Stevens Creek	Blackberry Farm	548	260	7/27/2018
			345	680	7/27/2017
205MAT030	Matadero Creek	Bol Park	613	159	7/27/2018
			816	**248**	7/27/2017

[1] USEPA 2012 water quality criteria are given in cfu/100 mL; whereas, the analytical method used by the Program gives results in MPN/100 mL. These units are used interchangeably in this analysis.

[24] See http://www.waterboards.ca.gov/bacterialobjectives/ for more information.

5.0 CHLORINE MONITORING

5.1 Introduction

Chlorine is added to potable water supplies and wastewater to kill microorganisms that cause waterborne diseases. However, the same chlorine can be toxic to the aquatic species. Chlorinated water may be inadvertently discharged to the MS4s and/or urban creeks from residential activities, such as pool dewatering or over-watering landscaping, or from municipal activities, such as hydrant flushing or water main breaks.

In compliance with provision C.8.d.ii of the MRP and to assess whether the chlorine in receiving waters is potentially toxic to the aquatic life living there, SCVURPPP field staff measured free chlorine and total chlorine residual in creeks where bioassessments were conducted. Total chlorine residual is comprised of combined chlorine and free chlorine, and is always greater than or equal to the free chlorine residual. Combined chlorine is the chlorine that has reacted with ammonia or organic nitrogen to form chloramines, while free chlorine is the chlorine that remains unbound.

5.2 Methods

In accordance with the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), WY 2018 field testing for free chlorine and total chlorine residual was conducted at all twenty probabilistic sites concurrent with spring bioassessment sampling (April - May). Probabilistic site selection methods are described in Section 2.0.

Field testing for free chlorine and total chlorine residual conformed to methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016a), which are comparable to those specified in the SWAMP QAPP. Per SOP FS-3 (BASMAAS 201ab), water samples were collected and analyzed for free and total chlorine using a Pocket Colorimeter™ II and DPD Powder Pillows, which has a manufacturer reported method detection limit of 0.02 mg/L. If concentrations exceed the MRP trigger criteria of 0.1 mg/L, the site was immediately resampled. Per provision C.8.d.ii(4) of the MRP, "if the resample is still greater than 0.1 mg/L, then Permittees report the observation to the appropriate Permittee central contact point for illicit discharges to that the illicit discharge staff can investigate and abate the associated discharge in accordance with its provision C.5.e – Spill and Dumping Complaint Response Program."

5.3 Results and Discussion

The section below summarizes results from chlorine monitoring conducted during WY 2018. Conclusion and recommendations for this section are presented in Section 7.0.

In WY 2018, SCVURPPP monitored the twenty probabilistic sties for free chlorine and total chlorine residual. These measurements were compared to the MRP trigger threshold of 0.1 mg/L.[25] Results are listed in Table 5.1. The trigger thresholds for free chlorine and total chlorine residual were not exceeded during sampling in WY 2018. This indicates that the chlorine levels in the sampled creeks were not of concern during this time frame.

[25] For reference, the Statewide General Permit for Drinking Water Discharges (Order WQ 2014-0194-DWQ) uses 0.1 mg/L as a reporting limit (minimum level) for field measurements of total residual chlorine.

For unknown reasons, the free chlorine result was greater than the total residual chlorine result at six stations (Table 5.1). Potential causes for these inverted results include matrix interferences and colorimeter user error. According to Hach, the supplier of the equipment and reagents, the free chlorine could have false positive results due to a pH exceedance of 7.6 and/or an alkalinity exceedance of 250 mg/L. The pH was measured concurrently with the chlorine sample, but alkalinity was not measured. At four of the six stations, the pH exceeded 7.6. It is unlikely that the higher free chlorine readings were caused by user error. The field crew is well trained and aware of potential problems with this testing method, such as wait times between adding reagents and taking the readings and keeping the free chlorine and total residual chlorine samples separate. At more than one station, the field crew immediately resampled the creek in response to the unexpected readings; with the second set of samples having identical results as the first set. Overall, the cause of the inverted free chlorine and total chlorine residual results (compared to expected) is unknown. However, it should be noted that colorimetric field instruments are generally not capable of providing accurate measurements of free chlorine and total chlorine residual below 0.13 mg/L, regardless of the method detection limit provided by the manufacturer. For this reason, the Statewide General Permit for drinking Water Discharges (Order WQ 2014-0194-DWQ) uses 0.1 mg/L as a reporting limit for field measurements of total chlorine residual.

Table 5.1. Summary of SCVURPPP chlorine testing results compared to MRP trigger of 0.1 mg/L, WY 2018.

Station Code	Date	Creek	Free Chlorine (mg/L) [1,2]	Total Residual Chlorine (mg/L) [1,2]	Exceeds Trigger Threshold? (0.1 mg/L)[2]
205R03683	4/30/2018	Permanente Creek	<0.02	<0.02	No
205R03699	4/30/2018	Hale Creek	<0.02	<0.02	No
205R03738	5/1/2018	Upper Silver Creek	<0.02	0.02	No
205R03825	5/1/2018	Thompson Creek	<0.02	0.02	No
205R03875	5/2/2018	Calabazas Creek	0.05	0.04	No
205R04266	5/2/2018	Calabazas Creek	0.08	0.04	No
205R04217	5/3/2018	Upper Penitencia	0.03	0.04	No
205R03591	5/7/2018	Los Trancos Creek	<0.02	<0.02	No
205R03847	5/7/2018	Los Trancos Creek	<0.02	<0.02	No
205R03619	5/8/2018	Saratoga Creek	0.08	0.06	No
205R03754	5/8/2018	San Tomas Aquino	0.03	0.02	No
204R00749	5/9/2018	Smith Creek	<0.02	<0.02	No
205R00769	5/10/2018	MF Coyote Creek	<0.02	0.03	No
205R03498	5/23/2018	Saratoga Creek	<0.02	<0.02	No
205R03562	5/23/2018	Saratoga Creek	<0.02	<0.02	No
205R00746	5/24/2018	Saratoga Creek	<0.02	<0.02	No
205R03843	5/29/2018	San Tomas Aquino	0.03	0.03	No
205R04190	5/29/2018	Guadalupe Creek	0.05	<0.02	No
205R03795	5/30/2018	Lower Silver Creek	0.04	0.03	No
205R03907	5/30/2018	Lower Penitencia	0.04	0.04	No

[1] The method detection limit is 0.02 mg/L; however, the Statewide General Permit for Drinking Water Discharges (Order WQ 2014-0194-DWQ) uses 0.1 mg/L as a reporting limit (minimum level) for field measurements of total chlorine residual.
[2] The MRP trigger threshold of 0.1 mg/L applies to both free chlorine and total chlorine residual measurements

A total of 144 stations have been monitored by SCVURPPP for free chlorine and total chlorine residual between WY 2012 and WY 2018 in compliance with MRP 1.0 and MRP 2.0. Occasional exceedances were recorded throughout the years and addressed by the appropriate follow-up process. Figure 4.1 maps of all the samples stations with their associated results. The results exceeding the MRP 2.0 trigger threshold of 0.1 mg/L are shown in red. The results exceeding MRP 1.0 trigger threshold of 0.08 mg/L (but below the MRP 2.0 trigger) are shown in orange. All results equal to or below 0.08 mg/L are shown in green. Trigger exceedances tend to occur in high order streams that have traveled through highly populated areas toward the Bay, such as Lower Penitencia Creek. The values range from non-detectable levels of chlorine to 0.4 mg/L with one outlier of 0.91 mg/L (Lower Silver Creek in WY 2016).

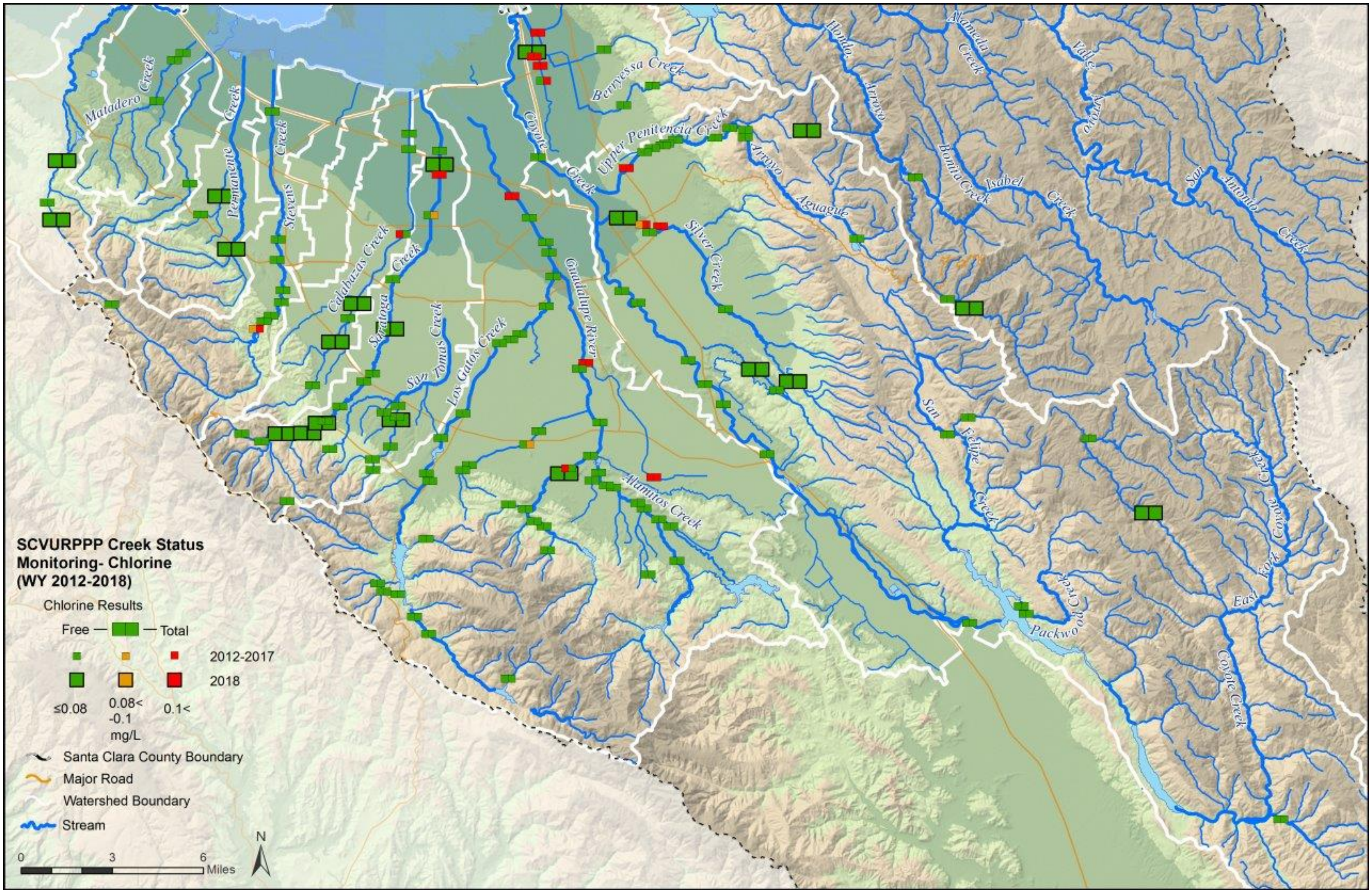

Figure 5.1 Chlorine sample stations and results WY 2012 – WY 2018 in Santa Clara County.

6.0 TOXICITY AND SEDIMENT CHEMISTRY MONITORING

6.1 Introduction

Toxicity testing provides a tool for assessing the toxic effects (acute and chronic) of all chemicals in samples of receiving waters or sediments, and allows the cumulative effect of the pollutants present in the sample to be evaluated. Because different test organisms are sensitive to different classes of chemicals and pollutants, several different organisms are monitored. Sediment and water chemistry monitoring for a variety of potential pollutants is conducted synoptically with toxicity monitoring to provide preliminary insight into the possible causes of toxicity should they be found.

Provision C.8.g of the MRP requires both wet and dry weather monitoring of pesticides and toxicity in urban creeks.

Dry Weather

The Program is required to conduct water toxicity and sediment chemistry and toxicity monitoring at two locations during the dry season, each year of the permit term beginning in WY 2016. The permit provides examples of possible monitoring location types, including sites with suspected or past toxicity results, existing bioassessment sites, or creek restoration sites. Dry weather monitoring includes:

- Toxicity testing in water is required using five species: *Ceriodaphnia* dubia (chronic survival and reproduction), *Pimephales promelas* (larval survival and growth), *Selenastrum capricornutum* (growth), *Hyalella azteca* (survival) and *Chironomus dilutus* (survival).
- Toxicity testing in sediment is required using two species: *Hyella azteca* (survival) and *Chironomus dilutus* (survival).
- Sediment chemistry analytes include pyrethroids, fipronil, carbaryl, total Polycyclic aromatic hydrocarbons (PAHs), metals, Total Organic Carbon (TOC), and sediment grain size.

Wet Weather

The wet weather monitoring requirements include collection of water column samples during storm events for toxicity testing (using the same five organisms required for dry weather toxicity testing) and analysis of pyrethroids, fipronil, imidacloprid and indoxacarb[26]. The MRP states that monitoring locations should be representative of urban watersheds (i.e., bottom of watersheds).

Provision C.8.g.iii.(3) requires a collective total of ten samples, with at least six samples collected by WY 2018, if the wet weather monitoring is conducted by the RMC on behalf of all Permittees. At the RMC Monitoring Workgroup meeting on January 25, 2016, RMC members agreed to collaborate on implementation of the wet weather monitoring requirements. All ten wet weather samples were collected in WY 2018 during a single storm event on January 8, 2018.

[26] Standard analytical methods for indoxacarb are not currently available. Indoxacarb analysis will not be required until the water year following notification by the Executive Officer than a method is available.

SCVURPPP and ACCWP each collected three samples, and SMCWPPP and CCCWP each collected two samples.

6.2 Methods

6.2.1 Site Selection

In WY 2018, in compliance with MRP Provisions C.8.g.i and C.8.g.ii, water and sediment toxicity and sediment chemistry samples were collected from two sites during dry weather: Stevens Creek and San Tomas Aquino Creek (see Figure 6.1). Sites were selected to represent urban watersheds that are not already being monitored for toxicity or pesticides by other programs, such as the SWAMP Stream Pollution Trends (SPoT) program or the California Department of Pesticide Regulation (DPR) Surface Water Protection Program Monitoring (SWPP). Specific stations within the watersheds were identified based on the likelihood that they would contain fine depositional sediments during dry season sampling and would be safe to access during wet weather sampling. SCVURPPP sampled the two stations located in Stevens Creek and San Tomas Aquino Creek during the dry weather events in WY 2016 and WY 2017, and it is anticipated that SCVURPPP will continue to sample these same two stations throughout the permit term with the goal of building a long-term dataset that complements data being gathered through SWAMP SPoT and DPR SWPP.

Additionally, in WY 2018, in compliance with MRP Provision C.8.g.iii, water toxicity and pesticides samples were collected from three sites during wet weather: Stevens Creek, San Tomas Aquino Creek, and Calabazas Creek (see Figure 6.1). The sites on Stevens Creek and San Tomas Aquino Creek were selected because they have been the focus of dry weather monitoring. The station on Calabazas Creek was selected because it is located at the bottom of large urban watershed.

6.2.2 Sample Collection

Water samples for pesticides and toxicity were collected using standard grab sampling methods. The required number of labeled amber glass bottles were filled and placed on ice to cool to < 6C. The laboratory was notified of the impending sampling delivery to meet sample hold times. Procedures used for sampling and transporting water samples are described in SOP FS-2 (BASMAA 2016a).

Before conducting sediment sampling, field personnel surveyed the proposed sampling area for appropriate fine-sediment depositional areas. Personnel carefully entered the stream to avoid disturbing sediment at collection sub-sites. Sediment samples were collected from the top 2 cm at each sub-site beginning at the downstream-most location and continuing upstream. Sediment samples were placed in a compositing container, thoroughly homogenized, and then aliquoted into separate jars for chemical or toxicological analysis using standard clean sampling techniques (see SOP FS-6, BASMAA 2016a).

Samples were submitted to respective laboratories and field data sheets were reviewed per SOP FS-13 (BASMAA 2016a). The laboratory responsible for analyzing water column pesticide samples in WY 2018 (i.e., Physis Laboratory in Anaheim, CA) was selected by the RMC because it is capable of conducting analyses with reporting limits below the maximum threshold specified in MRP Provision C.8.g. iii.(1).

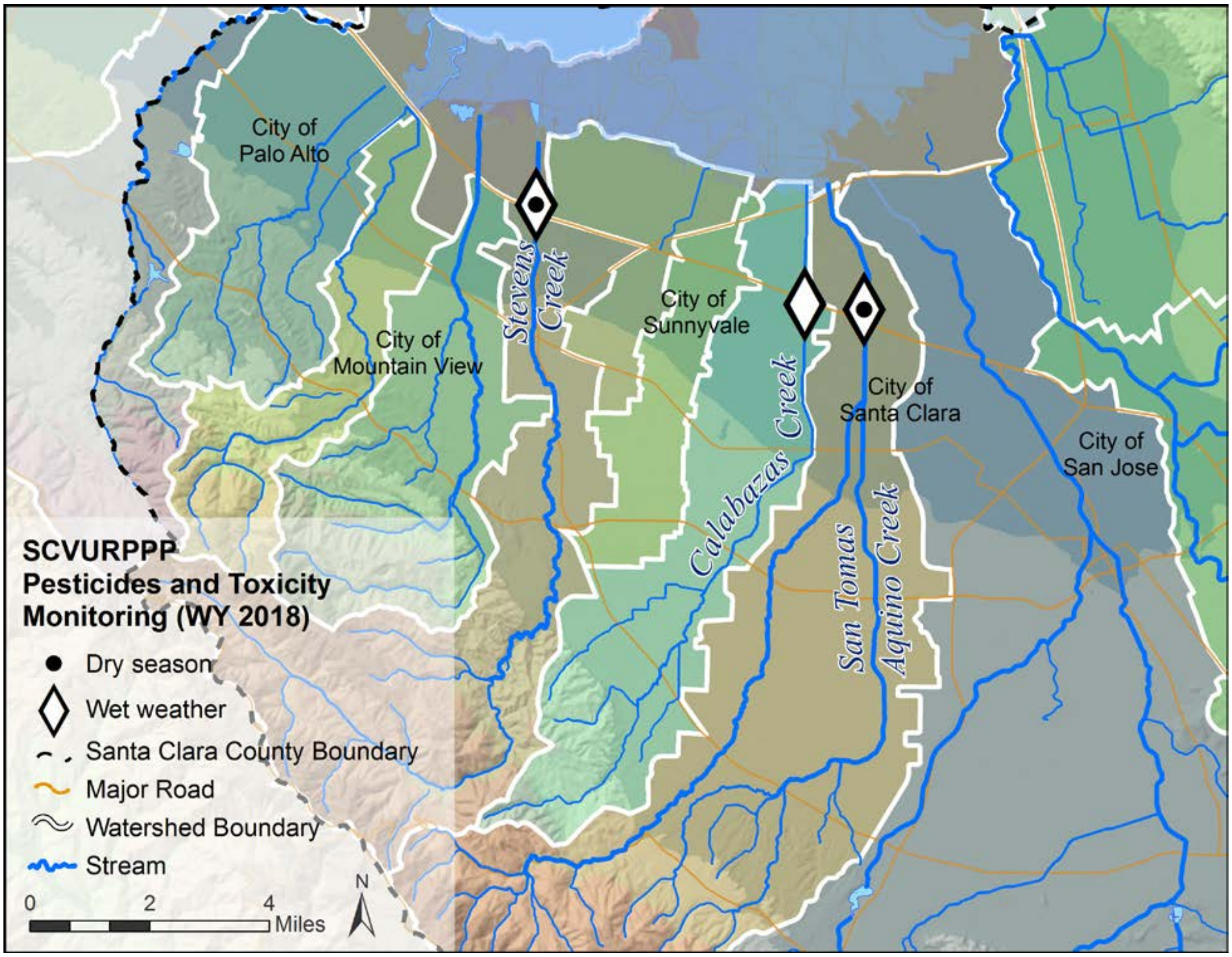

Figure 6.1 Pesticides and toxicity sampling stations in Santa Clara County during WY 2018.

6.2.3 Data Evaluation

Water and Sediment Toxicity

Data evaluation required by the MRP involves first assessing whether the samples are toxic to the test organisms relative to the laboratory control treatment via statistical comparison using the Test of Significant Toxicity (TST) statistical approach. For samples with toxicity (i.e., those that "failed" the TST), the Percent Effect is evaluated. The Percent Effect compares sample endpoints (survival, reproduction, growth) to the laboratory control endpoints. Follow-up sampling is required if any test organism is reported as "fail" via the TST approach *and* the Percent Effect is ≥ 50%. Both the TST result and the Percent Effect are determined by the laboratory. If both the initial and follow-up sample are reported as "fail" with ≥ 50% Percent Effect, the site is added to the list of candidate SSID projects.

Sediment Chemistry

In compliance with MRP Provision C.8.g.iv, sediment sample results are compared to Probable Effects Concentrations (PECs) and Threshold Effects Concentrations (TECs) as defined by MacDonald et al. (2000). PEC and TEC quotients are calculated as the ratio of the measured concentration to the respective PEC and TEC values from MacDonald et al. (2000). All results where a PEC or TEC quotient is equal to or greater than 1.0 are identified and added to the list of candidate SSID projects.

PECs and TECs are listed in MacDonald et al. (2000) for total PAHs, rather than the individual PAHs that are reported by the laboratory. Total PAH concentrations were calculated by summing the concentrations of 24 individual PAHs. Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that calculations and statistics could be computed. Therefore, some of the TEC and PEC quotients may be artificially elevated (and contribute to trigger exceedances) due to the method used to account for filling in non-detect data.

The TECs for bedded sediments are very conservative values that do not consider site specific background conditions, and are therefore not very useful in identifying real water quality concerns in receiving waters in the Santa Clara Valley. All sites in Santa Clara County are likely to have at least one TEC quotient equal to or greater than 1.0. This is due to high levels of naturally-occurring chromium and nickel in geologic formations (i.e., serpentinite) and soils that contribute to TEC and PEC quotients. These conditions will be considered when making decisions about SSID projects.

The current MRP does not require consideration of pyrethroid, fipronil, or carbaryl sediment chemistry data for follow-up SSID projects, perhaps because pyrethroids are ubiquitous in the urban environment and little is known about fipronil and carbaryl distribution. However, SCVURPPP computed toxicity unit (TU) equivalents for individual pyrethroid results based on available literature values for pyrethroids in sediment LC50 values.[27,28] Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized concentrations. Therefore, the pesticide concentrations as reported by the lab were divided by the measured total organic carbon (TOC) concentration at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each constituent. Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that these statistics could be computed, potentially resulting in artificially elevated results.

Water Chemistry

MRP Provision C.8.g.iv requires that chemical pollutant data from water and sediment monitoring is compared to the corresponding water quality objectives in the Basin Plan for each analyte sampled. If concentrations in the samples exceed their water quality objectives, then the site at which the exceedances were observed will be added to the list of candidate SSID projects. However, the Basin Plan does not contain numeric water quality objectives for the chemical analytes encompassed within the wet weather pesticide monitoring.

Due to the lack of numeric thresholds for these analytes, the data collected during the WY 2018 wet weather pesticide monitoring cannot be assessed to identify sites that should be added to the list of candidate SSID projects. However, there exist opportunities to compare and integrate wet weather pesticide monitoring data collected for MRP purposes with other similar data collected throughout the state. Mentioned previously in this document, the DPR SWPP is one of the largest pesticide monitoring and management efforts currently being undertaken in California. Pesticide studies conducted by DPR evaluate the frequency of pesticide detections

[27] The LC50 is the concentration of a given chemical that is lethal on average to 50% of test organisms.

[28] No LC50 is published for carbaryl in sediment.

at any concentration, and make use of aquatic benchmarks set by the United States Environmental Protection Agency (USEPA) for many pesticide compounds. DPR provides web access to a number of their monitoring reports which contain detailed analyses of USEPA aquatic benchmark exceedance rates. MRP pesticide data were compared to the USEPA benchmarks used by DPR to gain an understanding of how Santa Clara County data compare to the larger dataset being developed by DPR; however, sites with USEPA aquatic benchmark exceedances were not added to the list of candidate SSID projects on that basis alone. DPR also maintains the Surface Water Database (SURF) to provide public access to quantitative pesticide data from a wide array of surface water monitoring studies. This database could be queried in the future to allow the leverage of DPR monitoring data in more complex analyses of MRP pesticide data.

6.3 Results and Discussion

Toxicity and pesticides monitoring results are described in the sections below. Conclusions are provided in section 7.0.

6.3.1 Toxicity

Table 6.1 provides a summary of toxicity testing results for WY 2018 dry weather water and sediment samples. Based on the results, it is not necessary to add the sites to the list of potential SSID projects.

- **San Tomas Aquino Creek (205STQ010).** The water and sediment samples collected from San Tomas Aquino Creek were not significantly toxic to any of the test organisms.
- **Stevens Creek (205STE021).** The sediment sample collected from Stevens Creek in July 2017 was not significantly toxic to any of the test organisms; however, the water sample was found to be significantly toxic to C. dilutus (survival). The Percent Effect was not greater than 50%, so no follow-up samples were required.
- The cause of the dry weather water toxicity in Stevens Creek is unknown.

Table 6.2 provides a summary of toxicity testing results for WY 2018 wet weather water samples. Based on the results, it is not necessary to add the sites to the list of potential SSID projects.

- **Calabazas Creek (205CAL018).** The water sample collected from Calabazas Creek in January 2018 was significantly toxic to *H. azteca.* The Percent Effect was greater than 50%; therefore, a second sample was collected during a storm event in March 2018 and tested for *H. azteca* toxicity. This sample was also found to be significantly toxic, but the Percent Effect was not greater than 50%.
- **San Tomas Aquino Creek (205STQ010).** The water sample collected from San Tomas Aquino Creek in January 2018 was significantly toxic to *H.* azteca. The Percent Effect was greater than 50%; therefore, a second sample was collected during a storm event in March 2018 and tested for *H. azteca* toxicity. This sample was not found to be significantly toxic.
- **Stevens Creek (205STE021).** The water sample collected from Stevens Creek in January 2018 was significantly toxic to *H. azteca*. The Percent Effect was not greater than 50%, so no follow-up samples were required.

Table 6.1. Summary of SCVURPPP dry weather toxicity results for WY 2018.

	Organism	Test Type	Unit	Results: Lab Control	Results: Organism Test	% Effect	TST Value	Follow up needed (TST "Fail" and ≥50%)
205STQ010 San Tomas Aquino Creek July 17, 2018	Water							
	Ceriodaphnia dubia	Survival	%	100	100	0	NA[1]	No
		Reproduction	Num/Rep	23.8	28.6	-20	Pass	No
	Pimephales promelas	Survival	%	97.5	100	-33	Pass	No
		Growth	mg/ind	0.916	0.94	-33	Pass	No
	Chironomus dilutus	Survival	%	95	95	0	Pass	No
	Hyalella azteca	Survival	%	98	98	0	Pass	No
	Selenastrum capricornutum	Growth	cells/ml	4610000	12400000	-169	Pass	No
	Sediment							
	Chironomus dilutus	Survival	%	82.5	88.8	-88	Pass	No
	Hyalella azteca	Survival	%	92.5	93.8	-1	Pass	No
205STE021 Stevens Creek July 17, 2018	Water							
	Ceriodaphnia dubia	Survival	%	100	100	0	NA[1]	No
		Reproduction	Num/Rep	23.8	24.1	-1	Pass	No
	Pimephales promelas	Survival	%	97.5	92.5	5	Pass	No
		Growth	mg/ind	0.916	0.934	-2	Pass	No
	Chironomus dilutus	Survival	%	95	72.5	24	Fail	No
	Hyalella azteca	Survival	%	98	96	2	Pass	No
	Selenastrum capricornutum	Growth	cells/ml	4610000	7090000	-54	Pass	No
	Sediment							
	Chironomus dilutus	Survival	%	82.5	76.2	88	Pass	No
	Hyalella azteca	Survival	%	92.5	91.3	1	Pass	No

[1] TST analysis is not performed for survival endpoint - a percent effect <25% is considered a "Pass", and a percent effect ≥25% is considered a "Fail"

Table 6.2 Summary of SCVURPPP wet weather toxicity results for WY 2018.

Site	Organism	Test Type	Unit	Results: Lab Control	Results: Organism Test	% Effect	TST Value	Follow up needed (TST "Fail" and ≥50%)
205CAL018 Calabazas Creek Jan 8, 2018	Water							
	Ceriodaphnia dubia	Survival	%	100	90	10	NA[1]	No
		Reproduction	Num/Rep	35	34.2	2	Pass	No
	Pimephales promelas	Survival	%	100	92.5	8	Pass	No
		Growth	mg/ind	0.791	0.649	18	Pass	No
	Chironomus dilutus	Survival	%	97.5	95	3	Pass	No
	Hyalella azteca	Survival	%	100	40	60	Fail	Yes
	Selenastrum capricornutum	Growth	cells/ml	2560000	4580000	-79	Pass	No
205CAL018 Calabazas Creek Mar 1, 2018	*Hyalella azteca*	Survival	%	98	86	12	Fail	No
205STQ010 San Tomas Aquino Jan 8, 2018	Water							
	Ceriodaphnia dubia	Survival	%	100	90	10	NA[1]	No
		Reproduction	Num/Rep	35	35.3	-1	Pass	No
	Pimephales promelas	Survival	%	100	90	10	Pass	No
		Growth	mg/ind	0.791	0.658	17	Pass	No
	Chironomus dilutus	Survival	%	97.5	95	3	Pass	No
	Hyalella azteca	Survival	%	100	44	56	Fail	Yes
	Selenastrum capricornutum	Growth	cells/ml	2560000	4360000	-70	Pass	No
205STQ010 San Tomas Aquino Mar 1, 2018	*Hyalella azteca*	Survival	%	98	94	4	Pass	No
205STE021 Stevens Creek Jan 8, 2018	Water							
	Ceriodaphnia dubia	Survival	%	100	100	0	NA[1]	No
		Reproduction	Num/Rep	35	36	-3	Pass	No
	Pimephales promelas	Survival	%	100	100	0	Pass	No
		Growth	mg/ind	0.791	0.657	17	Pass	No
	Chironomus dilutus	Survival	%	97.5	95	3	Pass	No
	Hyalella azteca	Survival	%	100	72	28	Fail	No
	Selenastrum capricornutum	Growth	Cells/ml	2560000	4600000	-79	Pass	No

[1] TST analysis is not performed for survival endpoint - a percent effect <25% is considered a "Pass", and a percent effect ≥25% is considered a "Fail"

6.3.2 Sediment Chemistry

Sediment chemistry results are evaluated as potential stressors based on TEC quotients and PEC quotients according to criteria in provision C.8.g.iv of the MRP. SCVURPPP also evaluated TU equivalents of pyrethroids and fipronil.

Table 6.3 lists concentrations and TEC quotients for sediment chemistry constituents (metals and total PAHs). TEC quotients are calculated as the measured concentration divided by the highly conservative TEC value, per MacDonald et al. (2000)[29]. TECs are extremely conservative and are intended to identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. Both sites exceeded the relevant trigger criterion from the MRP of having at least one result exceeding the TEC and will be added to the list of potential SSID projects. There were TEC exceedances of nickel in both creeks and of chromium in Stevens Creek as expected in watersheds draining hillsides underlain by serpentinite formations. In Stevens Creek (205STE021), the TEC for copper and total PAHs was also exceeded.

Table 6.4 provides PEC quotients for sediment chemistry constituents (metals and total PAHs). PECs are intended to identify concentrations above which toxicity to benthic-dwelling organisms are predicted to be probable. No PEC quotients were greater than 1.0 in either of the two creeks, however the PEC quotient for nickel in Stevens Creek was equal to 1.0.

Table 6.3. Threshold Effect Concentration (TEC) quotients for WY 2018 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

	TEC	205STE021		205STQ010	
		Stevens Creek		San Tomas Aquino	
Metals (mg/kg DW)		Concentration	Quotient	Concentration	Quotient
Arsenic	9.79	3.0	0.3	1.9	0.2
Cadmium	0.99	0.32	0.3	0.1	0.1
Chromium	43.4	76	1.8	26	0.6
Copper	31.6	37	1.2	21	0.7
Lead	35.8	25	0.7	5.1	0.1
Nickel	22.7	66	2.9	27	1.2
Zinc	121	120	1	63	0.5
PAHs (ug/kg DW)					
Total PAHs	1,610	2577	1.6 [a]	2267	0.1 [a]

a. Total calculated using ½ MDLs.

[29] MacDonald et al. (2000) does not provide TEC or PEC values for pyrethroids, fipronil, or carbaryl. Pyrethroids are compared to LC50 values in Table 5.4. However, LC50 values for fipronil and carbaryl in sediment have not been published.

Table 6.4. Probable Effect Concentration (PEC) quotients for WY 2018 sediment chemistry constituents. Bolded and shaded values indicate PEC quotient ≥ 1.0.

	PEC	205STE021		205STQ010	
		Stevens Creek		San Tomas Aquino	
Metals (mg/kg DW)		Concentration	Quotient	Concentration	Quotient
Arsenic	33	3.0	0.1	1.9	0.1
Cadmium	4.98	0.3	0.1	0.1	0.02
Chromium	111	76	0.7	26	0.2
Copper	149	37	0.3	21	0.1
Lead	128	25	0.2	5.1	0.04
Nickel	48.6	66	1	27	0.6
Zinc	459	120	0.3	63	0.1
PAHs (ug/kg DW)					
Total PAHs	22,800	2577	0.1 [a]	227	0.01 [a]

a. Total calculated using ½ MDLs.

Table 6.5 lists the concentrations of pesticides measured in sediment samples and calculated TOC-normalized TU equivalents for the pesticides for which there are published LC50 values in the literature. Most of the pesticides measured were below method detection limits (MDLs) and are listed as "<MDL" in Table 6.5. Others are J-flagged, meaning that the measured concentration was above the MDL but below the reporting limit. No TU equivalents exceeded 1.0. The highest TU equivalents in both samples were for bifenthrin and deltamethrin. Bifenthrin is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013) and the most-commonly detected insecticide monitored by the DPR SWPP (Ensminger 2017).

Table 6.5. Pesticide concentrations and calculated toxic unit (TU) equivalents, WY 2018.

			205STE021 Stevens Creek			205STQ010 San Tomas Aquino		
	Unit	LC50 [d]	Concen-tration	Normalized to TOC	TU Equivalent	Concen-tration	Normalized to TOC	TU Equivalent
TOC	%	NA	2.1	NA	NA	2.7	NA	NA
Pyrethroid								
Bifenthrin	µg/g dw	0.52	0.00128	0.061	0.117 [b]	0.00127	0.047	0.090 [b]
Cyfluthrin	µg/g dw	1.08	<0.00059	0.014	0.013 [a]	<0.00058	0.011	0.010 [a]
Cypermethrin	µg/g dw	0.38	<0.00053	0.013	0.033 [b]	<0.00053	0.010	0.026 [a]
Deltamethrin	µg/g dw	0.79	0.00160	0.076	0.096	<0.00063	0.012	0.015
Esfenvalerate	µg/g dw	1.54	<0.00069	0.016	0.011 [a]	<0.00069	0.013	0.008 [a]
Lambda-Cyhalothrin	µg/g dw	0.45	<0.00032	0.008	0.017 [a]	<0.00032	0.006	0.013 [a]
Permethrin	µg/g dw	10.83	<0.00059	0.014	0.001 [a]	<0.00058	0.011	0.001 [a]
				Sum of TU equivalents	0.288 [a]		Sum of TU equivalents	0.163 [a]
Other MRP Pesticides of Concern								
Carbaryl	mg/Kg dw	NA	<0.53	NA	NA [c]	<0.021	NA	NA [c]
Fipronil	ng/g dw	410	<0.53	12.62	0.031 [a]	<0.53	0.011	0.00003 [a]
Fipronil Desulfinyl	ng/g dw	NA	<0.53	NA	NA [c]	<0.53	NA	NA [c]
Fipronil Sulfide	ng/g dw	NA	<0.53	NA	NA [c]	<0.53	NA	NA [c]
Fipronil Sulfone	ng/g dw	NA	<0.53	NA	NA [c]	<0.53	NA	NA [c]

a. Concentration was below the method detection limit (MDL). TU equivalents calculated using 1/2 MDL.
b. TU equivalents calculated from concentration below the reporting limit (J-flagged).
c. Currently there is no available LC50 value for Carbaryl or Fipronil degradates, however the observed concentrations were below the detection limit.
d. Sources: Amweg et al. 2005 and Maund et al. 2002.

In compliance with the MRP, a grain size analysis was conducted on both of the sediment samples (Table 6.6). The Stevens Creek (205STE021) sample was 23.8% fines (i.e., 6.8% clay and 16.9% silt); whereas the San Tomas Aquino Creek (205STQ010) sample was 25.0% fines (i.e., 3.0% clay and 22.0% silt).

Table 6.6. Summary of grain size for the two locations sampled in Santa Clara during WY 2018.

Grain Size (%)		205STE021	205STQ010
		Stevens Creek	San Tomas Aquino Creek
Clay	<0.0039 mm	6.8%	3.0%
Silt	0.0039 to <0.0625 mm	16.9%	22.0%
Sand	V. Fine 0.0625 to <0.125 mm	12.1%	15.1%
	Fine 0.125 to <0.25 mm	21.4%	14.0%
	Medium 0.25 to <0.5 mm	20.2%	18.8%
	Coarse 0.5 to <1.0 mm	13.3%	13.8%
	V. Coarse 1.0 to <2.0 mm	9.3%	13.3%
Granule	2.0 to <4.0 mm	6.4%	8.4%
Pebble	Small 4 to <8 mm	5.1%	36.5%
	Medium 8 to <16 mm	0.6%	26.7%
	Large 16 to <32 mm	0%	0%
	V. Large 32 to <64 mm	0%	0%

Note: Sum of grain size values for both sites is greater than 100% due to the laboratory analytical methods used.

6.3.3 Pesticides in Water

The pesticide concentrations measured at the three sites where wet weather pesticide sampling was conducted in WY 2018 are listed in Table 6.7. The concentrations of most pesticides were below the MDL, meaning that these analytes were reported as non-detects. Bifenthrin was found at detectable levels at two of the three sites (Calabazas Creek and Stevens Creek). Additionally, fipronil and its degradation products were found at detectable levels at all three sites.

Table 6.7. Summary of wet weather pesticide concentrations for the three locations sampled in Santa Clara County during WY 2018.

	Unit	205CAL018 Calabazas Creek	205STQ010 San Tomas Aquino Creek	205STE021 Stevens Creek	Lowest USEPA Benchmark [a]	
		Concentration	Concentration	Concentration	Concentration	
Pyrethroid						
Bifenthrin	µg/L	0.0185	<0.00005 [b]	0.0063	0.0013	IC
Cyfluthrin	µg/L	<0.00005 [b]	<0.00005 [b]	<0.00005 [b]	0.0074	IC
Cypermethrin	µg/L	<0.00005 [b]	<0.00005 [b]	<0.00005 [b]	0.069	IC
Deltamethrin	µg/L	<0.00005 [b]	<0.00005 [b]	<0.00005 [b]	0.0041	IC
Esfenvalerate	µg/L	<0.00005 [b]	<0.00005 [b]	<0.00005 [b]	0.017	IC
Fenvalerate	µg/L	<0.00005 [b]	<0.00005 [b]	<0.00005 [b]	0.017	IC
Lambda-Cyhalothrin	µg/L	<0.00005 [b]	<0.00005 [b]	<0.00005 [b]	0.002	IC
Permethrin, cis-	µg/L	<0.0002 [b]	<0.0002 [b]	<0.0002 [b]	0.0014	IC
Permethrin, trans-	µg/L	<0.0001 [b]	<0.0001 [b]	<0.0001 [b]	0.0014	IC
Other MRP Pesticides of Concern						
Fipronil	µg/L	0.0175	0.0162	0.0254	0.011	IC
Fipronil Desulfinyl	µg/L	0.0046	0.0052	0.0067	0.54	FC
Fipronil Sulfide	µg/L	0.0006	0.0008	0.0008	0.11	IC
Fipronil Sulfone	µg/L	0.0059	0.0068	0.0066	0.037	IC
Imidacloprid	µg/L	<0.002 [b]	<0.002 [b]	<0.002 [b]	0.01	IC

a. Source: USEPA Aquatic Life Benchmarks and Ecological Risk Assessments for Registered Pesticides. IC signifies that the invertebrate chronic USEPA benchmark was the lowest benchmark, while FC signifies that the fish chronic USEPA benchmark was the lowest benchmark.
b. Concentration was below the method detection limit (MDL), and values are displayed as "<MDL".

As previously stated, there are no water quality objectives specified in the San Francisco Bay Basin Plan for water column pesticide analytes. As a result, no in-depth analysis of the wet weather pesticide monitoring data collected in WY 2018 can be performed at this time. However, other studies that quantify pesticide concentrations in water can provide a perspective with which to view the results of the MRP WY 2018 wet weather pesticide monitoring. DPR routinely conducts pesticide monitoring at MS4 and receiving water sites in both Northern and Southern California with the objectives of evaluating pesticide concentrations in water, frequencies with which individual pesticide compounds are detected, and exceedances of USEPA pesticide benchmarks. In WY 2017, DPR monitored locations in Alameda, Contra Costa, Placer, Sacramento, and Santa Clara Counties in Northern California as well as locations in Los Angeles, Orange, and San Diego Counties in Southern California. The pesticide analytes sampled in both studies encompassed the analytes sampled by the MRP wet weather pesticide monitoring.

In the Northern California study, bifenthrin had a detection frequency (DF) of 74%, making it the most frequently detected insecticide. Other pyrethroids sampled during the study were either not detected at all or had significantly lower DF values than bifenthrin. Imidacloprid was the second-most frequently detected insecticide with a DF of 59%. Fipronil, with a DF of 50%, closely followed imidacloprid as the third-most frequently detected insecticide. Fipronil desulfinyl and fipronil sulfone were also detected at rates of 56% and 21%, respectively. Pyrethroid concentrations were generally above their USEPA minimum benchmarks for toxicity to aquatic life with the exception of cyfluthrin, which is generally detected below the USEPA toxicity benchmark. Concentrations of imidacloprid and fipronil were always above their minimum benchmarks when detected by the DPR SWPP. The fipronil degradates were not above their minimum benchmarks except for one fipronil sulfone sample (Ensminger 2017).

In the Southern California study, bifenthrin was the most frequently detected pyrethroid insecticide with a DF of 79%. The other sampled pyrethroids were again either not detected at all or detected significantly less frequently than bifenthrin. Fipronil also had a DF of 79%, and several of its degradates including fipronil sulfone and fipronil desulfinyl were also detected at comparably high concentrations (72 and 70%, respectively). Imidacloprid was the most frequently detected pesticide at a rate of 81% (Budd 2018).

The findings from the WY 2017 Northern and Southern California pesticide monitoring studies are largely comparable to the results of the fipronil and bifenthrin samples collected by SCVURPPP during the MRP WY 2018 wet weather pesticides monitoring. Bifenthrin, fipronil, and fipronil degradates were the only pesticides found at detectable levels during the SCVURPPP wet weather monitoring. Additionally, the minimum USEPA benchmarks for bifenthrin and fipronil concentrations during this monitoring effort were exceeded. It is of note, however, that although imidacloprid was frequently detected in the WY 2017 DPR studies, imidacloprid concentrations were not found at detectable levels during the SCVURPPP wet weather monitoring.

7.0 CONCLUSIONS AND RECOMMENDATIONS

In WY 2018, in compliance with provisions C.8.d and C.8.g of the MRP and the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), SCVURPPP continued to implement a two-component monitoring design that was initiated in WY 2012. The strategy includes a regional ambient/"probabilistic" bioassessment monitoring component and a component based on local "targeted" monitoring for general water quality parameters and pesticides/toxicity. The combination of these monitoring designs allows each individual RMC participating program to assess the status of Beneficial Uses in local creeks within its Program (jurisdictional) area, while also contributing data to eventually answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks).

Conclusions from the MRP Creek Status and Pesticides/Toxicity Monitoring conducted during WY 2018 in Santa Clara County are based on the management questions presented in Section 1.0 of this report:

1) *Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers, and tributaries?*
2) *Are conditions in local receiving water supportive of or likely supportive of beneficial uses?*

The first management question is addressed primarily through the evaluation of probabilistic and targeted monitoring data with respect to the triggers defined in the MRP. A summary of trigger exceedances observed for each site is presented in Table 7.1. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses and are considered for future evaluation of Stressor/Source identification (SSID) projects.

The second management question is addressed primarily by assessing indicators of aquatic biological health using benthic macroinvertebrate and algae data collected at probabilistic sites. The indices of biological integrity based on BMI and algae data (i.e., CSCI and ASCI) are direct measures of aquatic life beneficial uses. Biological condition scores were compared to physical habitat and water quality data collected synoptically with bioassessments to evaluate whether any correlations exist that may explain the variation in biological condition scores. Continuous monitoring data (temperature, dissolved oxygen, pH, and specific conductance) are evaluated with respect to COLD and WARM Beneficial Uses. And pathogen indicator data are used to assess REC-1 (water contact recreation) Beneficial Uses.

7.1 Conclusions

7.1.1 Biological Condition Assessment

Bioassessment monitoring was conducted in compliance with provision C.8.d.i of the MRP. In WY 2018, all bioassessment monitoring was performed at sites selected randomly using the regional probabilistic monitoring design. The probabilistic monitoring design allows each individual RMC participating program to objectively assess stream ecosystem conditions within its program area (e.g., County boundary) while contributing data to answer regional management questions about water quality and beneficial use condition in San Francisco Bay Area creeks. The monitoring design was developed to address the following management questions:

1. *What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are beneficial uses supported?*
2. *What are major stressors to aquatic life in the RMC area?*
3. *What are the long-term trends in water quality in creeks over time?*

The first question (i.e., *What is the condition of aquatic life in creeks in the RMC area?*) is addressed by assessing indicators of aquatic biological health at probabilistic sampling locations. Once a sufficient number of samples have been collected (i.e., 30 samples), ambient biological condition can be estimated for streams at countywide and a regional scale within known estimates of precision. Over the past seven years (WY 2012 through WY 2018), SCVURPPP and Regional Water Board have sampled 152 probabilistic sites in Santa Clara County, providing a sufficient sample size to estimate ambient biological condition for both urban and non-urban streams countywide. Analysis of the first five years of regional bioassessment monitoring data (WY 2012 – WY 2016) was conducted by BASMAA in the RMC 5-Year Report.

The second question (i.e., *What are major stressors to aquatic life in the RMC area?*) is addressed by the collection and evaluation of physical habitat and water chemistry data collected at the probabilistic sites, as potential stressors to biological health. The stressor levels can be compared to biological indicator data through correlation and relative risk analyses. Assessing the extent and relative risk of stressors can help prioritize stressors at a regional scale and inform local management decisions.

The third question (i.e., *What are the long-term trends in water quality in creeks over time?*) is addressed by assessing the change in biological condition over several years. Changes in biological condition over time can help evaluate the effectiveness of management actions. Based on review of the first five years of probabilistic data, it appears that long-term trend analysis for the probabilistic survey will require more than seven years of data.

The analyses presented in this report are limited to the WY 2018 dataset which does not contain a statistically significant number of records (i.e., approximately 30 samples). A more comprehensive analysis of the much larger bioassessment dataset from the first five years of MRP monitoring (WY 2012 – WY 2016) was conducted by the BASMAA RMC on a regional and countywide basis. The RMC 5-Year Report is summarized below and included with this report as Attachment 2. Analytical tools that BASMAA (2019) found to be useful in evaluating stressor association with biological condition (i.e., random forest models) may be used by SCVURPPP to evaluate the WY 2012 – WY 2019 dataset in the Integrated Monitoring Report which will be submitted in March 2020.

Bioassessment in Santa Clara County (WY 2018)

Twenty sites were sampled for BMIs, benthic algae, physical habitat, and nutrients using methods consistent with the BASMAA RMC QAPP (BASMAA 2016b) and SOPs (BASMAA 2016a). Stations were randomly selected using a probabilistic monitoring design. Seventeen of the sites were classified as urban and three were classified as non-urban.

The following conclusions are based on the WY 2018 data. An assessment of biological condition is provided, relationships with potential stressors are explored, and potential stressors are compared to applicable WQOs and triggers identified in the MRP. Sites with monitoring results that exceed WQOs and triggers are considered as candidates for further investigation as SSID projects, consistent with provision C.8.e of the MRP.

Biological Condition Assessment

Stream condition was assessed using three different types of indices/tools: the BMI-based CSCI, the draft benthic algae-based ASCI (diatom, soft algae, and hybrid), and the physical habitat-based IPI. Of these three, the CSCI is the only tool with a MRP trigger threshold for follow-up SSID consideration.

- **CSCI -** The diversity and abundance of BMI taxa are evaluated as indicators of biological condition of the stream. Ten of the twenty (50%) bioassessment sites monitored in WY 2018 had CSCI scores in the two higher condition categories - “possibly intact” and “likely intact” condition. Seven of these ten sites had scores greater than 1.0. These higher scoring sites were in relatively undeveloped watersheds, with impervious areas ranging between 1% and 6%. Five of these sites were located in two creeks: Saratoga Creek (3) and Los Trancos Creek (2).
    - The ten sites with CSCI scores below the MRP trigger threshold of 0.795 will be considered as candidates for SSID projects.
- **ASCI –** ASCI indices translate benthic algae data (diatoms and soft algae) into overall measures of stream health. Three algae indices (developed using statewide data) were calculated for diatoms, soft algae, and hybrid (combination of diatoms and soft algae). The hybrid ASCI appeared to have the best response to stressor data associated with landscape variables (e.g., percent imperviousness), but not with stressors associated with nutrients, which was a finding from statewide data analyses (Theroux et al. in prep.).
    - **Hybrid**. Seven of the twenty bioassessment sites had hybrid ASCI scores that were classified as “possibly intact” or “likely intact” condition. The higher scoring sites occurred in drainages with relatively low levels of urbanization, ranging from 1% to 5% impervious area. Six of the seven sites also received CSCI scores that were in two higher condition categories.
- **IPI –** The Index for Physical Habitat Integrity assesses the overall habitat condition of the sampling reach. IPI scores were positively correlated with qualitative habitat assessment Total PHAB scores. IPI scores were least correlated with the “channel alteration” component of the Total PHAB Scores (compared to the “epifaunal substrate” and “sediment deposition” components), indicating that the IPI metric score may not incorporate impacts associated with channel modification that are captured in the “channel alteration” assessment.
    - Seventeen of the twenty sites (85%) had IPI scores in the two upper condition categories. IPI scores were positively correlated with CSCI scores, and slightly less so with hybrid ASCI scores.
- **Overall Conditions –** There were six sites with biological condition scores in the two higher condition categories for all three indices (CSCI, hybrid ASCI, IPI) (Table 2.7, Figure 2.6). Two of the sites are located in upper reaches of Saratoga Creek (sites 205R03562 and 205R03498). The remaining three sites are located in Los Trancos Creek at Foothill Park (site 205R03591), Guadalupe Creek at the percolation ponds (site 205R04190), Upper Penitencia Creek upstream of Cherry Flat Reservoir (site 205R04217), and Smith Creek in Joseph Grant County Park (site 204R00749). All six sites were relatively undeveloped (less than < 5% impervious area).

The number of sites in the top two condition categories varied substantially by index, with as many as 17 of 20 sites for the IPI to as few as 7 of 20 sites for the hybrid ASCI. There was relatively good consistency among the indices for sites in the top two condition categories where lower urbanization (< 5% impervious area) was present. The diatom ASCI, soft algae ASCI, and IPI scores were relatively variable (i.e., both high and low scoring) at sites in more developed/urbanized watersheds. Further evaluation of the newer indices and their association with stressor data is needed to better understand how these indicators can be used to effectively assess site conditions.

Stressor Assessment

Relationships between potential stressors (water chemistry, physical habitat, landscape variables) and biological condition were explored using the WY 2018 dataset. Sites with stressor levels exceeding applicable WQOs and triggers identified in the MRP will be considered as candidates for SSID projects. The correlations between biological conditions and stressors are not expected to be very strong due to the small sample size.

- **General water quality** (pH, temperature, dissolved oxygen, specific conductance). None of the water quality measurements exceeded water quality objectives or MRP trigger thresholds. None of the water quality measurements were correlated with CSCI or hybrid ASCI scores.
- **Nutrients and conventional analytes** (ammonia, unionized ammonia, chloride, AFDM, chlorophyll a, nitrate, nitrite, total Kjeldahl nitrogen, ortho-phosphate, phosphorus, silica). There were no water quality objective exceedances for water chemistry parameters. Total nitrogen concentrations ranged from 0.12 to 8.1 mg/L. The two highest nitrogen concentrations were measured at site 205R03795 in Lower Silver Creek (8.1 mg/L) and site 205R03699 (3.1 mg/L) on Hale Creek. Total phosphorus concentrations ranged from <0.001 to 0.22 mg/L. The highest concentration of total phosphorus occurred at site 205R03699 on Hale Creek. None of the nutrient parameters were correlated with CSCI or hybrid ASCI scores.
- **Physical habitat metric scores** were generated from the physical habitat data. CSCI scores correlated with metrics associated with substrate size and composition. Hybrid ASCI scores were poorly correlated with all 11 physical habitat metrics.
- **Landscape variables** were calculated for each of the watershed areas draining into the bioassessment sites. CSCI scores were moderately correlated (negatively) with impervious area and road density.

RMC Five Year Bioassessment Report Summary (WY 2012 – WY 2016)

A comprehensive analysis of bioassessment data collected by the RMC partners is included in the RMC Five-Year Bioassessment Report (5-Year Report) (BASMAA 2019) (Attachment 2). The BASMAA-funded study evaluated bioassessment data collected by the RMC over the first five years of monitoring (WY 2012 – WY 2016). Bioassessment data from 354 sites were compiled and evaluated to address the three study questions:

1) What is the biological condition of streams in the region?
2) What stressors are associated with poor condition?
3) Are conditions changing over time?

The findings of the BASMAA study are intended to help stormwater programs better understand the current condition of wadable streams, prioritize stream reaches in need of protection or restoration, and identify stressors that are likely to pose the greatest risk to the health of streams in the Bay Area.

The BASMAA report also evaluated the existing RMC probabilistic monitoring design and identified a range of potential options for revising the design (if desired) to better address the questions posed. The redesign options are intended to provide considerations for discussion during the planning for reissuance of the Municipal Regional Permit, which is likely to be adopted in 2021.

<u>Biological Conditions</u>

Results of the survey indicate that streams in the RMC area are generally in poor biological condition. As such, aquatic life uses may not be supported at a majority of sites sampled by the RMC. Two biological indicators were used to assess conditions:

- The BMI-based CSCI shows that 58% of the stream length regionwide was ranked in the lowest CSCI condition category ("very likely altered"); 74% of the of the sampled stream length exhibited CSCI scores below 0.795, the MRP trigger for potential follow-up activity.
- The Southern California algae indices for diatoms (D18) and soft algae (S2) were evaluated for biological conditions[30]. Based on D18 and S2 scores, stream conditions regionwide appear slightly less degraded, with approximately 40% ranked in the lowest algae condition category. The algal indices also had greater stream length in the "likely intact" condition class (19-21%) compared to CSCI score (15%).

These findings should be interpreted with the understanding that the survey focused on urban stream conditions. Approximately 80% of the samples (284 of 354) were collected at urban sites. Although the low non-urban sample size precludes making any definitive comparisons, bioassessment scores in the non-urban area were generally higher than scores in the urban area for each County.

<u>Stressor Assessment</u>

The association between biological indicators (CSCI and D18) and stressor data was evaluated in the RMC 5-Year study using random forest statistical analyses. The results indicate that each of the biological indicators respond to different types of stressors.

- Biological condition, based on CSCI scores, was correlated with physical habitat and land use variables. Overall, the largest influence on CSCI scores in the random forest model was percent impervious area in a 5 km radius.
- Biological condition, based on D18 scores, was moderately correlated with water quality variables and less associated with the physical or landscape variables.

[30] The ASCI was not yet available during development of the RMC 5-Year Report.

In general, CSCI scores at urban sites were consistently low, indicating that degraded physical habitat conditions do not support healthy BMI assemblages. D18 scores at urban sites were more variable, indicating that healthy diatom assemblages potentially can occur at sites with poor habitat, but can also indicate poor water quality at sites with degraded habitat.

None of the nutrient variables (e.g., nitrate, total nitrogen, orthophosphate, phosphorus) correlated strongly with CSCI scores, or were highly ranked variables in the CSCI random forest model runs. Phosphorus and ash-free dry mass (which increases in response to biostimulation) were important in predicting D18 scores; however, no statistically significant relationships were observed. This finding suggests that the nutrient targets being developed by the State Water Board as part of the Biostimulatory/Biointegrity Project may not be appropriate in urban streams in the Bay Area.

Trend Assessment

The short time frame of the survey (five years) limited the ability to detect trends. However, the five-year bioassessment dataset does provide a baseline to compare with future assessments.

A potential application of bioassessment monitoring may be to assess stream conditions following implementation of stormwater treatment projects. It is anticipated that peak flow volumes and intensities will be reduced following the implementation of mandatory stormwater treatment via green infrastructure and low impact development (LID). Future creek status monitoring may provide additional insight into the potential positive impacts of green infrastructure and creek restoration to support water quality objectives and beneficial uses in urban creeks as these projects get built.

Assessment of the RMC Monitoring Design

Over the first five years of monitoring, the RMC evaluated about 25% (1455 out of 5740) of the sites in the sample frame to obtain 354 samples. Approximately 46% (873 out of 1896) of the total number of urban sites in the sample frame were evaluated during that time. Based on rejection rates from previous years, the sample frame is anticipated to only last through WY 2019. Revision of the RMC monitoring design could seek to reduce the future rejection rate through re-evaluation of the sample frame to exclude areas of low management interest or regions that would not be candidates for sampling (such as due to lack of permissions or physical barriers to access). This would improve the spatial balance of samples that more closely represents the proportion of the sample frame that can be reliably assessed.

The RMC sample design was created to probabilistically sample all streams within the RMC area, which resulted in a master list of 33% urban sites and 67% non-urban sites. However, because participating municipalities are primarily concerned with runoff from urban areas, the RMC focused sampling efforts on urban sites (80%) over non-urban sites (20%). As a result, non-urban samples are under-represented in the dataset resulting in much lower overall biological condition scores than would be expected for a spatially balanced dataset.

Based on evaluation of data collected during the first five years of the survey, several options to revise the RMC Monitoring Design are presented below:

1) Continue to sample new probabilistic sites until the draw is exhausted
2) Probabilistic monitoring design for a trends assessment
    a. Re-visit probabilistic sites using existing RMC Sample Frame

    b. Re-design sample frame that re-weights urban/non-urban sites; over sample list
3) Monitor targeted sites for special studies
4) Combination of two and three

The RMC will assess these and other options during discussions with Regional Water Board staff during the MRP reissuance process beginning in 2019.

7.1.2 Continuous Monitoring for Temperature and General Water Quality

Continuous monitoring of water temperature and general water quality in WY 2018 was conducted in compliance with provisions C.8.d.iii – Iv of the MRP. Hourly temperature measurements were recorded at nine sites in the Guadalupe River Watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at three sites in the Coyote Creek watershed during two 2-week periods in June (Event 1) and September (Event 2). Targeted monitoring stations were deliberately selected using the Directed Monitoring Design Principle and were generally consistent with those monitored in WY 2017.

Conclusions from targeted continuous monitoring in WY 2018 are organized on the basis of the management questions listed in Section 3.0:

1. *What is the spatial and temporal variability in water quality conditions during the spring and summer season?*
2. *Do general water quality measurements indicate potential impacts to aquatic life?*

Sites with targeted monitoring results exceeding the MRP trigger criteria and/or WQOs are identified as candidate SSID projects.

<u>Spatial and Temporal Variability (Temperature)</u>

- **Spatial**. Spatial trends in water temperatures measured at key locations along two tributaries to Guadalupe River were similar. Relatively warm conditions were observed at sites directly below reservoirs (possible influence from solar radiation on reservoir water). Water temperatures then decreased at sites in the middle of the sampled profiles, possibly due to shading from riparian vegetation. Farther downstream, temperatures gradually increased, possibly due to less shading of the creek and greater influence from urban land use and ground water return flows. These patterns were similar to WY 2017 monitoring results; however, the stations directly below the reservoirs, added in WY 2018, help paint a more complete picture of water temperature trends in Guadalupe Creek and Alamitos Creek.
- **Temporal**. Temperatures at all nine sites in the Guadalupe River Watershed increased from June (when the loggers were deployed) through mid-August 2018, followed by a gradual decline through the end of the monitoring period in late September. These patterns were similar to WY 2017 monitoring results at the same stations.

<u>Spatial and Temporal Variability (Water Quality)</u>

- **Spatial**. General water quality parameters measured at three stations along the mainstem of Coyote Creek were similar to each other throughout both monitoring windows, with the exception of dissolved oxygen which was consistently lower at the two downstream sites. The downstream decrease in dissolved oxygen may be associated with thermal stratification which was observed in that reach during the Coyote Creek SSID Project (SCVURPPP 2014).

- **Temporal**. Water quality at the Coyote Creek stations was relatively consistent between sampling events, with slight changes in dissolved oxygen following a rise in temperature during Event 1. The diurnal pattern was more pronounced at the upstream site (239), and less variable at the two downstream sites (235, 236). Compared to WY 2017 and WY 2013 data collected at the same stations, temperature in WY 2018 was lower and consequently dissolved oxygen was higher.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at nine targeted stations in the Guadalupe River watershed from April through September and analysis of continuous general water quality data (pH, dissolved oxygen, specific conductance, and temperature) collected at three targeted stations in Coyote Creek during two two-week periods (June and September).
- All nine temperature stations in the Guadalupe River Watershed exceeded the MRP trigger threshold of having two or more weeks where the Maximum Weekly Average Temperature exceeded 17°C. However, none of the stations exceeded the MRP maximum instantaneous trigger threshold of 24°C for more than 20% of total recorded samples.
    - All stations with MWAT trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of locally-derived temperature thresholds developed by NMFS (NMFS 2016) suggests that temperature may not be a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches, as long as sufficient dam releases maintain longitudinal connectivity and provide cooler water temperatures and potential refugia for juvenile steelhead during the summer.
- Sites on Coyote Creek had no exceedances of the maximum temperature trigger threshold of 24°C but did exceed the MWAT trigger of 17.0 °C for two consecutive weeks during both events and will therefore be added to the list of candidate SSID projects.
- The WQO for dissolved oxygen in waters designated as having cold freshwater habitat (COLD) Beneficial Uses (i.e., 7.0 mg/L) was not met in over 20% of the measurements recorded at all three water quality stations in Coyote Creek. The results were similar to the findings from WY 2017 Creek Status Monitoring. The middle reach of Coyote Creek is a potentially important migration corridor for salmonid fish populations; however, habitat and water quality conditions in this reach are more suitable for a warm water fishery. Steelhead migration is typically during winter season, when flows are much higher and dissolved oxygen levels are expected to be much higher than what was observed during this study.
- Values for pH and specific conductance measured at the three sites in Coyote Creek during WY 2018 did not exceed their respective triggers or water quality objectives during either event.

7.1.3 Pathogen Indicators

Pathogen indicator monitoring in WY 2018 was conducted in compliance with provision C.8.d.v of the MRP. Pathogen indicator grab samples were collected during a sampling event in July at five sites throughout Santa Clara County that coincide with public parks.

- Pathogen indicator densities were measured at five targeted sites during WY 2018. Although none of the stations could be considered "bathing beaches," monitoring locations were selected at city parks or trails that were considered to have a relatively high potential for public access. The *E. coli* concentrations did not exceed the MRP trigger threshold (410 cfu/100 ml) or the newly adopted (but not yet approved) statewide WQO (320 cfu/100 ml) at any of the five sites. Both the MRP threshold (130 cfu/100ml) and newly adopted WQO (110 cfu/100 ml) for enterococcus were exceeded at three sites: Saratoga Creek at Wildwood Park, Stevens Creek at Blackberry Farm, and Matadero Creek at Bol Park. These sites will be added to the list of candidate SSID projects.
- It is important to recognize that pathogen indicator thresholds are based on human recreation at beaches receiving bacteriological contamination from human wastewater, and may not be applicable to conditions found in urban creeks. Pathogen indicators observed at the WY 2018 stations may not be associated with human sources and therefore may not pose a threat to human health. As a result, the comparison of pathogen indicator results to water quality objectives and criteria for full body contact recreation may not be appropriate and should be interpreted cautiously.

7.1.4 Chlorine Monitoring

Free chlorine and total chlorine residual were measured concurrently with bioassessments at the twenty probabilistic sites in compliance with provision C.8.c.ii. While chlorine residual is generally not a concern in Santa Clara Valley urban creeks, prior monitoring results suggest there are occasional free chlorine and total chlorine residual exceedances in the County. Trigger exceedances that are observed are usually the result of a one-time potable water discharges that are difficult to trace. Furthermore, chlorine in surface waters can dissipate from volatilization and reaction with dirt and organic matter. In WY 2018, there were no exceedances of the MRP trigger for chlorine (0.1 mg/L). The Program will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

7.1.5 Pesticides and Toxicity Monitoring

In WY 2018, SCVURPPP conducted dry weather pesticides and toxicity monitoring at two stations (Stevens Creek and San Tomas Aquino Creek) and wet weather pesticides and toxicity monitoring at three stations (Calabazas Creek, Stevens Creek, and San Tomas Aquino Creek) in compliance with provision C.8.g of the MRP.

Statistically significant toxicity to *C. dilutus* (survival) was observed in the water sample collected from Stevens Creek during dry season sampling in July 2018. However, the magnitude of the toxic effects in this sample did not exceed MRP trigger criteria of 50 Percent Effect. Statistically significant toxicity to *H.* azteca (survival) was also observed in the Calabazas Creek, San Tomas Aquino Creek, and Stevens Creek water samples during wet weather sampling in January 2018. The magnitude of the toxic effects in the Stevens Creek sample did not exceed MRP trigger criteria, while the magnitude of the toxic effects in the Calabazas Creek and San Tomas Aquino Creek samples did exceed the MRP threshold for resampling (i.e., Percent Effect ≥ 50%). In follow-up sampling that was conducted during a storm event in March 2018, statistically significant toxicity was observed in the Calabazas Creek sample. However, the magnitude of the toxic effects was below the MRP threshold. No statistically significant toxicity was observed in the follow-up San Tomas Aquino Creek sample. The cause of the toxicity observations is unknown. Pesticide concentrations in the dry season sediment samples were all very low, most below MDLs, and calculated TU equivalents did not exceed 0.1 in either sample with the exception of bifenthrin in the Stevens Creek sample. Pesticide concentrations in wet weather water samples were also very low, with most values below MDLs.

Sediment chemistry results are evaluated as potential stressors based on TEC quotients and PEC quotients according to criteria in provision C.8.g.iv of the MRP. SCVURPPP also evaluated TU equivalents of pyrethroids and fipronil. TEC and PEC quotients were calculated for all metals and total PAHs measured in sediment samples. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with the MRP, both stations will therefore be placed on the list of candidate SSID projects. Decisions about which SSID projects to pursue should be informed by the fact that most of the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel due to serpentine soils in the watersheds. No TU equivalents exceeded 1.0. The highest TU equivalents in both samples were for bifenthrin and deltamethrin. Bifenthrin is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013) and the most-commonly detected insecticide monitored by the DPR SWPP (Ensminger 2017).

Pesticide analytes targeted by wet weather monitoring in WY 2018 were generally found at concentrations below the MDL, except for bifenthrin and fipronil compounds. As no water quality objectives are specified in the Basin Plan for these pollutants, they are not currently being used to identify SSID project locations. The wet weather pesticide monitoring data in WY 2018 was compared to pesticide data collected by the DPR SWPP and the USEPA aquatic benchmarks used in DPR SWPP studies to allow for interpretation of the WY 2018 results in the context of larger statewide datasets. However, sites sampled during the WY 2018 wet weather pesticide monitoring where exceedances of the USEPA benchmarks were observed were not added to the list of candidate SSID projects. In future years, data collected by the DPR SWPP and contained on the DPR SURF database can be queried to allow for comparison of MRP pesticide monitoring results.

7.2 Trigger Assessment

The MRP requires analysis of the monitoring data to identify candidate sites for SSID projects. Trigger thresholds against which to compare the data are provided for most monitoring parameters in the MRP and are described in the foregoing sections of this report. Stream condition was assessed based on CSCI scores that were calculated using BMI data. Nutrient data were evaluated using applicable water quality standards from the Basin Plan. Water and sediment chemistry and toxicity data were evaluated using numeric trigger thresholds specified in the MRP. In compliance with provision C.8.e.i of the MRP, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Follow up SSID projects will be selected from this list. Table 7.1 lists candidate SSID projects based on WY 2018 Creek Status and Pesticides/Toxicity monitoring data.

Additional data analysis is provided in the foregoing sections of this report and should be considered prior to selecting and defining SSID projects. The analyses include review of physical habitat and water chemistry data to identify potential stressors that may be contributing to degraded or diminished biological conditions. Analyses in this report also include historical and spatial perspectives that help provide context and deeper understanding of the trigger exceedances.

Table 7.1. Summary of SCVURPPP Trigger Threshold Exceedance Analysis, WY 2018. "No" indicates samples were collected but did not exceed the MRP trigger; "Yes" indicates an exceedance of the MRP trigger.

Station ID	Creek	Bioassessment [1]	Nutrients [2]	Chlorine [3]	Water Toxicity [4]	Sediment Toxicity [4]	Water Chemistry [5]	Sediment Chemistry [5]	Continuous Temperature [6]	Dissolved Oxygen [7]	pH [8]	Specific Conductance [9]	Pathogen Indicators [10]
204R00749	Smith Creek	No	No	No	--	--	--	--	--	--	--	--	--
205R00746	Saratoga Creek	No	No	No	--	--	--	--	--	--	--	--	--
205R00769	MF Coyote Creek	Yes	No	No	--	--	--	--	--	--	--	--	--
205R03498	Saratoga Creek	No	No	No	--	--	--	--	--	--	--	--	--
205R03562	Saratoga Creek	No	No	No	--	--	--	--	--	--	--	--	--
205R03591	Los Trancos Creek	No	No	No	--	--	--	--	--	--	--	--	--
205R03619	Saratoga Creek	Yes	No	No	--	--	--	--	--	--	--	--	--
205R03683	Permanente Creek	No	No	No	--	--	--	--	--	--	--	--	--
205R03699	Hale Creek	Yes	No	No	--	--	--	--	--	--	--	--	--
205R03738	Upper Silver Creek	Yes	No	No	--	--	--	--	--	--	--	--	--
205R03754	San Tomas Aquino	No	No	No	--	--	--	--	--	--	--	--	--
205R03795	Lower Silver Creek	Yes	No	No	--	--	--	--	--	--	--	--	--
205R03825	Thompson Creek	Yes	No	No	--	--	--	--	--	--	--	--	--
205R03843	San Tomas Aquino	Yes	No	No	--	--	--	--	--	--	--	--	--
205R03847	Los Trancos Creek	No	No	No	--	--	--	--	--	--	--	--	--
205R03875	Calabazas Creek	Yes	No	No	--	--	--	--	--	--	--	--	--
205R03907	Lower Penitencia	Yes	No	No	--	--	--	--	--	--	--	--	--
205R04190	Guadalupe Creek	No	No	No	--	--	--	--	--	--	--	--	--
205R04217	Upper Penitencia	No	No	No	--	--	--	--	--	--	--	--	--
205R04266	Calabazas Creek	Yes	No	No	--	--	--	--	--	--	--	--	--
205LGA400	Guadalupe River	--	--	--	--	--	--	--	--	--	--	--	No
205MAT030	Matadero Creek	--	--	--	--	--	--	--	--	--	--	--	Yes
205STE064	Stevens Creek	--	--	--	--	--	--	--	--	--	--	--	Yes
205GUA225	Arroyo Calero	--	--	--	--	--	--	--	--	--	--	--	No
205SAR075	Saratoga Creek	--	--	--	--	--	--	--	--	--	--	--	Yes
205GUA190	Guadalupe Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205GUA202	Guadalupe Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205GUA210	Guadalupe Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205GUA218	Guadalupe Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205GUA250	Alamitos Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205GUA255	Alamitos Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205GUA262	Alamitos Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205GUA270	Alamitos Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205GUA279	Alamitos Creek	--	--	--	--	--	--	--	Yes	--	--	--	--
205COY235	Coyote Creek	--	--	--	--	--	--	--	Yes	Yes	No	No	--
205COY236	Coyote Creek	--	--	--	--	--	--	--	Yes	Yes	No	No	--
205COY239	Coyote Creek	--	--	--	--	--	--	--	Yes	Yes	No	No	--
205CAL010	Calabazas Creek	--	--	--	No	--	No	--	--	--	--	--	--
205STE021	Stevens Creek	--	--	--	No	No	No	Yes	--	--	--	--	--
205STQ010	San Tomas Aquino	--	--	--	No	No	No	Yes	--	--	--	--	--

Notes:

1. CSCI score ≤ 0.795.
2. Unionized ammonia (as N) ≥ 0.025 mg/L, nitrate (as N) ≥ 10 mg/L, chloride > 250 mg/L.
3. Free chlorine or total chlorine residual ≥ 0.1 mg/L.
4. Test of Significant Toxicity = Fail and Percent Effect ≥ 50 %.
5. TEC or PEC quotient ≥ 1.0 for any constituent.
6. Two or more MWAT ≥ 17.0°C or 20% of results ≥ 24°C.
7. DO < 7.0 mg/L in COLD streams or DO < 5.0 mg/L in WARM streams.
8. pH < 6.5 or pH > 8.5.
9. Specific conductance > 2000 uS.
10. Enterococcus ≥ 130 cfu/100ml or *E. coli* ≥ 410 cfu/100ml.

7.3 Recommendations

The following recommendations are based on findings from WY 2018 Creek Status and Pesticides and Toxicity monitoring conducted by SCVURPPP, as well as reflections on other monitoring, data analysis, and policy development projects being conducted in the region (e.g., RMC 5-Year Report) and statewide.

- In WY 2019, the Program will continue to coordinate with RMC partners on implementation of monitoring requirements in MRP provisions C.8.d and C.8.g.
- A major component of the WY 2019 monitoring will be bioassessment surveys and data assessment. In WY 2019, SCVURPPP will conduct biological assessments at both probabilistic and targeted sites. To date, a total of 152 probabilistic sites have been monitored by SCVURPPP (n=140) and SWAMP (n=12). This exceeds the number of samples necessary for a statistically representative dataset. Therefore, SCVURPPP is eligible to select up to 20 percent of sample locations on a targeted basis to evaluate trends or address other aquatic life related concerns.
- In WY 2018, BASMAA funded a study to evaluate five years of regional bioassessment data (WY 2012 – WY 2016). Findings from the RMC 5-Year Report are summarized in Section 7.1.1 and the report is included as Attachment 2. In WY 2019, SCVURPPP will apply some of the tools used in the RMC 5-Year Report (i.e., random forest models) to analyze bioassessment data collected in Santa Clara County over all eight years of MRP monitoring (WY 2012 – WY 2019). Results of the analyses will be described in the Integrated Monitoring Report (IMR) which will be developed following WY 2019 and submitted by March 31, 2020 (the fifth year of the Permit term) in lieu of an annual UCMR.
- Biological condition and stressor data will also be evaluated in the IMR at finer spatial scales (e.g., watersheds). In addition, historical (pre-MRP) bioassessment data may be incorporated to evaluate spatial and temporal trends of biological condition.
- For the past two years (WY 2017 and WY 2018), SCVURPPP has conducted continuous temperature monitoring in the Guadalupe River Watershed and continuous water quality monitoring on the mainstem of Coyote Creek. During WY 2019, SCVURPPP will collect continuous temperature and water quality (sondes) data at the same locations that were monitored in WY 2017 and WY 2018. Monitoring activities will include continuous temperature monitoring at 4 to 5 sites on Alamitos Creek and 4 sites on Guadalupe Creek and continuous water quality monitoring at 3 sites on Coyote Creek mainstem. A third year of monitoring at these locations will provide additional data to evaluate inter-annual variability in water quality conditions across range of water years.
- Provision C.8.g Pesticides and Toxicity monitoring will be conducted during the dry season at the same two stations targeted in WY 2016, WY 2017, and WY 2018: Stevens Creek and San Tomas Aquino Creek. In WY 2019, the full dataset from these stations (WY 2016 – WY 2019) will be evaluated in the IMR.

7.4 Management Implications

The Program's Creek Status and Pesticides and Toxicity Monitoring programs (consistent with MRP provisions C.8.d and C.8.g, respectively) focus on assessing the water quality condition of urban creeks in the Santa Clara Valley and identifying stressors and sources of impacts observed. The sample size from WY 2018 (overall n=20; urban n=17) is not sufficient to develop statistically representative conclusions regarding the overall condition of all creeks. A more comprehensive bioassessment data analyses for the entire eight years of monitoring under the MRP (WY 2012 through WY 2019) will be conducted as part of the Integrated Monitoring Report during WY 2019.

Like previous years, WY 2018 data suggest that most urban streams have likely or very likely altered populations of aquatic life indicators (e.g., benthic macroinvertebrates). These conditions are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications to the watershed and riparian areas associated with the urban development that has occurred over the past 50 plus years. Additionally, episodic or site-specific increases in temperature (particularly in lower creek reaches or reaches directly below reservoirs) may not be optimal for aquatic life in some local creeks.

The Program and its Co-permittees are actively implementing many stormwater management programs to address these and other stressors and associated sources of water quality conditions observed in local creeks, with the goal of protecting these natural resources. For example:

- In compliance with MRP provision C.3, new and redevelopment projects in the Bay Area are now designed to more effectively reduce water quality and hydromodification impacts associated with urban development. Low impact development (LID) methods, such as rainwater harvesting and use, infiltration and biotreatment are required as part of development and redevelopment projects. In addition, Green Infrastructure planning is now part of all municipal projects. These LID measures are expected to reduce the impacts of urban runoff and associated impervious surfaces on stream health.
- In compliance with MRP provision C.7, the Program and its Co-permittees are implementing stormwater outreach activities through the Watershed Watch Campaign (Campaign) that directly engages citizens and youth to make watershed-friendly choices. Pollution prevention messages are delivered at 8 to 10 community events per year, communicating the value and protection of creeks' natural resources to citizens both in plain non-scientific wording and multiple native languages (e.g., Spanish, Vietnamese, Chinese). Media advertising, such as the Earthquakes' and Sharks' collaborations, teach citizens how to dispose properly of litter, hazardous wastes, and car wash water. The Campaign also conducts numerous activities and sessions to educate children about watersheds and urban runoff pollution prevention through the Don Edwards San Francisco Bay National Wildlife Refuge, including watershed-focused field trips, marsh walks, gardening events, bird watching, and wildlife observation. Additionally, the Campaign supports the musical assembly program, ZunZun that engages students through music and theatre while teaching them about stormwater, watersheds, and pollution prevention topics. These efforts are expected to encourage watershed-positive behavior change in Santa Clara Valley residents.
- In compliance with MRP provision C.9, the Program and Co-permittees are implementing pesticide toxicity control programs that focus on source control and pollution prevention measures. The control measures include the implementation of integrated pest management (IPM) policies/ordinances, public education and outreach programs, pesticide disposal programs, the adoption of formal State pesticide registration procedures, and sustainable landscaping requirements for new and

redevelopment projects. Through these efforts, it is estimated that the amount of pyrethroids observed in urban stormwater runoff will decrease by 80-90% over time, and in turn significantly reduce the magnitude and extent of toxicity in local creeks.

- Trash loadings to local creeks have been reduced through implementation of new control measures in compliance with MRP provision C.10 and other efforts by Co-permittees to reduce the impacts of illegal dumping directly into waterways. These actions include the installation and maintenance of trash capture systems, the adoption of ordinances to reduce the impacts of litter prone items, enhanced institutional controls such as street sweeping, and the on-going removal and control of direct dumping. The MRP establishes a mandatory trash load reduction schedule, minimum areas to be treated by trash full capture systems, and requires development of receiving water monitoring programs for trash.
- In compliance with MRP provisions C.2 (Municipal Operations), C.4 (Industrial and Commercial Site Controls), C.5 (Illicit Discharge Detection and Elimination), and C.6 (Construction Site Controls) Co-permittees continue to implement programs that are designed to prevent non-stormwater discharges during dry weather and reduce the exposure of contaminants to stormwater and sediment in runoff during rainfall events.
- In compliance with MRP provision C.13, copper in stormwater runoff is reduced through implementation of controls such as architectural and site design requirements, prohibition of discharges from water features treated with copper, and industrial facility inspections.
- Mercury and polychlorinated biphenyls (PCBs) in stormwater runoff are being reduced through implementation of the respective TMDL water quality restoration plans. In compliance with MRP provisions C.11 (mercury) and C.12 (PCBs), the Program will continue to identify sources of these pollutants and will implement control actions designed to achieve new minimum load reduction goals. Monitoring activities conducted in WY 2018 that specifically target mercury and PCBs are described in the Pollutants of Concern Monitoring Data Report that is included as Appendix E to the WY 2018 UCMR.

In addition to the Program and Co-permittee controls implemented in compliance with the MRP, numerous other efforts and programs designed to improve the biological, physical and chemical condition of local creeks are underway. For example, the SCVWD's Integrated Water Resources Master Plan (IWRMP) or "One Water Plan" is an ongoing, multi-year process to develop a framework for long-term management of Santa Clara County water resources. The One Water Plan identifies, prioritizes and implements activities at a watershed scale to meet flood protection, water supply, water quality and environmental stewardship goals and objectives. Additionally, SCVURPPP, via a Proposition 1 grant awarded to the SCVWD, continued to develop a Storm Water Resource Plan for the Santa Clara Basin in 2018 that will support the development and implementation of MRP-required Green Stormwater Infrastructure Plans and produce a list of prioritized runoff capture and use projects that will be eligible for future State implementation grant funds. Through the continued implementation of MRP-associated and other watershed stewardship programs, SCVURPPP anticipates that stream conditions and water quality in local creeks will continue to improve over time. In the near term, toxicity observed in creeks should decrease as pesticide regulations better incorporate water quality concerns during the pesticide registration process. In the longer term, control measures implemented to "green" the "gray" infrastructure and disconnect impervious areas constructed over the course of the past 50-plus years will take time to implement. Consequently, it may take several decades to observe the outcomes of these important, large-scale improvements to our watersheds in our local creeks. Long-term creek status monitoring programs designed to detect these changes over time are therefore beneficial to our collective understanding of the condition and health of our local waterways.

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ATTACHMENTS

Attachment 1

QA/QC Report

Quality Assurance/Quality Control Report

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Urban Runoff
Pollution Prevention Program

March 31, 2018

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LIST OF ACRONYMS

BASMAA	Bay Area Stormwater Management Agencies Association
BMI	Benthic Macroinvertebrates
CDFW	California Department of Fish and Wildlife
DPD	Diethyl-p-phenylene Diamine
DQO	Data Quality Objective
EDDs	Electronic data deliverables
EV	Expected Value
KLI	Kinnetic Laboratories, Inc.
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MPN	Most Probably Number
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MV	Measured Value
ND	Non-detect
NIST	National Institute of Standards and Technology
NPDES	National Pollution Discharge Elimination System
NV	Native Value
PAH	Polycyclic Aromatic Hydrocarbon
PR	Percent Recovery
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Limit
RMC	Regional Monitoring Coalition
RPD	Relative Percent Difference
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California Coastal Water Research Project
SFRWQCB	San Francisco Regional Water Quality Control Board
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SOP	Standard Operating Procedures
STE	Standard Taxonomic Effort
SV	Spike Value
SWAMP	Surface Water Ambient Monitoring Program
TKN	Total Kjeldahl Nitrogen
WY	Water Year

1. INTRODUCTION

In Water Year 2018 (WY 2018; October 1, 2017 through September 30, 2018), the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) conducted Creek Status Monitoring in compliance with provision C.8.d and Pesticide & Toxicity Monitoring in compliance with provision C.8.g of the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The monitoring strategy includes regional ambient/probabilistic monitoring and local “targeted” monitoring as described in the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). SCVURPPP implemented a comprehensive data quality assurance and quality control (QA/QC) program, covering all aspects of the probabilistic and targeted monitoring. QA/QC for data collected was performed according to procedures detailed in the BASMAA RMC Quality Assurance Project Plan (QAPP) (BASMAA 2016a) and the BASMAA RMC Standard Operating Procedures (SOP; BASMAA 2016b), SOP FS-13 (Standard Operating Procedures for QA/QC Data Review). The BASMAA RMC QAPP and SOPs are based on the QA program developed by the California Surface Water Ambient Monitoring Program (SWAMP; SCCWRP 2008).

Based on the QA/QC review, no WY 2018 data except for the continuous pH data collected in May and June. This data was rejected due to instrument failure. Additionally, some WY 2018 data were flagged due to issues identified in the QA/QC review. Overall, WY 2018 data met QA/QC objectives. Details are provided in the sections below.

1.1. DATA TYPES EVALUATED

During creek status monitoring, several data types were collected and evaluated for quality assurance and quality control. These data types include the following:

1. Bioassessment data
    a. Benthic Macroinvertebrates (BMI)
    b. Algae
2. Physical Habitat Assessment
3. Field Measurements
4. Water Chemistry
5. Pathogen Indicators
6. Continuous Water Quality (2-week deployment; 15-minute interval)
    a. Temperature
    b. Dissolved Oxygen
    c. Conductivity
    d. pH
7. Continuous Temperature Measurements (5-month deployment; 1-hour interval)

During pesticide & toxicity monitoring the following data types were collected and evaluated for quality assurance and quality control:

1. Water Toxicity (dry weather; MRP Provision C.8.g.i)
2. Sediment Toxicity (dry weather; MRP Provision C.8.g.ii)
3. Sediment Chemistry (dry weather; MRP Provision C.8.g.ii)
4. Water Pesticides (wet weather; MRP Provision C.8.g.iii)
5. Water Toxicity (wet weather; MRP Provision C.8.g.iii)

1.2. LABORATORIES

Laboratories that provided analytical and taxonomic identification support to SCVURPPP and the RMC were selected based on demonstrated capability to adhere to specified protocols. Laboratories are certified and are as follows:

- Caltest Analytical Laboratory (nutrients, chlorophyll a, ash free dry mass, sediment chemistry)
- Pacific EcoRisk, Inc. (water and sediment toxicity)
- Alpha Analytical Laboratories, Inc. (pathogen indicators)
- BioAsessment Services (benthic macroinvertebrate (BMI) identification)
- Jon Lee Consulting (BMI identification Quality Control)
- EcoAnalysts, Inc. (algae identification)
- Physis Environmental Laboratories, Inc. (water column pesticides)

1.3. QA/QC ATTRIBUTES

The RMC SOP and QAPP identify seven data quality attributes that are used to assess data QA/QC. They include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Precision, (6) Accuracy, and (7) Contamination. These seven attributes are compared to Data Quality Objectives (DQOs), which were established to ensure that data collected are of adequate quality and sufficient for the intended uses. DQOs address both quantitative and qualitative assessment of the acceptability of data – representativeness and comparability are qualitative while completeness, sensitivity, precision, accuracy, and contamination are quantitative assessments.

Specific DQOs are based on Measurement Quality Objectives (MQOs) for each analyte. Chemical analysis relies on repeatable physical and chemical properties of target constituents to assess accuracy and precision. Biological data are quantified by experienced taxonomists relying on organism morphological features.

1.3.1. Representativeness

Data representativeness assesses whether the data were collected so as to represent actual conditions at each monitoring location. For this project, <u>all samples and field measurements are assumed to be representative</u> if they are performed according to protocols specified in the RMC QAPP and SOPs.

1.3.2. Comparability

The QA/QC officer ensures that the data may be reasonably compared to data from other programs producing similar types of data. For RMC Creek Status monitoring, individual stormwater programs try to maintain comparability within the RMC. The key measure of comparability for all RMC data is the California Surface Water Ambient Monitoring Program.

1.3.3. Completeness

Completeness is the degree to which all data were produced as planned; this covers both sample collection and analysis. For chemical data and field measurements an overall completeness of greater than <u>90%</u> is considered acceptable for RMC chemical data and field measurements. For bioassessment-related parameters – including BMI and algae taxonomy samples/analysis and associated field measurement – a completeness of <u>95%</u> is considered acceptable.

1.3.4. Sensitivity

Sensitivity analysis determines whether the methods can identify and/or quantify results at low enough levels. For the chemical analyses in this project, sensitivity is considered to be adequate if the reporting limits (RLs) comply with the specifications in RMC QAPP Appendix E: RMC Target Method Reporting Limits. For benthic macroinvertebrate data, taxonomic identification sensitivity is acceptable provided taxonomists use standard taxonomic effort (STE) Level I as established by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT). There is no established level of sensitivity for algae taxonomic identification.

1.3.5. Accuracy

Accuracy is assessed as the percent recovery of samples spiked with a known amount of a specific chemical constituent. Chemistry laboratories routinely analyze a series of spiked samples; the results of these analyses are reported by the laboratories and evaluated using the RMC Database QA/QC Testing Tool. Acceptable levels of accuracy are specified for chemical analytes and toxicity test parameters in RMC QAPP Appendix A: Measurement Quality Objectives for RMC Analytes, and for biological measurements in Appendix B: Benthic Macroinvertebrate MQOs and Data Production Process.

1.3.6. Precision

Precision is nominally assessed as the degree to which replicate measurements agree, nominally determined by calculation of the relative percent difference (RPD) between duplicate measurements. Chemistry laboratories routinely analyze a series of duplicate samples that are generated internally. The RMC QAPP also requires collection and analysis of field duplicate samples 5% of all samples for all parameters[1]. The results of the duplicate analyses are reported by the laboratories and evaluated using RMC Database QA/QC Testing Tool. Results of the Tool are confirmed manually. Acceptable levels of precision are specified for chemical analytes and toxicity test parameters in RMC QAPP Appendix A: Measurement Quality Objectives for RMC Analytes, and for biological measurements in Appendix B: Benthic Macroinvertebrate MQOs and Data Production Process.

1.3.7. Contamination

For chemical data, contamination is assessed as the presence of analytical constituents in blank samples. The RMC QAPP requires collection and analysis of field blank samples at a rate of 5% for orthophosphate.

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[1] The QAPP also requires the collection of field duplicate samples for 10% of biological samples (BMI and algae). However, there are no prescribed methods for assessing the precision of these duplicate samples.

2. METHODS

2.1. Representativeness

To ensure representativeness, each member of the SCVURPPP field crew received and reviewed all applicable SOPs and the QAPP. Most field crew members also attended a two-day bioassessment and field sampling training session from the California Water Boards Training Academy. The course was taught by California Department of Fish and Wildlife, Aquatic Bioassessment Laboratory staff and covered procedures for sampling benthic macroinvertebrates, algae, and measuring physical habitat characteristics using the applicable SWAMP SOPs. As a result, each field crew member was knowledgeable of, and performed data collection according to the protocols in the RMC QAPP and SOPs, ensuring that all samples and field measurements are representative of conditions in Santa Clara County urban creeks.

2.2. Comparability

In addition to the bioassessment and field sampling training, SCVURPPP field crew members participated in an inter-calibration exercise with other stormwater programs prior to field assessments at least once during the permit term. During the inter-calibration exercise, the field crews also reviewed water chemistry (nutrient) sample collection and water quality field measurement methods. Close communication throughout the field season with other stormwater program field crews also ensured comparability.

Sub-contractors collecting samples and the laboratories performing analyses received copies of the RMC SOP and QAPP and have acknowledged reviewing the documents. Data collection and analysis by these parties adhered to the RMC protocols and was included in their operating contracts.

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by the SCVURPPP Program Quality Assurance staff and were compared against the methods and protocols specified in the SOPs and QAPP. Specifically, staff checked for conformance with field and laboratory methods as specified in SOPs and QAPP, including sample collection and analytical methods, sample preservation, sample holding times, etc.

Electronic data deliverables (EDDs) were submitted to the San Francisco Regional Water Quality Control Board (SFRWQCB) in Microsoft Excel templates developed by SWAMP, to ensure data comparability with the SWAMP program. In addition, data entry followed SWAMP documentation specific to each data type, including the exclusion of qualitative values that do not appear on SWAMP's look up lists[2]. Completed templates were reviewed using SWAMP's online data checker[3], further ensuring SWAMP-comparability.

2.3. Completeness

2.3.1. Data Collection

All efforts were made to collect 100% of planned samples. Upon completion of all data collection, the number of samples collected for each data type was compared to the number of samples planned and the number required by the MRP, and reasons for any missed samples were identified. When possible, SCVURPPP staff resampled sites if missing data were identified prior to the close of the monitoring period. Specifically, continuous water quality data were reviewed immediately following deployment, and if data were rejected, samplers were redeployed immediately.

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[2] Look up lists available online at http://swamp.waterboards.ca.gov/swamp_checker/LookUpLists.php
[3] Checker available online at http://swamp.waterboards.ca.gov/swamp_checker/SWAMPUpload.php

For bioassessments, the SCVURPPP field crew made all efforts to collect the required number of BMI and algae subsamples per site; in the event of a dry transect, the samples were slid to the closest sampleable location to ensure 11 total subsamples in each station's composite sample.

2.3.2. Field Sheets

Following the completion of each sampling event, the field crew leader/local monitoring coordinator reviewed any field generated documents for completion, and any missing values were entered. Once field sheets were returned to the office, a second SCVURPPP staff member reviewed the field sheets again and noted any missing data.

2.3.3. Laboratory Results

SCVURPPP staff assessed laboratory reports and EDDs for the number and type of analysis performed to ensure all sites and samples were included in the laboratory results.

2.4. Sensitivity

2.4.1. Biological Data

Benthic macroinvertebrates were identified to SAFIT STE Level I.

2.4.2. Chemical Analysis

The reporting limits for analytical results were compared to the target reporting limits in Appendix E (RMC Target Method Reporting Limits) of the RMC QAPP. Results with reporting limits that exceeded the target reporting limit were flagged.

2.5. Accuracy

2.5.1. Biological Data

Ten percent of the total number of BMI samples collected was submitted to a separate taxonomic laboratory, Jon Lee Consulting, for independent assessment of taxonomic accuracy, enumeration of organisms, and conformance to standard taxonomic level. For SCVURPPP, two samples were evaluated for QC purposes. Results were compared to MQOs in Appendix B (Benthic macroinvertebrate MQOs and Data Production Process).

2.5.2. Chemical Analysis

Caltest and Physis evaluated and reported the percent recovery (PR) of laboratory control samples (LCS; in lieu of reference materials) and matrix spikes (MS), which were recalculated and compared to the applicable MQOs set by Appendix A (Measurement Quality Objectives for RMC Analytes) of the RMC QAPP MQOs. If a QA sample did not meet MQOs, all samples in that batch for that particular analyte were flagged.

For reference materials, percent recovery was calculated as:

$$PR = MV / EV \times 100\%$$

Where: MV = the measured value
EV = the expected (reference) value

For matrix spikes, percent recovery was calculated as:

$$PR = [(MV - NV) / SV] \times 100\%$$

Where: MV = the measured value of the spiked sample
NV = the native, unspiked result
SV = the spike concentration added

2.5.3. Water Quality Data Collection

Accuracy for continuous water quality monitoring sondes was assured via continuing calibration verification for each instrument before and after each two-week deployment. Instrument drift was calculated by comparing the instrument's measurements in standard solutions taken before and after deployment. The drift was compared to measurement quality objectives for drift listed on the SWAMP calibration form, included as an attachment to the RMC SOP FS-3.

Temperature data were checked for accuracy by comparing measurements taken by HOBO temperature loggers with NIST thermometer readings in room temperature water and ice water prior to deployment. The mean difference and standard deviation for each HOBO was calculated, and if a logger had a mean difference exceeding 0.2 ^{o}C, it is replaced.

2.6. PRECISION

2.6.1. Field Duplicates

For creek status monitoring, duplicate biological samples were collected at 10% (two) of the 20 probabilistic sites and duplicate water chemistry samples were collected at 10% (two) of the probabilistic sites sampled to evaluate precision of field sampling methods. The RPD for water chemistry field duplicates was calculated and compared to the MQO (RPD < 25%) set by Table 26-1 in Appendix A of the RMC QAPP. If the RPD of the two field duplicates did not meet the MQO, the results were flagged.

The RMC QAPP requires collection and analysis of duplicate sediment chemistry and toxicity samples at a rate of 5% of total samples collected for the project. One field duplicate was collected in San Mateo County for dry weather sediment chemistry, sediment toxicity, and water toxicity samples and an additional field duplicate was collected in Contra Costa County for wet weather pesticides to account for the 16 pesticide & toxicity sites collectively monitored by the RMC in WY 2018. The sediment sample and field duplicate were collected together using the Sediment Scoop Method described in the RMC SOP, homogenized, and then distributed to two separate containers. For sediment chemistry and water pesticides field duplicates, the RPD was calculated for each analyte and compared to the MQOs (RPD < 25%) set by Tables 26-7 through 26-11 in Appendix A of the RMC QAPP. For sediment and water toxicity field duplicates, the RPD of the batch mean was calculated and compared to the recommended acceptable RPD (< 20%) set by Tables 26-12 and 26-13 in Appendix A. If the RPD of the field duplicates did not meet the MQO, the results were flagged.

The RPD is calculated as:

$$RPD = ABS([X1-X2] / [(X1+X2) / 2])$$

Where: X1 = the first sample result
X2 = the duplicate sample result

No field duplicate is required for pathogen indicators.

2.6.2. Chemical Analysis

Caltest and Physis evaluated and reported the RPD for laboratory duplicates, laboratory control duplicates, and matrix spike duplicates. The RPDs for all duplicate samples were recalculated and compared to the applicable MQO set by Appendix A of the RMC QAPP. If a laboratory duplicate sample did not meet MQOs, all samples in that batch for that particular analyte were flagged.

2.7. CONTAMINATION

Blank samples were analyzed for contamination, and results were compared to MQOs set by Appendix A of the RMC QAPP. For creek status monitoring, the RMC QAPP requires all blanks (laboratory and field) to be less than the analyte reporting limits. If a blank sample did not meet this MQO, all samples in that batch for that particular analyte were flagged.

3. RESULTS

3.1. Overall Project Representativeness

The SCVURPPP staff and field crew members were trained in SWAMP and RMC protocols, and received significant supervision from the local monitoring coordinator and QA officer. As a result, creek status monitoring data were considered to be representative of conditions in Santa Clara County Creeks.

3.2. Overall Project Comparability

SCVURPPP creek status monitoring data were considered to be comparable to both other agencies in the RMC and to SWAMP due to trainings, use of the same electronic data templates, and close communication.

3.3. Bioassessments and Physical Habitat Assessments

In addition to algae and BMI taxonomic samples, the SCVURPPP field crew collected chlorophyll a and ash free dry mass samples during bioassessments. The BMI taxonomic laboratory, BioAssessment Services, confirmed that the laboratory QA/QC procedures aligned with the procedures in Appendices B through D of the RMC QAPP and met the BMI MQOs in Appendix B.

3.3.1. Completeness

SCVURPPP completed bioassessments and physical habitat assessments for 20 of 20 planned/required sites for a 100% sampling completion rate. However, physical habitat assessments could not be taken at several transects due to inaccessibility.

3.3.2. Sensitivity

The BMI taxonomic identification met sensitivity objectives; the taxonomy laboratory, BioAssessment Services, and QC laboratory, Jon Lee Consulting, confirmed that organisms were identified to SAFIT STE Level I, with the exception of Chironomidae which was analyzed to SAFIT level 1a.

The analytical RL for ash free dry mass analysis (8 mg/L) was much higher than the RMC QAPP target RL (2 mg/L) due to high concentrations requiring large dilutions. The results were several orders of magnitude higher than the actual and target reporting limit and were not affected by the higher RL. While the chlorophyll a analyses also required large dilutions due to high concentrations within the samples, the chlorophyll a analytical RL was below that of the RMC QAPP target RL.

Note that the target RLs in the RMC QAPP are set by the SWAMP, but there are currently no appropriate SWAMP targets for either ash free dry mass or chlorophyll a. Limits in the RMC QAPP are meant to reflect current laboratory capabilities. At lower analyte concentrations where a dilution would not be necessary, the analytical RLs would have met the target RLs.

3.3.3. Accuracy

The BMI samples that were submitted to an independent QC taxonomic laboratory had three specimen misidentifications and no counting errors. The specimen misidentifications were speculated to be due to sorting errors. The QC laboratory calculated sorting and taxonomic identification metrics, which were compared to the measurement quality objectives in Table 27-1 in Appendix B of the RMC QAPP. All MQOs were met. A comparison of the metrics with the MQOs is shown in Table 1. A copy of the QC laboratory report is available upon request.

There is currently no protocol for evaluating the accuracy of algae taxonomic identification.

Table 1. Quality control metrics for taxonomic identification of benthic macroinvertebrates collected in Santa Clara County in WY 2018 compared to measurement quality objectives.

Quality Control Metric	MQO	Error Rate	Exceeds MQO?
Recount Accuracy	> 95%	99.84%	No
Taxa ID	≤ 10%	1.85%	No
Individual ID	≤ 10%	0.65%	No
Low Taxonomic Resolution Individual	≤ 10%	0%	No
Low Taxonomic Resolution Count	≤ 10%	0%	No
High Taxonomic Resolution Individual	≤ 10%	0%	No
High Taxonomic Resolution Count	≤ 10%	0%	No

3.3.4. Precision

Field blind duplicate chlorophyll a and ash free dry mass samples were collected at two sites in WY 2018 and were sent to the laboratory for analysis.

Duplicate field samples do not provide a valid estimate of precision in the sampling and are of little use to assessing precision, because there is no reasonable expectation that duplicates will produce identical data. Nonetheless, the RPD of the chlorophyll a and ash free dry mass duplicate results were calculated and compared to the MQO (< 25%) for conventional analytes in water (Table 26-1 in Appendix B of the RMC QAPP). Due to the nature of chlorophyll a and ash free dry mass collection, the RPDs for both parameters are expected to exceed the MQO. For site 205R00746, the chlorophyll a RPD exceeded the MQO while the ash free dry mass RPD did not. For site 205R03591, the ash free dry mass RPD exceeded the MQO while the chlorophyll-a RPD did not. The field duplicate results and their RPDs are shown in Table 2.

Again, discrepancies were to be expected due to the potential natural variability in algae production within the reach and the collection of field duplicates at different locations along each transect (as specified in the protocol). As a result, both parameters have frequently exceeded the field duplicate RPD MQOs during past years' monitoring efforts.

Table 2. Field duplicate water chemistry results for site 205R03591, collected on May 7, 2018 and site 205R00746, collected May 24, 2018.

Analyte	Units	205R03591 May 7, 2018				205R00746 May 24, 2018			
		Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Chlorophyll a	mg/m^3	14.6	14.8	2%	No	89.2	68.4	27%	Yes
Ash Free Dry Mass	mg/L	99.6	49.6	67%	Yes	37.9	35.3	7%	No

[a]In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

Laboratory duplicates were also collected for chlorophyll a and ash free dry mass samples. The RPD for ash free dry mass was below the MQO limit, however the RPD for chlorophyll a was above the limit. As a result, associated chlorophyll a samples were flagged.

3.3.5. Contamination

All field collection equipment was decontaminated between sites in accordance with the RMC SOP FS-8 and CDFW Aquatic Invasive Species Decontamination protocols. As a result, it is assumed that samples were free of biological contamination.

3.4. Field Measurements

Field measurements of temperature, dissolved oxygen, pH, specific conductivity, and chlorine residual were collected concurrently with bioassessments and water chemistry samples. Chlorine residual was measured using a HACH Pocket Colorimeter™ II, which uses the DPD method. All other parameters were measured with a YSI Professional Plus or YSI 600XLM-V2-S multi-parameter instrument. All data collection was performed according to RMC SOP FS-3 (Performing Manual Field Measurements).

3.4.1. Completeness

Temperature, dissolved oxygen, pH, specific conductivity, total chlorine residual, and free chlorine residual were collected at all 20 bioassessment sites for a 100% completeness rate.

3.4.2. Sensitivity

Free and total chlorine residual were measured using a HACH Pocket Colorimeter™ II, which uses the DPD method. For this method, the estimated detection limit for the low range measurements (0.02-2.00 mg/L) was 0.02 mg/L. There is, however, no established method reporting limit. Based on industry standards and best professional judgment, the method reporting limit is assumed to be 0.13 mg/L, which is much lower than the 0.5 mg/L target reporting limit listed in the RMC QAPP for free and total chlorine residual.

There are also no method reporting limits for temperature, dissolved oxygen, pH, and conductivity measurements, but the actual measurements are much higher than target reporting limits in the RMC QAPP, so it is assumed that target reporting limits are met for all field measurements.

3.4.3. Accuracy

Data collection occurred Monday through Thursday, and the multi-parameter instrument was calibrated at most 12 hours prior to the first sample on Monday, with the dissolved oxygen sensor calibrated every morning to ensure accurate measurements. Calibration solutions are certified standards, whose expiration dates were noted prior to use. The chlorine kit is factory-calibrated and is sent into the manufacturer every other year to be calibrated.

Free chlorine was measured to be higher than total chlorine at six of the 20 sites sampled in WY 2018. In past years, free chlorine has also occasionally been measured as higher than total chlorine. Theoretically, the free chlorine measurement should always be less than or equal to the total chlorine measurement, as the total chlorine concentration in water encompasses the free chlorine concentration in addition to any other chlorine species. The reason for free chlorine concentrations exceeding total chlorine concentrations at a sample site has not been definitively established. However, it is suspected that this could be due to inaccuracy of the chlorine meter at concentrations below 0.13 mg/L or varying chlorine concentrations between the water sample used for the total chlorine measurement and the water sample used for the free chlorine measurement. When free chlorine was observed to be higher than total chlorine at a sample site, the free chlorine measurement was retaken with a new water sample and recorded on the field form. It was deemed unnecessary to flag free chlorine measurements that were higher than total chlorine measurements.

3.4.4. Precision

Precision could not be measured as no duplicate field measurements are required or were collected.

3.5. WATER CHEMISTRY

Water chemistry samples were collected by SCVURPPP staff concurrently with bioassessment samples and analyzed by Caltest Analytical Laboratory (Caltest) within their respective holding times. Caltest performed all internal QA/QC requirements as specified in the QAPP and reported their findings to the RMC. Key water chemistry MQOs are listed in RMC QAPP Table 26-2.

3.5.1. Completeness

SCVURPPP collected 100% of planned/required water chemistry samples at the 20 bioassessment sites including two field duplicate samples. Samples were analyzed for all requested analytes, and 100% of results were reported. Water chemistry data were flagged when necessary, but none were rejected.

3.5.2. Sensitivity

Laboratory reporting limits met or were lower than target reporting limits for all nutrients except ammonia, chloride, and nitrate. The reporting limit for all chloride samples exceeded the target reporting limit, but concentrations were much higher than reporting limits, and the elevated reporting limits do not decrease confidence in the measurements.

The reporting limit (0.05 mg/L) and method detection limit (0.02 mg/L) for nitrate samples were higher than the target reporting limit (0.01 mg/L). As a result, one sample was flagged as "detected, not quantified", but it would have been quantified at the lower reporting limit. Additionally, the nitrate concentration at one other site was measured to be below the method detection limit. Due to the reporting limit (0.1 mg/L) and method detection limit (0.04 mg/L) for ammonia samples being higher than the target reporting limit (0.02 mg/L), three samples were flagged as "detected, not quantified", but they would have been quantified at the lower reporting limit. Additionally, the ammonia concentrations at 15 other sites were measured to be below the method detection limit. SCVURPPP has discussed the reporting limits with Caltest, and there is the possibility for a lower reporting limit for future analysis. Target and actual reporting limits are shown in Table 3.

Table 3. Target and actual reporting limits for nutrients analyzed in SCVURPPP creek status monitoring. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte	Target RL mg/L	Actual RL mg/L
Ammonia	0.02	0.02-0.1
Chloride	0.25	1-10
Total Kjeldahl Nitrogen	0.5	0.1
Nitrate	0.01	0.05
Nitrite	0.01	0.005
Orthophosphate	0.01	0.01
Silica	1	1
Phosphorus	0.01	0.01

3.5.3. Accuracy

Recoveries on all LCS were within the MQO target range of 80-120% recovery, and most MS and matrix spike duplicates (MSD) PRs were within the target range. Fifteen MS/MSD PRs exceeded the MQO range listed in the RMC QAPP for conventional analytes, including ammonia, total Kjeldahl nitrogen (TKN), and chloride. The QA samples affected 14 sites, whose results have been assigned the appropriate SWAMP flag. Though the results were flagged, none of the analytical data were rejected by the local QA officer due to accuracy.

The PR ranges on laboratory reports were 70-130%, 85-115% or 90-110% for some conventional analytes (nutrients) while the RMC QAPP lists the PR as 80-120% for all conventional analytes in water. As a result, some QA samples that exceeded RMC MQOs were flagged by the local QA officer, but not by the laboratory and vice versa.

3.5.4. Precision

The RPD for all laboratory control sample duplicate pairs were consistently below the MQO target of < 25%. However, the RPD for one MS/MSD pair exceeded the target.

Water chemistry field duplicates were collected at two sites in Santa Clara County and were compared against the original samples. For WY 2018, one of the total Kjeldahl nitrogen duplicate samples exceeded the RPD MQO. In past years of sampling, total Kjeldahl nitrogen has been common among the analytes that exceed the field duplicate RPD MQOs. Field crews will continue to make an effort in subsequent years to collect the original and duplicate samples in an identical fashion.The field duplicate water chemistry results and their RPDs are shown in Tables 4 and 5. Because of the variability in reporting limits, values less than the RL were not evaluated for RPD. For those analytes whose RPDs could be calculated and did not meet the RMC MQO, they were assigned the appropriate SWAMP flag.

Table 4. Field duplicate water chemistry results for site 205R03591, collected on May 7, 2018. Data in highlighted rows exceed measurement quality objectives in RMC QAPP.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Ammonia as N	Total	mg/L	ND	ND	N/A	N/A
Chloride	None	mg/L	18	18	0%	No
Nitrate as N	None	mg/L	0.11	0.11	0%	No
Nitrite as N	None	mg/L	ND	ND	N/A	N/A
Nitrogen, Total Kjeldahl	None	mg/L	0.35	ND	N/A	N/A
Orthophosphate as P	Dissolved	mg/L	0.017	0.02	16%	No
Phosphorus as P	Total	mg/L	0.018	0.02	11%	No
Silica as SiO2	Total	mg/L	17	17	0%	No

[a]In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

Table 5. Field duplicate water chemistry results for site 205R00746, collected on May 24, 2018. Data in highlighted rows exceed measurement quality objectives in RMC QAPP.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Ammonia as N	Total	mg/L	ND	ND	N/A	N/A
Chloride	None	mg/L	16	16	0%	No
Nitrate as N	None	mg/L	0.21	0.21	0%	No
Nitrite as N	None	mg/L	ND	ND	N/A	N/A
Nitrogen, Total Kjeldahl	None	mg/L	0.4	0.18	76%	Yes
Orthophosphate as P	Dissolved	mg/L	0.072	0.072	0%	No
Phosphorus as P	Total	mg/L	0.06	0.058	3%	No
Silica as SiO2	Total	mg/L	23	22	4%	No

[a]In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

3.5.5. Contamination

None of the target analytes were detected in any of the laboratory blanks at levels above their reporting limit. All analytes were non-detect in the laboratory blanks. The RMC QAPP does not require field blanks to be collected, and possible contamination from sample collection was not assessed. However, the SCVURPPP field crew takes appropriate precautions to avoid contamination, including wearing gloves during sample collection and rinsing sample containers with stream water when preservatives are not needed.

3.6. Pathogen Indicators

Pathogen indicator samples were collected by SCVURPPP staff and were analyzed by Alpha Analytical Laboratories, Inc for *E. coli* and enterococcus. Samples were collected on July 27, 2018.

3.6.1. Completeness

All five required/planned pathogen indicator samples were collected for a 100% completeness rate. These samples and were received and incubated by the laboratory well within the 8-hour hold time.

3.6.2. Sensitivity

The reporting limits for *E. coli* and enterococcus (1 MPN/100mL and 2 MPN/100m, respectively) met the target RL of 2 MPN/100mL listed in the project QAPP.

3.6.3. Accuracy

Negative and positive laboratory controls were run for microbial media. A negative response was observed in the negative control and a positive response was observed in the positive control required by the project QAPP Table 26-4.

3.6.4. Precision

The RMC QAPP requires one laboratory duplicate to be run per 10 samples or per analytical batch, whichever is more frequent. In WY 2018, one laboratory duplicate was run for the five samples/one batch. However, determining precision for pathogen indicators requires 15 duplicate sets. Due to the small number of samples collected for this project, there were not enough laboratory duplicates to determine precision. In WY 2018, only one laboratory duplicate was run and is not sufficient in determining precision.

The RMC QAPP does not require a field duplicate to be collected for pathogen indicators. However, one field duplicate was collected in WY 2018 at 205STE064. The RPD for *E.coli* was 6% and 29% for enterococcus. Since there is no requirement for pathogen field duplicates, there is no corresponding MQO, and the precision could not be assessed. See Table 6 for the field duplicate results.

Table 6. Lab and field duplicate pathogen results collected on July 27, 2018.

Duplicate Type	Analyte	Original Result (MPN/100mL)	Duplicate Result (MPN/100mL)	RPD
Lab Duplicate	E.coli	> 2419.6	> 2419.6	NA
Lab Duplicate	Enterococcus	> 2419.6	> 2419.6	NA
Field Duplicate	E.coli	260.3	275.5	6%
Field Duplicate	Enterococcus	547.5	410.6	29%

3.6.5. Contamination

One method blank (sterility check) was run in the batch for *E. coli* and enterococcus. No growth was observed in the blank.

3.7. CONTINUOUS WATER QUALITY

Continuous water quality measurements were recorded at three sites during the spring (May/June 2018), concurrent with bioassessments, and again in the summer (September 2018) in compliance with the MRP. Temperature, pH, dissolved oxygen, and specific conductivity were recorded once every 15 minutes for approximately two-weeks using a multi-parameter water quality sonde (YSI 6600-V2).

3.7.1. Completeness

The MRP requires one to two-week deployments, and both deployments exceeded the one week minimum. The first deployment lasted 14 days while the second deployment lasted 9 days. Sondes collected data for 100% of the planned deployments. However, the pH sensor for the sonde deployed at station 205COY236 during the spring deployment failed and associated pH data were rejected.

3.7.2. Sensitivity

There are no method reporting limits for temperature, dissolved oxygen, pH, and conductivity measurements, but the actual measurements are much higher than target reporting limits in the RMC QAPP, so it is assumed that target reporting limits are met for all field measurements.

3.7.3. Accuracy

The SCVURPPP staff conduct pre- and post-deployment sonde calibrations for the three sondes used during monitoring events and calculate the drift during the deployments. A summary of the drift measurements is shown in Table 7. During the first monitoring event, the sonde deployed at 205COY236 exceeded both the pH 7and pH 10 MQOs. The pH results at this site were subsequently flagged and rejected for this deployment.

Table 7. Drift measurements for two continuous water quality monitoring events in Santa Clara Valley urban creeks during WY 2018. Bold and highlighted values exceeded measurement quality objectives.

Parameter	Measurement Quality Objectives	205COY235		205COY236		205COY239	
		Event 1	Event 2	Event 1	Event 2	Event 1	Event 2
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	-0.20	-0.06	0.21	-0.08	-0.04	-0.20
pH 7.0	± 0.2	0.04	0.13	-0.88	-0.08	0.12	0.02
pH 10.0	± 0.2	-0.05	0.12	-2.78	-0.19	-0.08	-0.07
Specific Conductance (uS/cm)	± 10%	0.0%	7.8%	0.4%	-0.1%	1.6%	0.5%

3.7.4. Precision

There is no protocol listed in the RMC QAPP for measuring the precision of continuous water quality measurements.

3.8. Continuous Temperature Monitoring

Continuous temperature monitoring was conducted from April through September 2018 at nine sites in Santa Clara County. Onset HOBO Water Temperature data loggers recorded one measurement per hour.

3.8.1. Completeness

The MRP requires SCVURPPP to monitor eight stream reaches for temperature each year, but anticipating the potential for a HOBO temperature logger to be lost during such a long deployment, SCVURPPP deployed one extra temperature logger, for a total of nine loggers. In the middle of the deployment, SCVURPPP staff checked the loggers to ensure that they were still present and recording. During the field check, staff also downloaded the existing data and redeployed the loggers. During retrieval of the temperature loggers at the end of the deployment, one logger was missing. Since the other eight loggers recorded 100% of the deployment period, SCVURPPP was still able to achieve a completion rate of 100%.

3.8.2. Sensitivity

There is no target reporting limit for temperature listed in the RMC QAPP, thus sensitivity could not be evaluated for continuous temperature measurements.

3.8.3. Accuracy

A pre-deployment accuracy check was run on the temperature loggers in March 2018. None of the deployed loggers exceeded the 0.2 ºC mean difference threshold for either the room temperature bath or the ice bath. The loggers were subsequently deployed, and no flagging of the data was necessary.

3.8.4. Precision

There are no precision protocols for continuous temperature monitoring.

3.9. Sediment Chemistry

The dry season sediment chemistry samples were collected by Kinnetic Laboratories, Inc (KLI) concurrently with the dry season toxicity sample on July 17, 2018. Inorganic and synthetic organic compounds were analyzed by Caltest and grain size distribution was analyzed by Soil Control Laboratories, a subcontractor laboratory. Caltest conducted all QA/QC requirements as specified in the RMC QAPP and reported their findings to the RMC. Key sediment chemistry MQOs are listed in RMC

QAPP Tables 26-9 through 26-11. Sediment chemistry data were flagged when necessary, but none were rejected.

3.9.1. Completeness

The MRP requires a sediment chemistry sample to be collected at two locations each year. In WY 2018, SCVURPPP collected the sediment chemistry sample at 205STE021 and 205STQ010. The laboratories analyzed within the one year holding time for analytes in sediment, set by the RMC SOP, and reported 100% of the required analytes.

3.9.2. Sensitivity

A comparison of target and actual reporting limits for those parameters is shown in Table 8. For sediment chemistry analysis conducted in WY 2018, laboratory reporting limits were higher than RMC QAPP target reporting limits for 20 analytes. Since reporting limits for a sample are dependent on the percent solids of that sample, it is likely that the amount of solids in the sample resulted in these exceedances.

Table 8. Comparison of target and actual reporting limits for sediment analytes where reporting limits exceeded target limits. Sediment samples were collected in Santa Clara County creeks in WY 2018.

Analyte	Target RL	Actual RL	Unit
Arsenic	0.3	1.1	mg/Kg
Cadmium	0.01	0.08	mg/Kg
Chromium	0.1	1.1	mg/Kg
Copper	0.01	0.42	mg/Kg
Lead	0.01	0.08	mg/Kg
Nickel	0.02	0.08	mg/Kg
Zinc	0.1	0.8	mg/Kg
Bifenthrin	0.33	1.3	ng/g
Cyfluthrin	0.33	1.3	ng/g
Total Lambda-cyhalothrin	0.33	1.3	ng/g
Total Cypermethrin	0.33	1.3	ng/g
Total Deltamethrin	0.33	1.3	ng/g
Total Esfenvalerate/Fenvalerate	0.33	1.3	ng/g
Permethrin	0.33	1.3	ng/g
Carbaryl	30	64	ng/g
Fipronil	0.33	1.3	ng/g
Fipronil Desulfinyl	0.33	1.3	ng/g
Fipronil Sulfide	0.33	1.3	ng/g
Fipronil Sulfone	0.33	1.3	ng/g
Total Organic Carbon	0.01	0.05	% dw

3.9.3. Accuracy

Inorganic Analytes

No QA samples exceeded the QAPP MQO for LCS percent recovery (PR) for metals (75-125%), but the MSD sample for lead exceeded the PR MQO. This sample was flagged but not rejected.

Synthetic Organic Compounds

The percent recovery MQO for pyrethroids and other synthetic organic compounds in sediment is 50-150% in the RMC QAPP. However, the PR MQOs listed in the laboratory reports for synthetic organic compounds varied by analyte and were much larger than PR ranges listed in the QAPP. The MQOs ranged from 1 to 275% in certain cases. As a result, several analytes were flagged by the local QA officers, but not by the laboratory.

None of the LCS PRs exceeded the RMC MQO range. However, the MS/MSD PRs exceeded the RMC MQO range for 11 PAHs, two pyrethroids (deltamethrin and bifenthrin), fipronil, fipronil sulfide, and fipronil sulfone. The PAH MS/MSD samples that exceeded the PR MQO include benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-c,d)pyrene, perylene, phenanthrene, and pyrene.

3.9.4. Precision

<u>Inorganic Analytes</u>

The RMC QAPP lists the maximum RPD for inorganic analytes (metals) as 25%. All MS/MSD sets for metals were well below the RMC RPD MQO of 25%.

<u>Synthetic Organic Compounds</u>

The maximum RPD for synthetic organics listed in the sediment laboratory report lists ranges from 30 to 50% for most analytes. However, the RMC QAPP lists the MQO as < 25% RPD for most synthetic organics, < 35% for pyrethroids and fipronil, and < 40% for carbaryl. One MS/MSD pair for cypermethrin exceeded the QAPP MQOs for RPD (< 35%). Results for this analyte were flagged by the local QA officer, but not by the laboratory. Twelve of the LCS duplicates exceeded the RPD MQO including acenaphthylene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, biphenyl, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, methylnaphthalene, 2-, naphthalene, perylene, phenanthrene, and benz(a)anthracene.

<u>Field Duplicates</u>

A sediment sample field duplicate was collected in San Mateo County on July 17, 2018 and evaluated for precision. The field duplicate sample and corresponding RPDs are shown in Table 9. Because of the variability in reporting limits, values less than the RL were not evaluated for RPD. The measured concentrations of a majority of analytes from the original and duplicate samples were below the method detection limit and therefore reported as "ND". As a result, the RPDs were non-calculable. All calculable RPDs were below the MQO limits. Analytes that exceeded the MQO of RPD < 25% were cadmium; chromium; lead; anthracene; benz(a)anthracene; chrysene; dimethylnaphthalene, 2,6-; fluoranthene; methylnaphthalene, 1-; methylnaphthalene, 2-; naphthalene; phenanthrene; and pyrene.

Given the inherent variability associated with field duplicates, the number of analytes with RPDs outside of the MQO limits is acceptable. The method used to collect sediment field duplicates provides more insight to laboratory precision than precision of field methods; however, the results do suggest that field methods are precise.

Table 9. Sediment chemistry duplicate field results for site 204COR010, collected on July 17, 2018 in San Mateo County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
Grain Size Distribution	Clay: <0.0039 mm	%	3.35	3.36	0%	No
	Silt: 0.0039 to <0.0625 mm	%	7.38	7.22	2%	No
	Sand: V. Fine 0.0625 to <0.125 mm	%	4.72	4.78	1%	No
	Sand: Fine 0.125 to <0.25 mm	%	13.39	13.79	3%	No
	Sand: Medium 0.25 to <0.5 mm	%	26.74	27.12	1%	No
	Sand: Coarse 0.5 to <1.0 mm	%	27.42	27.14	1%	No
	Sand: V. Coarse 1.0 to <2.0 mm	%	17.01	16.59	2.5%	No
	Granule: 2.0 to <4.0 mm	%	10.56	9.24	13%	No

Table 9. Sediment chemistry duplicate field results for site 204COR010, collected on July 17, 2018 in San Mateo County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

	Analyte	Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
	Pebble: Small 4 to <8 mm	%	13.14	12.64	4%	No
	Pebble: Medium 8 to <16 mm	%	ND	6.09	N/A	N/A
	Pebble: Large 16 to <32 mm	%	ND	ND	N/A	N/A
	Pebble: V. Large 32 to <64 mm	%	ND	ND	N/A	N/A
Metals	Arsenic	mg/Kg dw	4.1	4.1	0%	No
	Cadmium	mg/Kg dw	0.12	0.09	29%	Yes
	Chromium	mg/Kg dw	91	55	49%	Yes
	Copper	mg/Kg dw	25	23	8%	No
	Lead	mg/Kg dw	15	38	87%	Yes
	Nickel	mg/Kg dw	92	74	22%	No
	Zinc	mg/Kg dw	78	75	4%	No
Pyrethroids (MQO <35%)	Bifenthrin	ng/g dw	1.2	1.1	9%	No
	Cyfluthrin, total	ng/g dw	ND	0.6	N/A	N/A
	Cyhalothrin, Total lambda-	ng/g dw	ND	ND	N/A	N/A
	Cypermethrin, total	ng/g dw	ND	ND	N/A	N/A
	Deltamethrin/Tralomethrin	ng/g dw	0.69	ND	N/A	N/A
	Esfenvalerate/Fenvalerate, total	ng/g dw	ND	ND	N/A	N/A
	Permethrin, Total	ng/g dw	0.81	0.81	0%	No
	Total Organic Carbon	%	0.92	0.93	1%	No
	Carbaryl	mg/Kg dw	ND	ND	N/A	N/A
Fipronil	Fipronil	ng/g dw	ND	ND	N/A	N/A
	Fipronil Desulfinyl	ng/g dw	ND	ND	N/A	N/A
	Fipronil Sulfide	ng/g dw	ND	ND	N/A	N/A
	Fipronil Sulfone	ng/g dw	ND	ND	N/A	N/A
Polycyclic Aromatic Hydrocarbons	Acenaphthene	ng/g dw	ND	ND	N/A	N/A
	Acenaphthylene	ng/g dw	ND	ND	N/A	N/A
	Anthracene	ng/g dw	3.1	4.1	28%	Yes
	Benz(a)anthracene	ng/g dw	4.1	6.1	39%	Yes
	Benzo(a)pyrene	ng/g dw	ND	ND	N/A	N/A
	Benzo(b)fluoranthene	ng/g dw	ND	ND	N/A	N/A
	Benzo(e)pyrene	ng/g dw	ND	ND	N/A	N/A
	Benzo(g,h,i)perylene	ng/g dw	ND	ND	N/A	N/A
	Benzo(k)fluoranthene	ng/g dw	ND	ND	N/A	N/A
	Biphenyl	ng/g dw	8.2	10	20%	No
	Chrysene	ng/g dw	21	31	38%	Yes
	Dibenz(a,h)anthracene	ng/g dw	ND	ND	N/A	N/A
	Dibenzothiophene	ng/g dw	ND	ND	N/A	N/A
	Dimethylnaphthalene, 2,6-	ng/g dw	7.2	20	94%	Yes
	Fluoranthene	ng/g dw	21	31	38%	Yes
	Fluorene	ng/g dw	ND	ND	N/A	N/A
	Indeno(1,2,3-c,d)pyrene	ng/g dw	ND	ND	N/A	N/A
	Methylnaphthalene, 1-	ng/g dw	7.2	10	33%	Yes
	Methylnaphthalene, 2-	ng/g dw	10	20	67%	Yes
	Methylphenanthrene, 1-	ng/g dw	ND	ND	N/A	N/A

Table 9. Sediment chemistry duplicate field results for site 204COR010, collected on July 17, 2018 in San Mateo County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte	Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
Naphthalene	ng/g dw	6.2	10	47%	Yes
Perylene	ng/g dw	ND	ND	N/A	N/A
Phenanthrene	ng/g dw	21	51	83%	Yes
Pyrene	ng/g dw	21	31	38%	Yes

[a] MQO for pyrethroids is <35%. In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

Laboratory Duplicates

Laboratory duplicates were collected and analyzed for grain sizes and total organic carbon. All RPDs were below the MQO limits except for small (4 to <8 mm) and medium (8 to <16 mm) pebbles in addition to coarse (0.5 to <1.0 mm) and very coarse (1.0 to <2.0 mm) sand. As a result, the associated samples were flagged.

3.9.5. Contamination

Nickel was detected in an instrument (lab) blank at a concentration above the reporting limit. As a result, nickel samples were flagged. None of the other target analytes were detected in any of the blanks.

3.10. Wet Season Pesticides

Wet season pesticide samples were collected by KLI concurrently with the wet season toxicity sample on January 8, 2018. Pesticide compounds were analyzed by Physis Environmental Laboratories, Inc. within the respective hold times for pesticides, including pyrethroids, fipronil, fipronil degradates, and imidacloprid. Physis conducted all QA/QC requirements as specified in the RMC QAPP and reported their findings to the RMC. Key water chemistry MQOs are listed in RMC QAPP Tables 26-9 through 26-11. Water chemistry data were flagged when necessary, but none were rejected.

3.10.1. Completeness

The MRP requires the RMC to collect ten water column pesticides samples over the permit term if sampling is conducted by the RMC on behalf of Permittees. Permittees have decided to collaborate and in WY 2018, three pesticides samples were collected in Santa Clara County at 205CAL018, 205STE021, and 205STQ010. A total of ten samples were collected by the RMC on behalf of Permittees in WY 2018.The laboratories analyzed and reported 100% of the planned/required analytes.

3.10.2. Sensitivity

The reporting limits for wet season pesticide analytes collected in WY 2018 were all below the target reporting limits specified in the RMC QAPP.

3.10.3. Accuracy

The percent recovery MQO for pyrethroids and other synthetic organic compounds in sediment is 50-150% in the RMC QAPP. None of the LCS percent recoveries exceeded the RMC MQO range. However, the MS/MSD percent recovery for fipronil exceeded the RMC MQO range.

3.10.4. Precision

The RPD listed in the laboratory report for water column pesticides is listed as 30%. However, the RMC QAPP lists the MQO as < 25% RPD for most synthetic organics and < 35% for pyrethroids and fipronil. None of the MS/MSD pairs or LCS duplicates exceeded the RPD MQOs.

<u>Field Duplicates</u>

A field duplicate was collected in Contra Costa on January 8, 2018 and evaluated for precision. The field duplicate sample and corresponding RPDs are shown in Table 10. Because of the variability in reporting limits, values less than the Reporting Limit (RL) were not evaluated for RPD. The measured concentrations of a majority of analytes from the original and duplicate samples were below the method detection limit and therefore reported as ND, meaning that the RPDs were non-calculable. All calculable RPDs were below the MQO limits.

Table 10. Water column pesticides duplicate field results for site 204R01412, collected on January 8, 2018 in San Mateo County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[v]
Pyrethroids (MQO <35%)	Bifenthrin	ug/L	0.017	0.019	8%	No
	Cyfluthrin, total	ug/L	ND	ND	N/A	N/A
	Cyhalothrin, Total Lambda-	ug/L	ND	ND	N/A	N/A
	Cypermethrin, total	ug/L	ND	ND	N/A	N/A
	Deltamethrin/Tralomethrin	ug/L	ND	ND	N/A	N/A
	Esfenvalerate	ug/L	ND	ND	N/A	N/A
	Fenvalerate	ug/L	ND	ND	N/A	N/A
	Permethrin, cis-	ug/L	ND	ND	N/A	N/A
	Permethrin, trans-	ug/L	ND	ND	N/A	N/A
	Imidacloprid	ug/L	0.050	0.059	16%	No
Fipronil	Fipronil	ug/L	0.024	0.022	8%	No
	Fipronil Desulfinyl	ug/L	0.009	0.009	1%	N/A[b]
	Fipronil Sulfide	ug/L	0.002	0.002	9%	N/A[b]
	Fipronil Sulfone	ug/L	0.016	0.015	9%	N/A[b]

[a] MQO for pyrethroids is <35%. In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable.
[b] No MQO is listed in the RMC QAPP for Fipronil Desulfinyl, Sulfide, or Sulfone.

<u>Laboratory Duplicates</u>

Laboratory duplicates were collected and analyzed for all wet weather pesticides analytes in addition to total organic carbon. All RPDs were below the MQO limits except for imidacloprid. As a result, the imidacloprid samples were flagged.

3.10.5. Contamination

No target analytes were detected in corresponding instrument (lab) blanks at a concentration above their reporting limits. As a result, no samples were flagged.

3.11. Toxicity Testing

Dry season water and sediment toxicity samples were collected by KLI concurrently with dry season sediment chemistry samples at two Santa Clara County sites on July 17, 2018. All toxicity tests were performed by Pacific EcoRisk. The water samples were analyzed for toxicity to five organisms (*Selenastrum capricornutum, Ceriodaphnia dubia, Pimephales promelas, Hyalella azteca, and Chronomus dilutus*) and the sediment samples were analyzed for toxicity to *Hyalella azteca* and *Chironomus dilutus.*

Wet season water toxicity samples were collected by KLI concurrently with wet season water column pesticides samples at three Santa Clara County sites on January 8, 2018. Follow-up water toxicity samples were collected by KLI at two of the original Santa Clara County sites on March 1, 2018. All wet season water toxicity tests were also performed by Pacific EcoRisk. The initial samples were analyzed for toxicity to five organisms (*Selenastrum capricornutum, Ceriodaphnia dubia, Pimephales promelas, Hyalella azteca, and Chironomus dilutus*). The follow-up samples were analyzed for toxicity to Hyalella Azteca, as the initial acute toxicity test for this organism was failed.

3.11.1. Completeness

The MRP requires the collection of dry season water and sediment toxicity samples at two sites per year in Santa Clara County. Additionally, the MRP requires ten wet season water toxicity samples to be collected by the RMC participants over the permit term. SCVURPPP staff collected a wet season water toxicity samples in WY 2018. Pacific EcoRisk tested the required organisms for toxicity, and 100% of results were reported.

3.11.2. Sensitivity and Accuracy

Internal laboratory procedures that align with the RMC QAPP, including water and sediment quality testing and reference toxicant testing, were performed and submitted to SCVURPPP. The laboratory data QC checks found that all conditions and responses were acceptable. A copy of the laboratory QC report is available upon request.

3.11.3. Precision

One field duplicate was collected in San Mateo County on behalf of the RMC and tested for toxicity by Pacific EcoRisk. The mean toxicity endpoints of test organisms (mean survival, mean cell count, mean biomass, and mean young per female) for the field duplicates were compared, and the RPD for each toxicity test was calculated. These RPDs are compared to the RMC QAPP MQO of <20% for acute and chronic freshwater toxicity testing (Appendix A, Table 26-12 and 26-13) in Table 8. There is no MQO for sediment toxicity field duplicates listed in the RMC QAPP, so the recommended MQO listed in the RMC QAPP for the water toxicity field duplicates (< 20%) was used as an MQO for the sediment toxicity field duplicates. Samples met the MQO for toxicity testing for all species and endpoints.

Table 11. Water and sediment toxicity duplicate results for site 204COR010, collected on July 17, 2018 in San Mateo County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Matrix	Organism	Endpoint	Original Sample Mean	Duplicate Sample Mean	RPD	Exceeds Recommended MQO (<20%)?
Water	Pimephales promelas	% Survival	95	97.5	3%	No
Water	Pimephales promelas	Biomass (mg/individual)	0.905	0.959	6%	No
Water	Ceriodaphnia dubia	% Survival	100	100	0%	No
Water	Ceriodaphnia dubia	Young per female	33	32	3%	Yes

Water	Selenastrum capricornutum	Total Cell Count (cells/mL)	8680000	8960000	3%	No
Water	Hyalella azteca	% Survival	98	100	2%	No
Water	Chironomus dilutus	% Survival	85	85	0%	No
Sediment	Hyalella azteca	% Survival	95	91.3	4%	No
Sediment	Chironomus dilutus	% Survival	88.8	81.2	9%	No

3.11.4. Contamination

There are no QA/QC procedures for contamination of toxicity samples, but staff followed applicable RMC SOPs to limit possible contamination of samples.

4. CONCLUSIONS

Sample collection and analysis followed MRP and RMC QAPP requirements and data that exceeded measurement quality objectives were flagged. Additionally, continuous pH data collected in May and June were rejected due to instrument failure. Overall, WY 2018 data met QA/QC objectives.

5. REFERENCES

Bay Area Stormwater Management Agency Association (BASMAA). 2012. Regional Monitoring Coalition Final Creek Status and Long-Term Trends Monitoring Plan. Prepared By EOA, Inc. Oakland, CA. 23 pp.

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Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Team. 2008. SWAMP Quality Assurance Program Plan, Version 1.0. Prepared for the California State Water Quality Control Board by Moss Landing Marine Laboratories and San Jose State University Research Foundation. 1 September. 108 pp.

Attachment 2

RMC 5-Year Report

BASMAA Regional Monitoring Coalition Five-Year Bioassessment Report

Water Years 2012 - 2016

Prepared for:

Bay Area Stormwater Management Agencies Association

Prepared by:

EOA inc.

Applied Marine Sciences

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Executive Summary

Biological assessment (bioassessment) is an evaluation of the biological condition of a water body based on the organisms living within it. In 2009, the Bay Area Stormwater Management Agencies Association's (BASMAA) Regional Monitoring Coalition (RMC) developed a bioassessment monitoring program to answer management questions identified in the Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit (referred to as the Municipal Regional Permit or MRP):

- *Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?*
- *Are conditions in local receiving waters supportive or likely to be supportive of beneficial uses?*

Bioassessment data collected over the first five years of RMC monitoring (2012-2016) are included in this report. The RMC's monitoring design addresses these management questions on a regional (Bay Area) scale to monitoring results across the five participating Bay Area counties (Alameda, Contra Costa, San Mateo, Santa Clara and Solano). Three study questions, developed to assist with addressing the management questions described above, including:

1) What is the biological condition of perennial and non-perennial streams in the region?
2) What stressors are associated with poor condition?
3) Are conditions changing over time?

The findings of this study are intended to help stormwater programs better understand the current condition of these water bodies and identify stressors that are likely to pose the greatest risk to the health of streams in the Bay Area. The report evaluates the existing RMC monitoring design and identifies a range of potential options for revising the design (if desired) to better address the questions posed. These options are intended to provide considerations for discussion during the planning for reissuance of the Municipal Regional Permit, which is likely to be adopted in 2020 or 2021.

Key Findings

- **Most streams in the region are in poor biological condition.** The biological conditions of streams in the RMC area are assessed using two ecological indicators: benthic macroinvertebrates (BMIs) and algae. Results from 2012 through 2016 study period indicate that streams in the RMC area are generally in poor biological condition. Based on BMIs, over half (58%) of stream length was ranked in the lowest condition category of the California Stream Condition Index (CSCI). For algae indices (D18 and S2), stream conditions appear slightly less degraded, with approximately 40% of the streams ranked in lowest condition category. These findings should be interpreted with the understanding that the survey focused on urban stream conditions, and that these data represent current (baseline) conditions.
- **Poor biological conditions are strongly associated with physical habitat and landscape stressors.** The associations between biological indicators (CSCI and D18) and stressor data were evaluated using random forest and relative risk analyses. The study results showed that different biological indicators responded to different types of stressors. CSCI scores were strongly influenced by

physical habitat variables (e.g., level of human disturbance at a site) and land use factors (e.g., level of impervious surfaces near the site), while D18 scores were moderately influenced by water quality variables (e.g., dissolved oxygen and conductivity). Together, BMI and algae indices can be used to assess the overall biological condition of water bodies and potentially identify the causes of poor (or good) conditions. In general, CSCI scores at urban sites were consistently low, indicating that degraded physical habitat conditions common in urban settings are impacting biological conditions in streams. In contrast, D18 scores at urban sites were more variable, indicating that healthy diatom (algae) assemblages can occur at sites with poor physical habitat, which may provide valuable information about the overall water quality conditions in urban streams.

- **No changes in biological conditions are evident over the 5-year survey.** The short time frame of the survey (five years) limited the ability to detect trends. The variability in biological condition observed over the five years of the current analysis may have been associated with annual variation in precipitation, which included drought conditions during the first four years of the survey. A longer time period may be needed to detect trends in biological condition at a regional scale.
- **Baseline biological assessment data can assist Bay Area stormwater managers in evaluating the long-term effectiveness of ongoing or planned management actions.** Baseline bioassessment monitoring data collected by the RMC provides valuable information about the current status of aquatic life uses in the Bay Area and how RMC streams compare to other regions in the State of California. The baseline dataset provides context for potential future biological integrity policies being developed by the State Water Resources Control Board (State Water Board) and serves as a foundation for evaluating on-going and future watershed management actions that attempt to reduce the impacts of urbanization on creeks and channels. Future creek status monitoring may provide additional insight into the potential positive impacts of actions, such as green stormwater infrastructure and creek restoration, that improve water quality and address other needs of aquatic life uses in urban creeks.
- **The RMC monitoring design provides estimates for overall stream conditions in RMC area and urban stream conditions for each county.** Because participating municipalities are primarily concerned with stormwater runoff from urban areas, the RMC focused sampling efforts on urban sites (approximately 80%) over non-urban sites (approximately 20%). As a result, non-urban sites are under-represented in the dataset, resulting in lower overall biological condition scores than would be expected for a spatially balanced dataset. Depending on the goals for the RMC moving forward, consideration should be given to developing a new sample draw that establishes a new list of assessment sites that are weighted for specific land uses categories and Program areas of interest. Based on evaluation of data collected during the first five years of the survey, several options to revise the RMC Monitoring Design are presented in the report.

1 Introduction

1.1 Background

The Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) is a consortium of six San Francisco Bay Area municipal stormwater programs that joined together in 2010 to coordinate and oversee water quality monitoring required by the Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit (referred to as the Municipal Regional Permit or "MRP"). The MRP was first adopted in 2009 (Order R2-2009-0074) by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). The MRP was reissued in 2015 through Order R2-2015-1049. The 2009 and 2015 versions of the MRP are referred to as MRP 1.0 and MRP 2.0, respectively. Both versions of the MRP require bioassessment monitoring in accordance with Standard Operating Procedures (SOPs) established by the California Surface Water Ambient Monitoring Program (SWAMP), including sampling of benthic macroinvertebrates (BMIs), benthic algae (i.e., diatoms and soft algae), and water chemistry, and the characterization of physical habitat.

The MRP identifies two broad management questions that required bioassessment monitoring (and other creek status monitoring requirements) is intended to address:

- *Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?*
- *Are conditions in local receiving waters supportive or likely to be supportive of beneficial uses?*

Consistent with the requirements of the MRP, the RMC developed a probabilistic monitoring design to address the management questions on a regional scale and compare monitoring results across stormwater programs. The probabilistic design is based on the Generalized Random Tessellation Stratified (GRTS) approach (Stevens and Olson 2004) for evaluating and selecting sampling stations in perennial and nonperennial streams. A power analysis estimated a minimum sample size of 30 sites to evaluate the condition of aquatic life within a confidence interval of approximately 12%. This was considered sufficient for decision-making in the RMC area. Under the MRP, each municipal Stormwater Program is required to assess a minimum number of stream/channel sites based on their relative population. As a result, the number of sites required each year varies by county: 20 sites for Santa Clara and Alameda counties and 10 sites for San Mateo and Contra Costa counties. Fairfield-Suisun and Vallejo are required to sample 8 and 4 sites, respectively, during each five-year period. In addition, the San Francisco Bay Regional Water Quality Control Board (SF Bay Water Board) collaborated with the RMC by monitoring additional sites in non-urban areas in each of the counties.

1.2 Project Goal

This goal of this project was to compile and evaluate bioassessment data collected over the first 5-years of bioassessment monitoring conducted by the RMC (2012 – 2016). The evaluation was designed to address three main questions, consistent with the overarching questions in the MRP:

1) What is the biological condition of perennial and non-perennial streams in the region?

2) What stressors are associated with poor condition?

3) Are conditions changing over time?

The findings of this report are intended to help stormwater programs better understand the current condition of these water bodies, prioritize stream reaches in need of protection or restoration, and identify stressors that are likely to pose the greatest risk to the health of streams in the Bay Area.

This report also provides an evaluation of the existing RMC monitoring design and identifies a range of potential options for revising the design (if desired) in anticipation of the next version of the MRP, which is likely to be adopted in 2020 or 2021. These options can inform the monitoring re-design process as part of a future BASMAA Regional Project.

This project was implemented by a Project Team comprised of EOA, Inc. and Applied Marine Sciences, Inc. (AMS) with technical review provided by the Southern California Coastal Water Research Project (SCCWRP). A BASMAA Project Management Team (PMT) consisting of representatives from BASMAA stormwater programs and municipalities provided oversight and guidance to the Project Team.

Sections of this report are organized according to the following topics:

- **Section 1.0** – Introduction including summary of other Regional Monitoring Programs using biological assessments, development of State policies that are relevant to bioassessment data collection, and description of the goals for this report;
- **Section 2.0** – Methods including monitoring survey design, site evaluation procedures, field sampling and data analyses;
- **Section 3.0** – Results summarizing biological conditions, stressor association with conditions, and trends;
- **Section 4.0** – Discussion organized by the management questions and goals; and
- **Section 5.0** – Conclusions and recommendations.

1.3 Bioassessments Programs in California

Bioassessment programs are currently implemented on a statewide and regional basis in California. The RMC's monitoring design is consistent with the design used by the statewide Perennial Streams Assessment (PSA) program and is specifically intended to allow for future integration of data between the two monitoring programs. The RMC has also integrated lessons learned from the Stormwater Monitoring Coalition (SMC), which spearheads a similar collaborative monitoring effort in Southern California, in the development of alternatives for potential re-design of the RMC monitoring survey described at the end of this report.

Since 2000, the State of California has conducted probability surveys of its perennial streams and rivers with a focus on biological endpoints. These surveys are managed collectively by the Surface Water Ambient Monitoring Program (SWAMP) under its PSA program. The PSA collects samples for biological indicators (BMIs and algae), chemical constituents (nutrients, major ions, etc.), and physical habitat assessments for both in-stream and riparian corridor conditions. As of 2012, over 1300 unique perennial stream sites have been monitored by PSA and its partner programs.[1] In 2015, the PSA developed a management memorandum summarizing biological conditions (based on California Stream Condition Index score) and associated stressor data collected at probabilistic sites over a 13-year time period (2000 – 2012) (SWRCB 2015).

The SMC, a coalition of multiple state, federal, and local agencies, initiated a regional monitoring program in 2009. The SMC uses multiple biological indicators to assess ecological health of streams, including BMIs, benthic algae (diatoms and soft algae) and riparian wetland condition. The SMC also collects water chemistry, water column toxicity, and physical habitat data to evaluate potential stressors to biological health. During the first five years of the program (2009 to 2013), the SMC monitored more than 500 probabilistic sites in 15 major watersheds in California's South Coast region, with a focus on perennial streams (Mazor 2015). Evolution of those data suggested that few perennial, wadeable streams in the SMC study area are in good biological condition (Mazor 2015a). Recognizing that perennial streams account for only 25% of stream-miles in the region, in 2015, the SMC expanded its monitoring program to include nonperennial streams, which account for approximately 59% of stream-miles (Mazor 2015b). The SMC program also focused about 30% of the monitoring effort towards revisiting probabilistic sites to provide an estimate of change in condition (Mazor 2015b). The next iteration of the SMC monitoring program will likely include a larger focus on trends monitoring (Rafael Mazor, SCCWRP, personal communication, 2018).

1.4 Biostimulatory/Biointegrity Policy Development

Bioassessment monitoring conducted by the RMC not only provides information about the condition of aquatic life uses in Bay Area streams and how they compare to other regions (i.e., SMC), it also generates a significant baseline dataset that provides context for potential future biological integrity and biostimulatory policies that are currently under development by the State Water Resources Control Board (State Water Board). The biostimulatory policy will likely develop water quality objectives for biostimulatory substances (e.g., nutrients) along with an implementation program as an amendment to the Water Quality Control Plan for Inland Surface Water, Enclosed Bays and Estuaries of California (ISWEBE Plan).[2] The biostimulatory substances policy may include a numeric and/or narrative objective(s) that will be applicable to streams in California. The State Water Board plans is expected to establish the implementation plan for the biostimulatory substances policy in three phases, with each phase including a plan that would be unique for each of the three different water body types. The first phase of the Biostimulatory Amendment would be applicable to wadeable streams.

The biostimulatory policy will also include a water quality control policy (i.e., Biointegrity Policy) to establish and implement biological condition assessment methods, scoring tools, and targets aimed at protecting the biological integrity in wadeable streams. The policy will utilize a multi-indicator approach that includes the California Stream Condition Index (CSCI) for benthic macroinvertebrates and statewide

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[1] The Stormwater Monitoring Coalition has collected a majority of samples at probabilistic sites in Coastal Southern California watersheds and the US Forest Service has collected PSA-comparable data from sites in National Forests of the Sierra Nevada.

[2] Information obtained from: https://www.waterboards.ca.gov/water_issues/programs/biostimulatory_substances_biointegrity

algal stream condition index (ACSI), which is currently under development. The State Water Board's plan is to establish "assessment endpoints" as primary lines of evidence to assess beneficial use support in wadeable streams. These endpoints may be used to establish default nutrient objectives or thresholds for California streams, with potential option to refine the thresholds under a "watershed approach."

The State Water Board's biostimulatory/biointegrity project has been delayed due to several unresolved policy issues that need to be addressed prior to development of the policy, including[3]:

1) Consideration of channels in highly developed landscapes (i.e., where assessment endpoints may not be achieved);
2) Identify Beneficial Uses;
3) Relationship between established biological assessment endpoints and nutrient endpoints; and
4) Define process for coordinated watershed approach.

The State Water Board is currently planning to develop draft policy options to present to Stakeholder Advisory and Regulatory Groups in 2019.

[3] Information obtained from presentation by Jessie Maxfield, California State Water Board, given at the 2017 California Aquatic Bioassessment Workgroup conference in Davis, California.

2 METHODS

2.1 STUDY AREA

The study area for RMC creek status monitoring consists of the perennial and non-perennial streams, channels and rivers within the portions of the five participating counties (San Mateo, Santa Clara, Alameda, Contra Costa, Solano) that overlap with the San Francisco Bay Regional Water Quality Control Board (Region 2) boundary, and the eastern portion of Contra Costa County that drains to the Central Valley region (Region 5). The RMC creek status sample frame consists of the urban and non-urban portions of the stream network flowing through the RMC area. The source dataset used to create the sample frame was the 1:100,000 National Hydrography Dataset (NHD).

2.2 SURVEY DESIGN AND SAMPLING SITES

Creek status monitoring sites were selected based on a probabilistic survey design consisting of a master draw of 5,740 sites (approximately one site for every stream kilometer in the sample frame). The selection procedure employed the U.S. EPA's Generalized Random Tessellation Stratified (GRTS) survey design methodology (Stevens and Olson, 2004). The GRTS approach generated a spatially-balanced distribution of sites covering the majority of the San Francisco Bay Area. It should be noted that the sample draw of 5,740 sites did not account for land use designations or other emphases (i.e., County) and therefore, the master draw of sample sites was weighted towards commonly occurring conditions (i.e., non-urban sites), with less common conditions (i.e., reference and urban sites) being less represented due to their lower relative abundance in the sample frame.

The RMC sampling design targeted the population of accessible streams with flow conditions suitable for sampling (i.e., adequate flow during spring index period). A random set of potential monitoring sites (i.e., the master draw) was established, with each site having an equal, non-zero weight, proportional to the inverse of its selection probability. Thus, all sites were assumed to have an equal probability of selection throughout the sample frame. The weights represent the amount of stream length encompassed by each site in the overall target population.

Once the master draw was established, the list of monitoring sites was separated into 19 categories to facilitate site evaluations and implement creek status monitoring, including bioassessment (Table 1). The following attributes were used to generate the categories:

- County (n=5): San Mateo, Santa Clara, Alameda, Contra Costa, Solano (source: California Department of Forestry and Fire, 2009);
- Water Quality Control Board Region (n=2): Region 2, Region 5 (source: San Francisco Regional Water Quality Control Board, undated);
- Land use Category (n = 4): Urban or nonurban in all counties, except Solano ('urban_V' and 'urban_FS' in Solano County). Urban land use was defined as a combination of US Census (2000) areas classified as urban, and areas within Census City boundaries. This definition of urban land use results in some relatively undeveloped areas and parks along the fringes of cities to be

classified as urban. Urban sites therefore represent a broad range of developed (i.e., impervious surface) conditions. Non-urban area was defined as all remaining area in the RMC boundary not classified as urban.

Table 1. Number of sites and stream length from the master draw in each post-stratification category.

County	Urban		Non-Urban		Total	
	Sites	Stream Length (km)	Sites	Stream Length (km)	Sites	Stream Length (km)
San Mateo	222	233.8	528	556.0	750	789.8
Santa Clara	542	570.8	1376	1449.1	1918	2019.8
Alameda	454	478.1	842	886.7	1296	1364.8
Contra Costa (Region 2)	587	618.2	363	382.3	845	889.9
Contra Costa (Region 5)			349	367.5	454	478.1
Solano (Vallejo)	12	12.6	386	406.5	477	502.3
Solano (Fairfield-Suisun)	79	83.2				
				Overall Total	**5740**	**6,044.7**

To maintain a spatially-balanced pool of monitoring sites, sites were evaluated in the order that they appeared in the master draw list (with a few exceptions). Sites were evaluated for sampling using both desktop and field reconnaissance. Field crews attempted to locate a reach suitable for sampling within 300 m of the target coordinates. Sites without a suitable reach were rejected for sampling. Reasons for rejection included physical barriers, lack of flowing water, refusal or lack of response from landowners, unwadeable (i.e., >1 m deep for at least 50% of the reach) and inappropriate waterbody types (e.g., tidally influenced). Sites with temporary inaccessibility, unsafe/hazardous or permission issues (e.g., construction, lack of response from landowners) were re-evaluated for sampling in subsequent years. All program participants were instructed to use a standard set of codes to identify the reason behind exclusion of sites.

In contrast to the PSA and SMC regional monitoring designs, which targeted perennial streams, the RMC sampled both perennial and non-perennial streams. Additionally, at the outset, each countywide Program agreed they would attempt to assess up to 20% of their required sites in non-urban areas.

2.3 Sampling Protocols/Data Collection

Biological sample collection and processing was consistent with the BASMAA RMC Quality Assurance Project Plan (QAPP)[4] (BASMAA 2016a) and Standard Operating Protocols (SOPs) (BASMAA 2016b) which

[4] The RMC QAPP and SOP documents were initially developed in 2012 (Version 1.0), revised in 2013 (Version 2.0) and 2016 (Version 3.0)

were developed to be consistent with the current SWAMP Quality Assurance Program Plan (QAPrP) and SOPs. Bioassessments were conducted during the spring index period (approximately April 15 – June 30) with the goal to sample a minimum of 30 days after any significant storm (defined as at least 0.5-inch of rainfall within a 24-hour period). A 30-day grace period allows diatom and soft algae communities to recover from peak flows that may scour benthic algae from the bottom of the stream channel.

2.3.1 Biological Indicators

Each monitoring site consisted of an approximately 150-meter stream reach that was divided into 11 equidistant transects placed perpendicular to the direction of flow. Benthic macroinvertebrate (BMI) and algae (i.e., diatom and soft algae) samples were collected at each transect using the Reach-wide Benthos (RWB) method described in Ode et al. (2016). The algae composite sample was also used to collect chlorophyll a and ash free dry mass (AFDM) samples following methods described in Ode et al. (2016).

Biological samples were sent to laboratories for analysis. The laboratory analytical methods used for BMIs followed Woodward et al. (2012), using the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Level 1a Standard Taxonomic Level of Effort, with the additional effort of identifying chironomids (midges) to subfamily/tribe instead of family (Chironomidae). Soft algae and diatom samples were analyzed following SWAMP protocols (Stancheva et al. 2015). The taxonomic resolution for all data was standardized to the SWAMP master taxonomic list.

2.3.2 Physical Habitat

Both quantitative and qualitative measurements of physical habitat structure were taken at each of the 11 transects and 10 inter-transects at each monitoring site. At the outset of the monitoring program in 2012, Physical habitat measurements followed procedures defined in the "BASIC" level of effort (Ode 2007), with the following exceptions as defined in the "FULL level of effort: stream depth and pebble count + coarse particulate organic matter (CPOM), cobble embeddedness, and discharge measurements. In 2016, the entire "FULL" level of effort for the characterization of physical habitat described in Ode et al. (2016) was adopted, consistent with the reissued MRP 2.0 (SFBRWQCB 2015). Physical habitat measurements include channel morphology (e.g., channel width and depth), habitat features (e.g., substrate size, algal cover, flow types, and in-stream habitat diversity) and human disturbance in the riparian zone (e.g., presence of buildings, roads, vegetation management). In addition, a qualitative Physical Habitat Assessment (PHAB) score was assessed for the entire bioassessment reach. The PHAB score is composed of three characteristics for the reach, including channel alteration, epifaunal substrate, and sediment deposition. Each attribute is individually scored on a scale of 0 to 20, with a score of 20 representing good condition.

2.3.3 Water Quality

Immediately prior to biological and physical habitat data collection, general water quality parameters (dissolved oxygen, pH, specific conductance and temperature) were measured at each site, at or near the centroid of the stream flow using pre-calibrated multi-parameter probes. In addition, water samples were collected for nutrients and conventional analytes analysis using the Standard Grab Sample Collection Method as described in SOP FS-2 (BASMAA 2016b).

2.3.4 Stressor Variables

Physical habitat, land-use, and water quality data were compiled and evaluated as potential stressor variables for biological condition. Land-use variables were calculated in GIS by overlaying the drainage area for sample locations with land use and road data. The variables included percent urbanization, percent impervious, total number of road crossings and road density at three different spatial scales (1 km, 5 km, and entire watershed).

Physical habitat metrics were calculated using the SWAMP Bioassessment Reporting Module (SWAMP RM). The SWAMP RM output includes calculations based on parameters that are measured using EPA's Environmental Monitoring and Assessment Program (EMAP) for freshwater wadeable streams (Kaufmann et al. 1999), as well as parameters collected under the SWAMP protocol (Marco Sigala, personal communication, 2017). The RM produces a total of 176 different metrics based on data collected using the SWAMP "FULL" habitat protocol. Ten of the best performing metrics (Andy Rehn, CDFW, personal communication) were selected based on best professional judgment from the SWAMP RM output to analyze physical habitat data collected by the RMC.

General water quality (e.g., DO, SpCond) and chemistry (e.g., nitrate and phosphorus) data collected at the bioassessment sites were also included. Some of the water chemistry variables were calculated from the analytes that were measured. These include Total Nitrogen (sum of Nitrate, Nitrite and Total Kjeldahl Nitrogen) and Unionized Ammonia (calculated using pH and temperature).

2.3.5 Rainfall Data

For evaluation of trends, a representative rainfall dataset was collated for San Mateo, Santa Clara, Contra Costa, and Alameda counties. The total accumulated rainfall in each water year during the period of 2012-2016 was calculated. The rainfall dataset assembled was derived from: San Jose Airport (Santa Clara), San Francisco Airport (San Mateo), Oakland Airport (Alameda), and Walnut Creek (Contra Costa).

2.4 Data Analyses

All statistical, tabular, and graphical analyses were conducted in R Studio, running R version 3.4.3 (R Core Team 2016). For analyses involving water quality data, censored results (i.e., below the method detection limit) were substituted with 50% of the method detection limit (MDL). Generally, analytical sensitivity was good, with only three variables having > 30% non-detects (Suspended Sediment Concentration, Nitrite, Ammonia). To facilitate use of the data for random forest and relative risk analyses, missing values were subject to an imputation method to fill in data gaps. Seven variables were found to have missing values. Three of these, Suspended Sediment Concentration (SSC), Dissolved Organic Carbon (DOC), and Alkalinity[5], consisted of more than 50 missing values, and were excluded from further analysis. The remaining four variables (Silica, Ash Free Dry Mass, Chlorophyll a, Nitrate) were subject to imputation using the R-package *mice* (van Buuren and Groothuis-Oudshoorn, 2011). In this method, replacement values were randomly selected from the distribution of observed data. Overall, fewer than 25 values were

[5] Suspended Sediment Concentration (SSC), Dissolved Organic Carbon (DOC) and alkalinity were not monitored in 2016, due to the removal of these parameters in Provision C.8.c of the reissued MRP.

imputed for any variable (Silica, n = 24; AFDM, n = 4; Nitrate, n = 1; Chl a, n = 1), and thus their influence on the analysis is assumed to be minor.

2.4.1 Biological Condition Indices

The California Stream Condition Index (CSCI) was developed by the State Water Board as a standardized measure of benthic macroinvertebrate assemblage condition in perennial wadeable rivers and streams. The CSCI was developed using a large reference data set representing the range of natural conditions in California (Ode et al. 2016). The CSCI tool (Mazor et al. 2016) translates BMI data into an overall measure of stream health by combining two types of indices: 1) ratio of observed-to-expected taxa (O/E) (used as a measure of taxonomic completeness), and 2) a predictive multi-metric index (pMMI) for reference conditions (used as a measure of ecological structure and function). The CSCI score is computed as the average of the sum of O/E and pMMI.

The CSCI scoring tool was used to assess BMI data collected at both perennial and non-perennial sites in the RMC area. The CSCI scores for RMC sites should be interpreted with caution, as the CSCI tool has not been fully validated at non-perennial sites. Preliminary analyses suggest that the CSCI is valid in certain types of nonperennial streams in southern California, but its validity in nonperennial streams in other regions, such as the Bay Area, remains unknown.

The algae data were analyzed using algal indices of biological integrity (IBIs) that were developed for streams in Southern California (Fetscher 2014). These include a soft algae index (S2), diatom index (D18) and soft algae-diatom hybrid index (H20). The algal indices were calculated using the SWAMP Algae Reporting Module (Algae RM). The interpretation of algae data collected in San Francisco Bay area using IBIs developed in Southern California (SoCal) should be considered preliminary. The State Board and SCCWRP are currently developing and testing a statewide index using benthic algae data as a measure of biological condition for streams in California. The statewide Algae Stream Condition Indices (ASCIs) were not available at the time this project was conducted, but are expected to be available in late 2018 (personal communication, Jessie Maxfield, SWRCB).

2.4.2 Biological Indicator Thresholds

Existing thresholds for biological indicator scores (CSCI, D18, S2) defined in Mazor (2015) were used to evaluate bioassessment data compiled and analyzed in this report (Table 2, Figure 1). The thresholds for each index were based on the distribution of scores for data collected at reference calibration sites in California (BMI) or in Southern California (algae). Four condition categories are defined by these thresholds: "likely intact" (greater than 30th percentile of calibration reference site scores); "possibly altered" (between the 10th and the 30th percentiles); "likely altered" (between the 1st and 10th percentiles; and "very likely altered" (less than the 1st percentile). The probability-based approach to develop the threshold classes was consistent across indices, allowing comparison for all indicators across sites.

The performance of CSCI on a statewide basis is the subject of ongoing review by the State Water Board. In the current MRP, the SF Bay Water Board defined a CSCI score of 0.795 as a threshold for identifying sites with degraded biological condition that should be considered candidates for Stressor Source Identification (SSID) projects. No MRP threshold has been established for any of the algae indices.

Table 2. Biological condition indices, categories and thresholds.

Index	Likely Intact	Possibly Altered	Likely Altered	Very Likely Altered
Benthic Macroinvertebrates (BMI)				
CSCI Score	≥ 0.92	≥ 0.79 to < 0.92	≥ 0.63 to < 0.79	< 0.63
Benthic Algae				
S2 Score	≥ 60	≥ 47 to < 60	≥ 29 to < 47	< 29
D18 Score	≥ 72	≥ 62 to < 72	≥ 49 to < 62	< 49

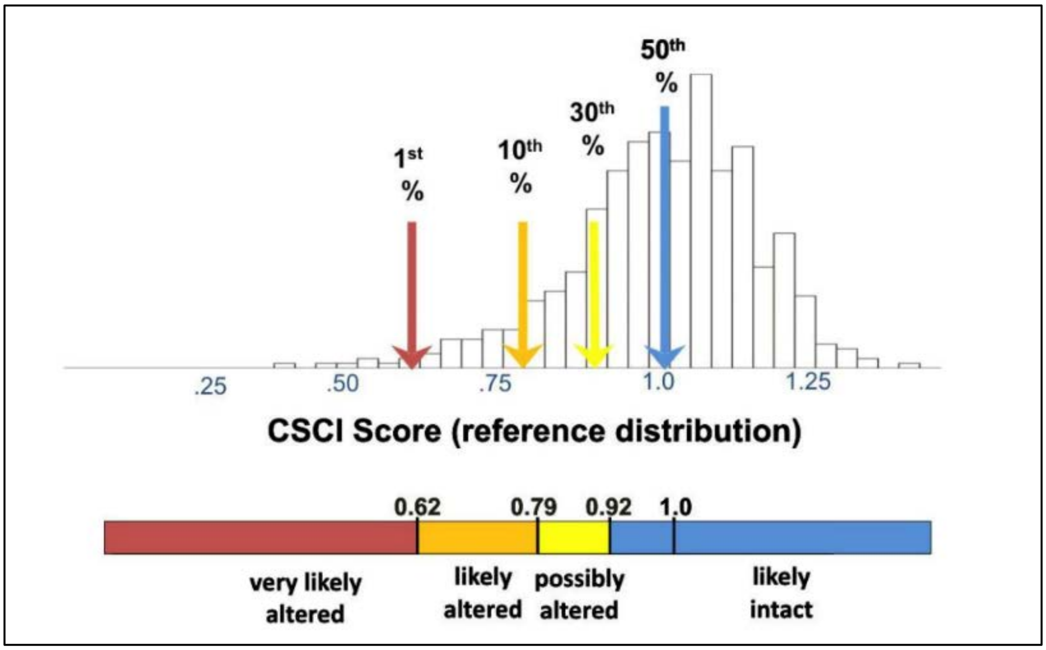

Figure 1. Distribution of CSCI scores at reference sites with thresholds and condition categories used to evaluate CSCI scores (from Rehn et al. 2015). Note: colors in this figure differ from other figures in this report.

2.4.3 Estimating Extent of Healthy Streams in SF Bay Area

To estimate overall extent of biological conditions in streams within the RMC area, cumulative distribution functions (CDFs) of biological condition scores were generated. Because the survey focused significantly more effort in urban areas compared to non-urban areas, sample weights were re-calculated as the total stream length in the sample frame, and divided by the stream length evaluated in each land use category. Therefore, sites contribute a proportional amount of stream length to the extent estimates, based on the number of sites assessed in each land use category. Sites without evaluations (6%), primarily non-urban sites, were excluded from the analysis. The adjusted sample weights were used to estimate the proportion of stream length represented by CSCI, D18, and S2 scores both regionwide and for urban sites only. Estimates for non-urban streams were not calculated separately due to the lower number of monitoring events at non-urban sites and greater width of confidence intervals. Condition estimates and 95% confidence intervals were calculated for all sampled sites in the RMC sample frame and for urban sites only. Post-stratification of the urban sites by County was also performed. However, Solano County was excluded from this assessment, due to the relatively low sample size compared to the other areas. All calculations were conducted using the R-package *spsurvey* (Kincaid and Olsen 2016). See Section 4.4 for further discussion of the RMC sample design.

2.4.4 Evaluating the Importance of Stressors

2.4.4.1 Random Forest Analyses

Stressor association with biological condition scores was evaluated using random forest statistical analyses. Random forest analysis is a non-parametric classification and regression tree (CART) method commonly applied to large datasets of multiple explanatory variables. Recent papers describe their use for stressor identification in stream bioassessment studies (e.g., Maloney et al. 2009, Waite et al. 2012, Mazor et al. 2016). Random forest models use bootstrap averaging to determine splits of numerous trees (Elith et al. 2008) for reducing error and optimizing model predictions. Model outputs provide an ordered list of importance of the explanatory variables that can be applied to a new or validation dataset for prediction.

Random forest models were developed using the R-package *randomForest* to determine a list of explanatory variables related to biological condition scores (CSCI or D18 score). The stressor data consisted of 49 variables, related to (1) water quality; (2) habitat; and (3) land use factors that could potentially influence condition scores (Appendix 1, Table A). Subsequently, the data were partitioned into training (80%) and validation (20%) sets for model testing. A random selection of samples was generated by sub-sampling from within each RMC County to maintain a regional balance of samples within the partitioned datasets. The training dataset had 278 sites, while the validation data encompassed 76 sites across all counties.

First, several iterations of the model procedure were performed with the training data set to optimize the random forests, including tuning the model to the maximum number of predictors per branch, the number of trees to build, and validation of the predictions. Appendix 1 presents the results of initial steps to optimize the random forest model outputs. The final set of models evaluated a maximum of 6 predictor interactions, and 1000 trees. Two variable importance statistics were used to estimate the relative influence of predictor variables: (1) % Increase in MSE = percent increase in mean-square-error of predictions as a result of variable values being permuted; (2) Increase in Node Purity = difference between the residual sum-of-squares before and after a split in the tree. More important variables achieve larger changes in MSE and node purity. K-fold cross validation of the selected models was performed to assess prediction error, by evaluating residual error and R-squared differences.

Random forest models were developed in two steps: (1) random forest models were run with all variables included (N = 49), retaining the top 10 variables in the variable relative importance list ranked by % increase in MSE, and (2) random forest models were re-run with just the top 10 variables from step 1. Subsequently, the variable list was further trimmed by evaluating the corresponding variable importance scores, partial dependency plots, and the change in R^2 once the variable was excluded. Partial dependency plots show the predicted biological response based on an individual explanatory variable with all other variables removed. No variable with less than 10% influence on CSCI or D18 predictions was retained in the final models. Finally, random forest models were used to predict biological condition scores for the validation data set. Appendix 1, Figure B presents the observed and predicted values for the validation models with CSCI and D18 in Steps 1 and 2 of the model development.

2.4.4.2 Stressor Thresholds and Relative Risk Assessment

Relative risk analyses were also conducted to evaluate associations between stressors with biological condition scores. From the list of potential stressors discussed in Section 2.3.4, eight variables were selected to conduct a relative risk analyses (Table 3). Six of the stressor thresholds were derived from statewide data collected for the Perennial Streams Assessment (SWAMP 2015). The thresholds were based on the 90^{th} percentile of data collected at bioassessment sites that exhibited good biological condition (i.e., CSCI scores > 0.92, likely intact). The 90^{th} percentile of stressor values at these sites was used to define the most-disturbed thresholds for variables where higher values indicate more disturbance (SWRCB 2015). Similarly, the chlorophyll a threshold (100 mg/m2) used for this report (Table 3) was based on 90^{th} percentile of data that was collected at all RMC sites that had CSCI scores > 0.92 (Figure 2). The threshold for Dissolved Oxygen (7.0 mg/l) was based on Water Quality Objectives (WQOs) for COLD Freshwater Habitat Beneficial Use in the Water Quality Control Plan for the San Francisco Basin (SFBRWQCB 2017).

Table 3. Biological condition and stressor variable thresholds used for relative risk assessment.

Variables	Thresholds		Units	Reference	Criteria
Biological Condition	*Poor*	*Good*			
CSCI Score	< 0.625	≥ 0.925		Mazor et al. 2016	
Stressor Condition	*High*	*Low*			
Dissolved Oxygen (DO)	<7.0	≥ 7.0	mg/L	SF Bay Water Quality Control Plan	WQO
Specific Conductivity (SpCon)	> 1460	≤ 1460	us/cm	SWAMP 2015	90^{th} Percentile of sites with CSCI score > 0.925
Chloride	> 122	≤ 122	mg/L		
Total Nitrogen (TotN)	> 2.3	≤ 2.3	mg/L		
Total Phosphorus (TotP)	> 0.122	≤ 0.122	mg/L		
Chlorophyll a (Chla)	> 100	≤ 100	mg/m^2	RMC data	
Sand and Fines (SaFn)	> 69	≤ 69	%	SWAMP 2015	
Human Disturbance Index (HDI)	> 1.3	≤ 1.3			

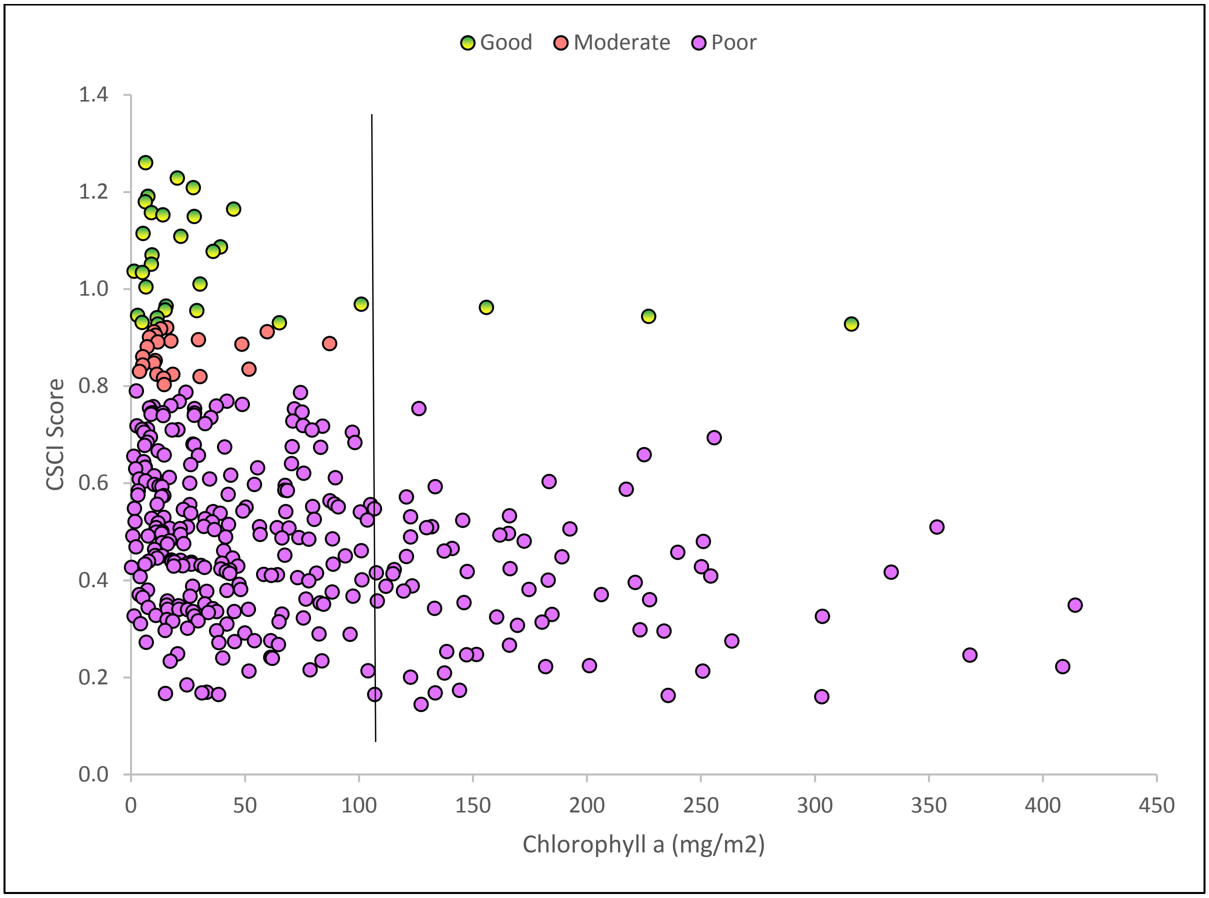

Figure 2. Plot of CSCI score and *chlorophyll a* concentration at RMC sites. Threshold for *chlorophyll a* used for relative risk assessment is shown. Sites classified as "good" include the two highest CSCI condition categories.

The relative risk approach was used to evaluate the association between stressors and biological condition (Van Sickle et al., 2008). The relative risk is a conditional probability representing the likelihood that poor biological condition is associated with high stressor levels and is calculated as follows:

$$\text{Relative Risk} = \frac{\Pr(CSCI_p)/S_h}{\Pr(CSCI_p)/S_l}$$

The numerator is the probability of finding poor biological condition ($CSCI_p$) given high stressor scores (S_h) and denominator is the probability of finding poor biological condition given low stressor scores (S_l). Poor biological conditions were defined as CSCI scores < 0.625. High and low stressor levels are defined in Table 3. In cases where RR is equal to 1, there is no association between stressor and biological indicator score. Where RR > 1, the higher the value, the more likely poor biological condition would occur given high stressor levels.

3 Results

3.1 Site Evaluation Results

A total of 354 monitoring sites were sampled in the RMC region between 2012 and 2016. These are identified as "target" sites in Figure 3 and Table 4. Samples were collected at 284 urban sites (80%) and 70 non-urban sites (20%) (Table 4). The greatest number of non-urban sampling locations were in Santa Clara (n=25) and San Mateo Counties (n=19). Samples were collected at 8 or 9 non-urban sites for each of the other counties.

The population of 354 monitored sites was obtained through the evaluation of 1,455 unique sites, which equate to a rejection rate of 76% for entire RMC area over the 5-year period. Solano County had the highest rejection rate (90%) and San Mateo County had the lowest (65%). The most common reason for site rejection (55% of all evaluated sites) was that a site did not present the physical requirements to support monitoring within a 300-meter radius of target coordinates. These "non-target sites" were rejected for several reasons, including lack of flowing water, site was not a stream (e.g., aqueduct or pipeline), tidally influenced, or non-wadeable. The lack of flow was the most common reason for rejection. The extended drought period between 2012 and 2014 may have resulted in an unusually high number of sites with no or low flow conditions during the target index period.

Another reason for site rejection was the inability to obtain access to conduct the sampling (e.g., physical access or obtain private land/permission). These "target non-sampleable" sites comprised 21% of sites that were rejected. These sites were often located on private land in non-urban areas where permissions were not granted and/or where steep, highly-vegetated conditions prevented access. Obtaining access to sites in urban areas was variable by county. For example, most of the streams in the urban area of San Mateo County are privately owned, while most of the urban sites in Santa Clara County are owned by municipal jurisdictions and water district agencies, making permissions more easily obtained.

Table 4. Number of sites per county in each site evaluation class.

County	Target Not-Sampleable		Non-Target		Target		Total by County
	Non-Urban	Urban	Non- Urban	Urban	Non- Urban	Urban	
Alameda	12	74	162	91	9	96	444
Contra Costa	12	34	32	89	9	48	224
San Mateo	21	42	9	37	19	41	169
Santa Clara	37	24	74	161	25	87	408
Solano	44	3	109	34	8	12	210
Total RMC	126	177	386	412	70	284	1,455
% of Total RMC	9%	12%	27%	28%	5%	20%	-

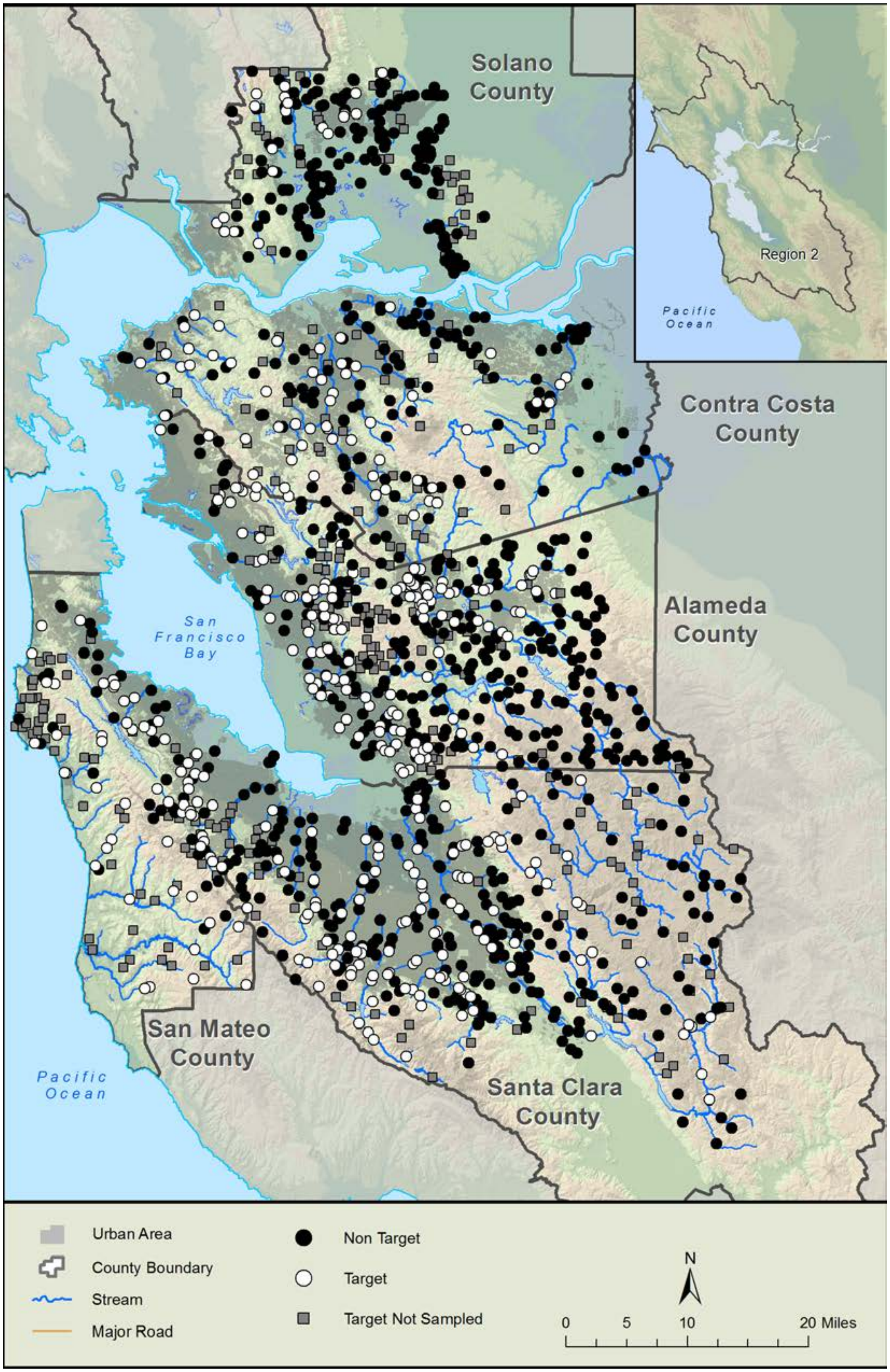

Figure 3. RMC sites evaluated by evaluation class.

Figure 4 presents rainfall for the 2000-2017 time period at the San Francisco Airport. Rainfall was generally below average during the 2012-2016 period, especially in 2014, and therefore, the RMC monitoring occurred in a drier-than-normal period. Because biological condition index scores can vary natural due to multi-year climatic patterns, it is important to note that the 5-year period of monitoring may not be representative of the long-term condition.

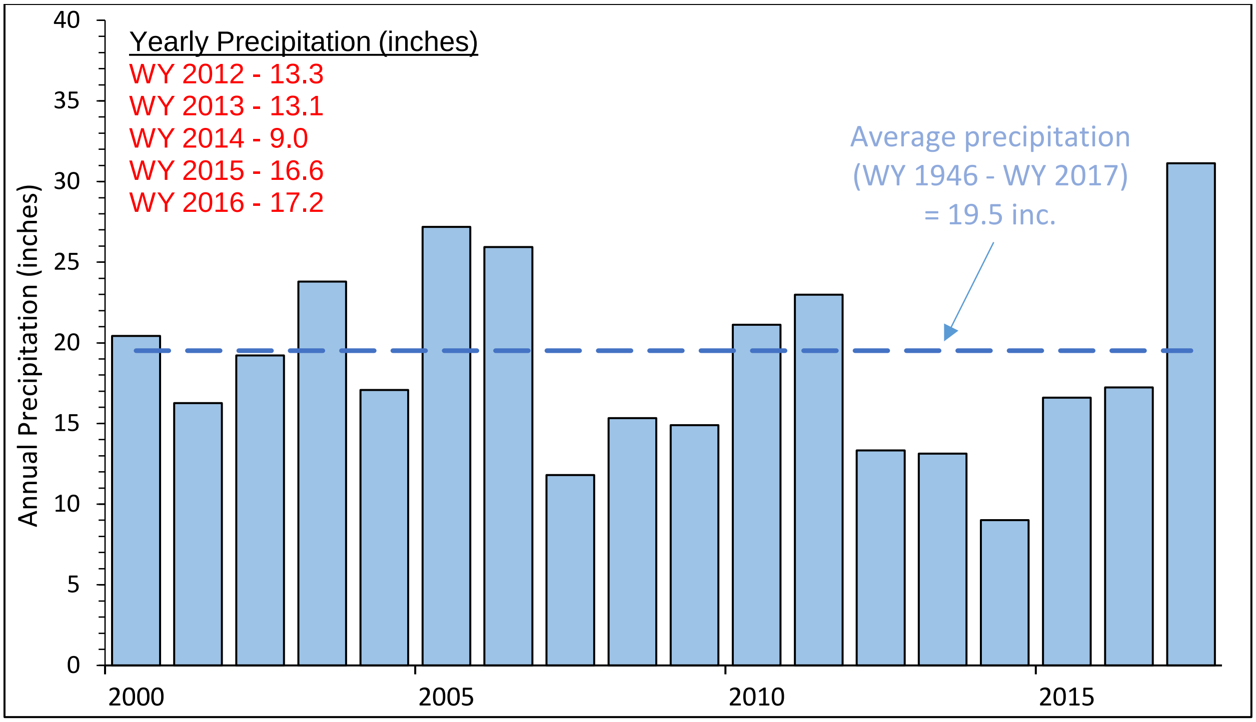

Figure 4. Annual precipitation at San Francisco Airport (2000-2017)

3.2 Biological Condition of Bay Area Streams

3.2.1 Regional Assessment

The distribution of BMI and algae index scores observed during 2012-2016 suggests that the majority of streams in the RMC sample area do not exhibit healthy biological conditions. Figures 5, 6 and 7 show cumulative distribution functions of the biological index scores for the entire regional dataset (i.e., urban and non-urban sites) and the urban dataset. Across all sites, over half (58%) of the stream-length was in the lowest condition class for CSCI (Very Likely Altered) and 15% of the stream-length was in the highest condition class (Likely Intact) (Figure 5).

Both of the algae index scores (D18 and S2) exhibited higher condition scores than CSCI regionally. For D18 (diatoms), 41% of the stream-length in the Bay Area was in the Very Likely Altered condition class and 19% of the stream-length was in the Likely Intact condition class (Figure 6). Similar distribution of scores was evident with S2 (soft-algae), where less than half (44%) of the stream-length was in the Very Likely Altered condition class and 21% of the stream-length was in the Likely Intact condition class (Figure 7). The higher proportion of sites in the Likely Intact condition for algae indices compared to CSCI suggest that the algae communities in streams may be less degraded than BMI assemblages.

Bay Area wide, urban sites were responsible for the majority of poor CSCI scores. Seventy-nine percent (79%) of the stream length in urban areas was in the Very Likely Altered condition category for CSCI, while only 3.5% was in the Likely Intact class (Figure 5). Additionally, over 80% of the sampled stream length in urban areas was below the MRP trigger for CSCI scores (0.795), where potential follow-up source/stressor identification studies should be considered.

The influence of urban sites on the stream condition of all sites was also apparent for algae scores, although to a lesser degree than for CSCI. For D18, just over half (53%) of the stream length in urban areas was in the Very Likely Altered condition class, compared to 9% in the Likely Intact class (Figure 6). For S2 scores, 65% of stream length in urban areas was in the Very Likely Altered class, and only 7% in the Likely Intact class (Figure 7). These patterns suggest that stressors in the urban landscape may still exert influence on algae condition. Section 4.0 provides additional discussion about the results presented here.

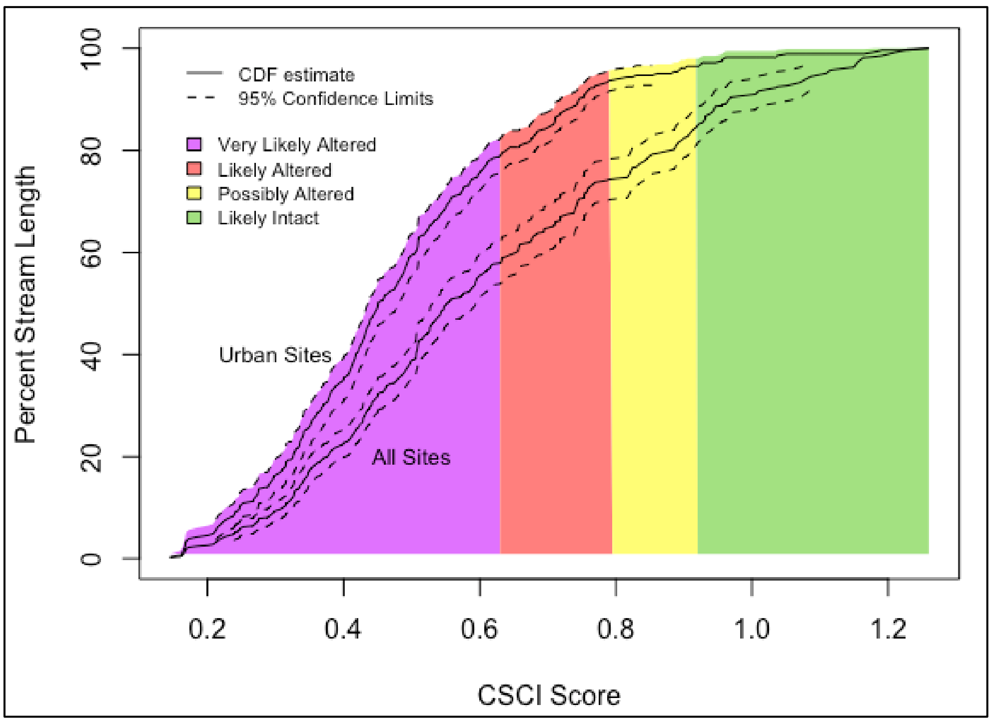

Figure 5. Cumulative distribution function (CDF) of CSCI scores at all RMC sites and urban sites.

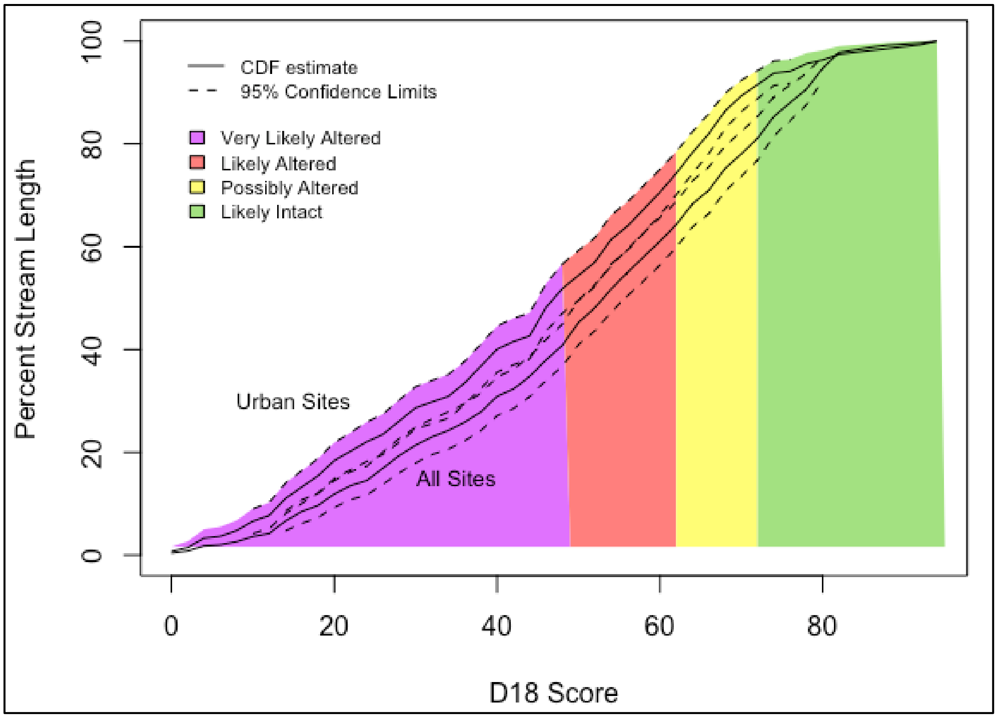

Figure 6. Cumulative distribution function (CDF) of D18 scores at all RMC sites and urban sites.

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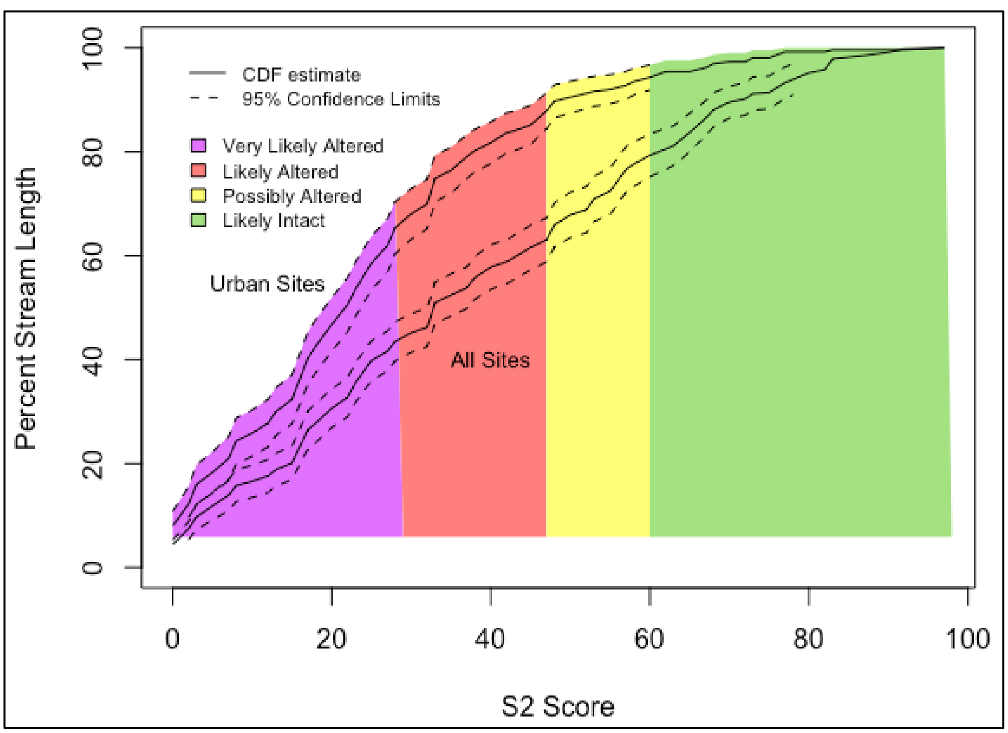

Figure 7. Cumulative distribution function (CDF) of S2 scores at all RMC sites and urban sites.

3.2.2 County Assessment

In addition to Bay Area wide biological condition estimates of streams, post-stratification of the CSCI condition estimates for urban sites in each County (excluding Solano County due to low sample size) suggests that poor condition scores are widespread in each Bay Area county. The proportion of urban stream length in the Very Likely Altered condition class was highest for Contra Costa (96%), followed by Alameda County (83%), San Mateo County (73%), and Santa Clara County (64%) (Figure 8). Less than 10% of the urban stream length in each of the counties was in the Likely Intact condition class. The highest proportion of Likely Intact BMI communities occurred in San Mateo and Santa Clara counties (7% each), followed by Alameda (1%) and Contra Costa (0%) counties. In comparison to the MRP threshold of 0.795, the vast majority of urban streams in each county fall below this threshold.

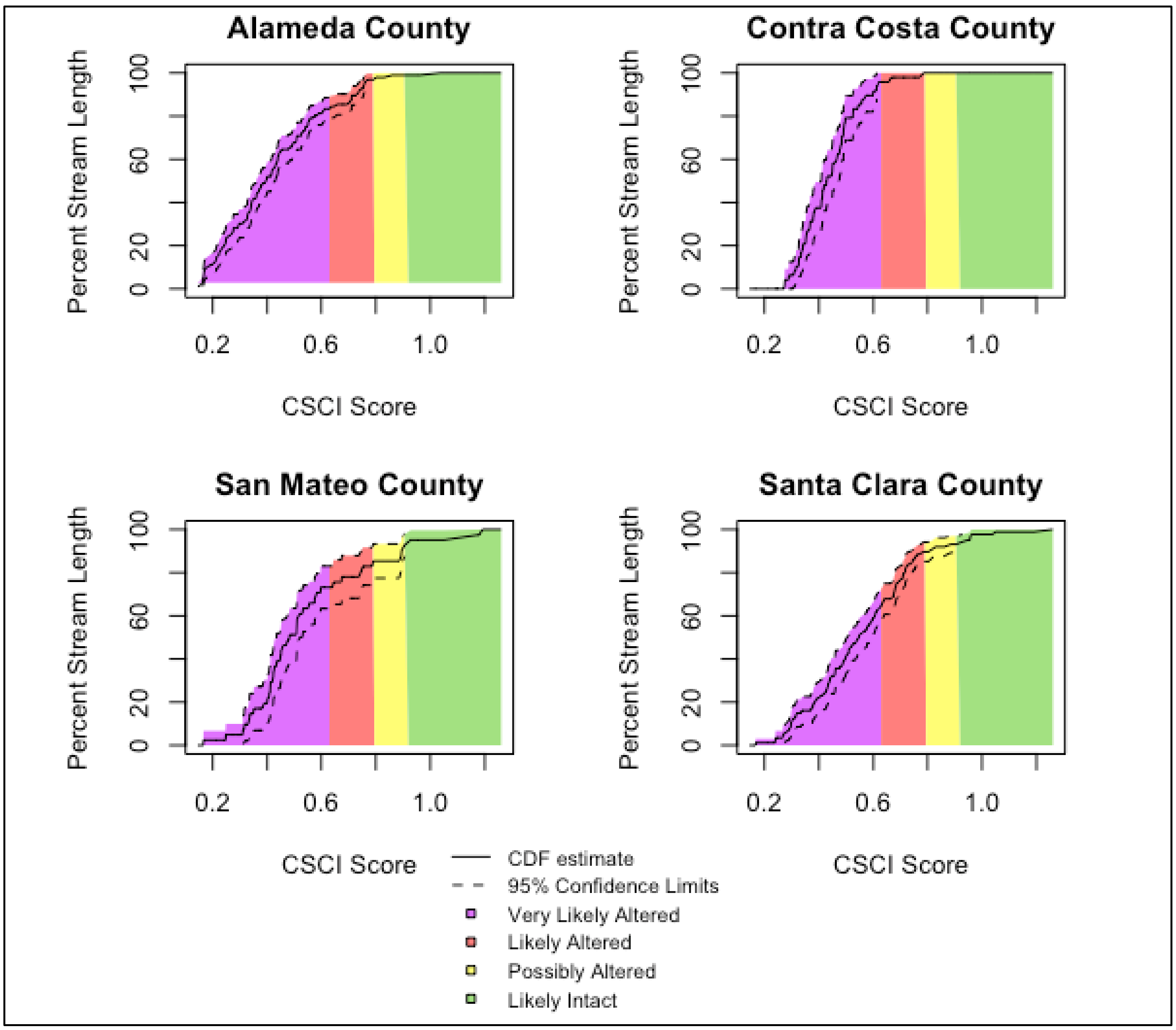

Figure 8. Cumulative distribution functions of CSCI scores at RMC urban sites in each participating Bay Area County.

3.2.3 Biological Condition of Urban and Non-Urban Streams

Figure 9 illustrates CSCI scores (by condition category) for the region and includes county boundaries and urban areas for reference. Maps illustrating the biological condition of stream in each county based on CSCI and D18 scores are included in Appendix 4.

Figure 9. Biological condition of streams in the RMC area based on CSCI scores.

CSCI scores grouped by land use class (urban vs. non-urban) showed that all counties, with the exception of Solano, exhibit higher scores in non-urban areas (Figure 10), which generally span a narrower scoring range than urban sites. Santa Clara and San Mateo counties had the highest median CSCI scores compared to other counties, with several sites in both counties receiving scores greater than 1.0, which typically represent reference conditions. However, non-urban sites for all five counties had CSCI scores below the MRP trigger (0.795), indicating that some sites non-urban areas have degraded biological condition.

Stratification of D18 and S2 scores by land use (urban vs non-urban; Figures 11 and 12) suggests that biological condition scores based on algae metrics generally mirror CSCI scores, which are based on BMIs. Generally, algae scores in the non-urban area were higher than scores for sites in urban areas within each county. The low sample sizes of the non-urban population preclude making any definitive comparisons, however, it was noteworthy that sites in the urban areas may receive similar or higher algae index scores than sites non-urban areas.

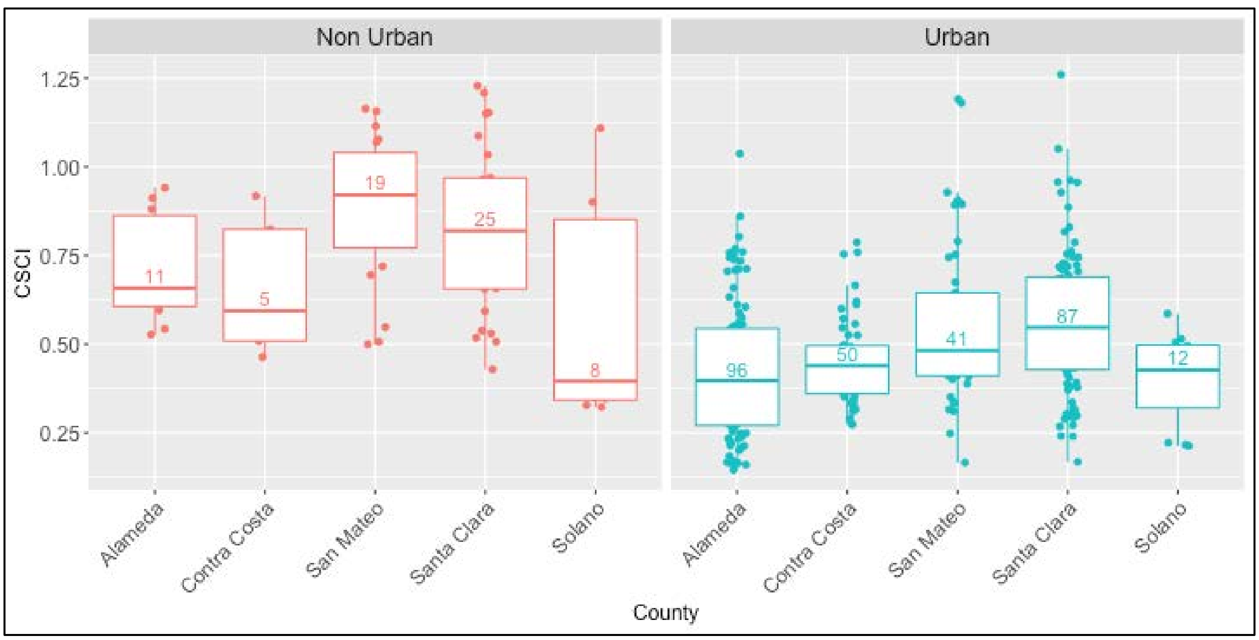

Figure 10. CSCI scores for urban and non-urban sites in each County. Sample sizes for each county are included in each boxplot.

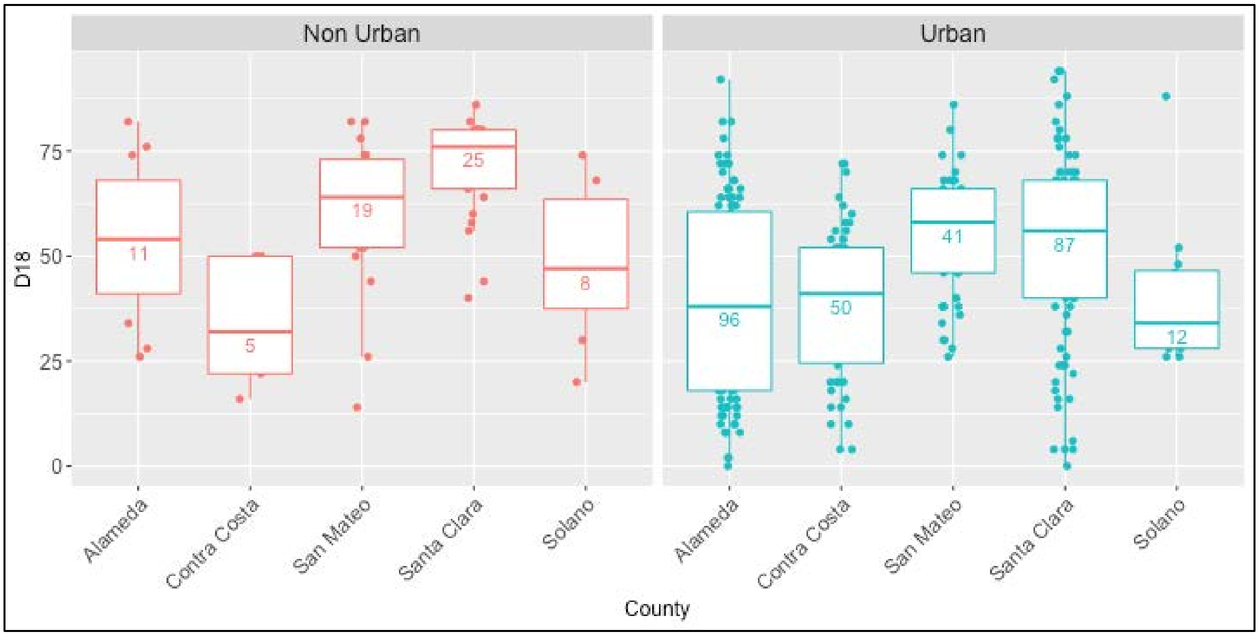

Figure 11. D18 scores for urban and non-urban sites in each County. Sample sizes for each county are included in each boxplot.

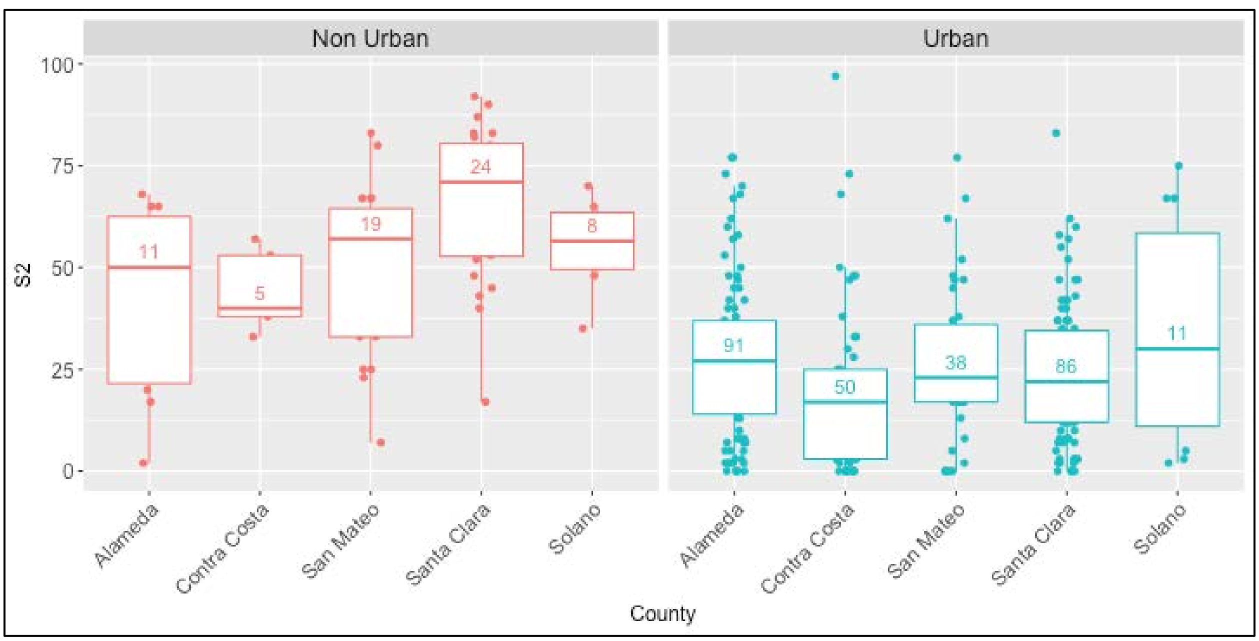

Figure 12. S2 scores for urban and non-urban sites in each County. Sample sizes for each county are included in each boxplot.

3.3 Stressors Associated with Biological Condition

3.3.1 Random Forest Model Outputs

To evaluate stressors associated with biological condition within the RMC area, random forest models were developed using the CSCI and D18 index results. A parallel analysis was not performed for the S2 indicator due to the lack of soft algae at many of the assessment sites. Stressor data consisted of 49 variables grouped into three types: (1) water quality; (2) habitat; and (3) land use (Appendix 1, Table A). Model results clearly indicated better relationships between stressors and the CSCI, versus the D18 index. Validation of the final random forest models showed that the CSCI model explained 61% of the variance using eight predictor (stressor) variables, while the D18 model only explained 34% of the variance using six predictors.

The CSCI random forest model indicated that land use and physical habitat variables were most influential to most biological condition (Table 5). Of the eight variables in the final CSCI model, four were landscape-based (HDI, PctImp_5K, PctImp_1K, PctImp), three were habitat associated (PctFines, PctGra, PctFstH20), and one was a water quality variable (Dissolved Oxygen, DO). There was general consistency amongst the individual variables within each of the landscape and habitat groups. The landscape variables that were most influential to CSCI scores were associated with the degree of human impact/imperviousness and the habitat variables were associated with the characteristics of the sediment substrate and water flow. Overall, the largest influence on the CSCI random forest model was percent impervious area within a 5 km radius (35.2%) of the site. The other seven variables in the final model exerted a lesser, but similar degree of influence (18.8 – 25.3%) on CSCI scores. It was notable that none of the nutrient variables were identified as indicators of biological condition scores using the CSCI model (Appendix 3 Figure A). The same may be true for DO, where the apparent relationship was driven by a few high values (Appendix 3 Figure B).

Table 5. Summary statistics for the CSCI random forest model. Rank of importance of selected stressor variables are colored according to categories: physical habitat (green), land use (brown), and water quality (blue). The correlation coefficient (rho) for each stressor variable is also presented.

Stressor Variable	% Increase MSE	Increase Node Purity	Rank Correlation Coefficient (Rho)
Percent Impervious Area in 5km (PctImp_5K)	35.21	4.74	-0.62
Percent Impervious Areas of Reach (PctImp)	25.37	1.03	-0.59
Dissolved Oxygen (DO)	24.43	1.60	0.24
Percent Fast Water of Reach (PctFstH20)	22.52	1.62	0.51
Percent Fines (PctFin)	20.73	1.13	-0.36
Percent Substrate Smaller than Sand (PctSmalSnd)	20.64	1.36	-0.46
Percent Impervious Area in 1km (PctImp_1K)	20.64	2.26	-0.61
Human disturbance Index (HDI)	18.81	1.45	-0.62

The results of the random forest model for D18 indicated that different variables explained biological condition than the CSCI model. Water quality variables exerted greater influence in the D18 model (Table 6). Of the six variables in the final D18 model, four were water quality variables (SpCond, Chloride, AFDM, Phosphorus), one was a habitat variable (PctSmalSnd), and one was a landscape variable (RdDen_1k). Overall, the variable with the largest influence on the random forest model was specific conductivity (29.5%). The remaining five variables exerted a lesser, but similar influence (12.5% – 22.0%) on the model. The importance of water quality variables in the model suggests that general water quality conditions (e.g., conductivity) likely influence algae condition scores. Specific types of water quality stress, such as from nutrients, however, appear to be less important to algal community condition on a regionwide scale.

Table 6. Summary statistics for the D18 random forest model. Rank of importance of selected stressor variables are colored according to categories: physical habitat (green), land use (brown), and water quality (blue). The correlation coefficient (rho) for each stressor variable is also presented.

Stressor Variable	% Increase MSE	Increase Node Purity	Rank Correlation Coefficient (Rho)
Specific Conductivity (SpCond)	29.55	35357.81	-0.49
Percent Substrate Smaller than Sand (PctSmalSnd)	21.99	24671.80	-0.46
Phosphorus	21.93	17465.87	-0.33
Chloride	18.53	18873.52	-0.51
Ash Free Dry Mass (AFDM)	15.09	21937.23	-0.44
Road Density in 1km (RdDen_1k)	12.51	16383.17	-0.33

Using the random forest model outputs, plots of individual stressor variables versus observed response values (i.e., CSCI and D18 scores) were developed to illustrate relationships between stressors and biological condition (Figures 13 to 18 and Appendix 2). For the CSCI model output, the plots of habitat and landscape variables indicate patterns of dose-response. For example, the Human Disturbance Index (HDI) stressor variable indicated that poor condition scores are observed when HDI exceeds a value of 2. This pattern was also evident in the regressions of observed CSCI values, relative to HDI and separating out HDI scores by their condition class (Figure 13). It is worth noting that Ode et al. (2016) identified a cutoff of HDI = 1.5 for reference sites (Ode et al. 2016). Based on the analysis conducted on this five-year Bay Area dataset, the range between 1.5 and 2.0 appeared to separate out the urban and non-urban sites, supporting the previous authors' assertion that sites with HDI values below this range exhibit reference conditions.

Similar to HDI, the stressor variables related to imperviousness indicated a threshold-style response with CSCI scores. For the variable 'percent imperviousness in 5km', a value above 10% appeared to correspond to poor CSCI condition scores (Figure 14). All sites that had less than 10% impervious area within 5km were classed as either Possibly Intact or Likely Intact condition. In the case of the habitat variables included in the final model, response patterns were less pronounced than for the landscape variables (Figure 15). For example, the variable 'percent reach habitat smaller than sand', indicated that poor sites spanned a wide-range in stressor values, while sites in the top three condition classes had a much narrower range in this metric. Biological condition at sites where more than 50% of the stream reach had substrate smaller than sand appeared to be a line of demarcation between the bottom two and top three condition categories.

The results of the D18 model indicated dose-response relationships between biological condition and all four water quality variables (i.e. SpCond, Chloride, AFDM, Phosphorus), however there were less obvious patterns delineating biological condition. For example, the partial dependency plots for D18 scores indicated that poor condition (i.e., bottom two condition categories) was evident when chloride was above 200 mg/L (Figure 16) and specific conductivity was above 1200 µS/cm[6] (Figure 17). However, the plots of observed D18 values relative to these variables suggested that only some of the lowest scoring sites could be delineated using these threshold values. Similarly, response patterns of the habitat variables were inconclusive for delineating biological condition. A value of approximately 60% or greater of the stream habitat 'smaller than sand' corresponded to lower D18 scores (Figure 18), but there was considerable variability to this signal.

[6] This corresponds well with the MRP threshold of 2000 uS/cm^2 for evaluating continuous monitoring data. Sites with 20% or more of instantaneous specific conductance results greater than 2000 uS/cm^2 are considered as candidates for SSID projects.

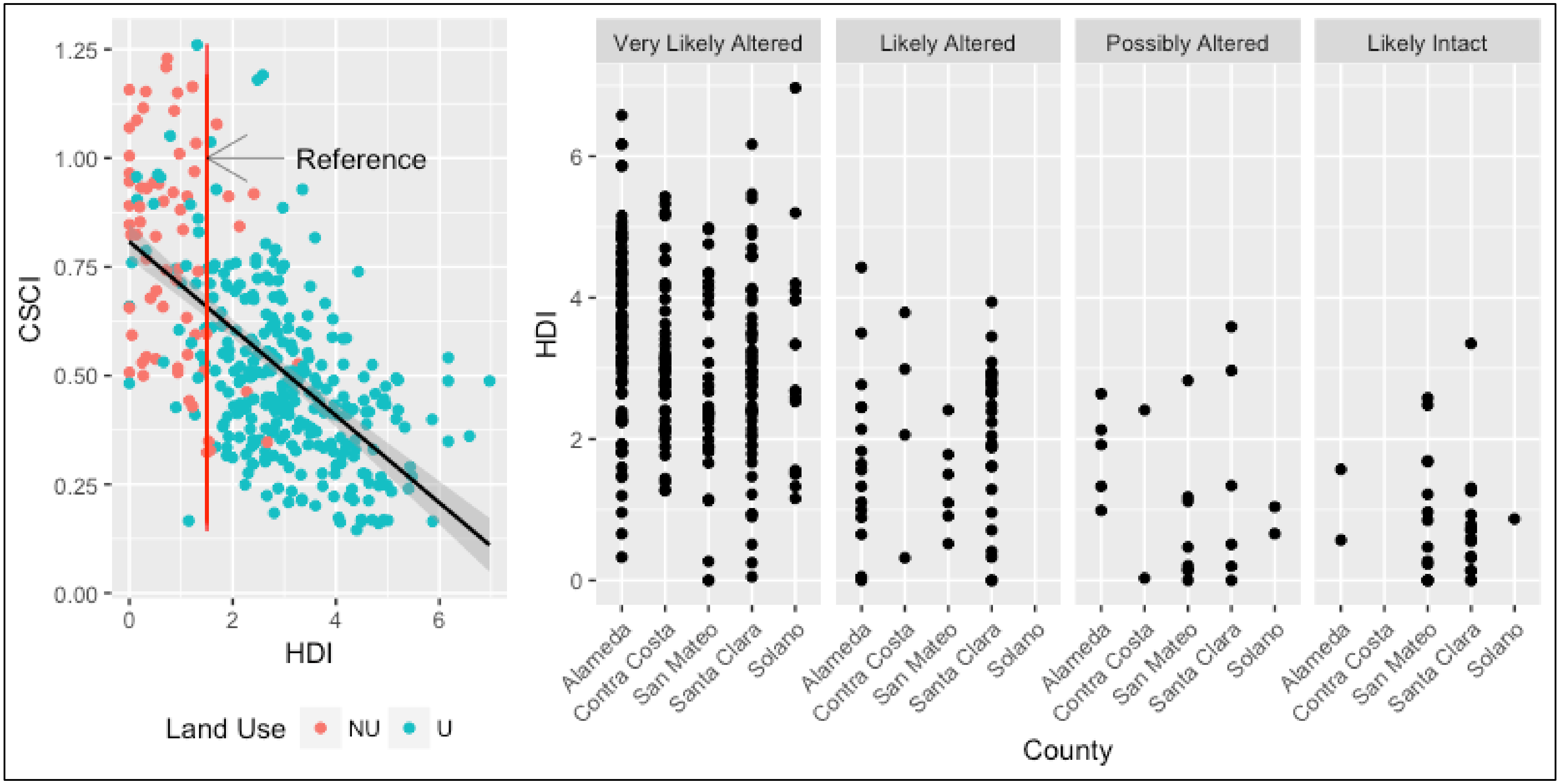

Figure 13. Relationship of CSCI scores to the Human Disturbance Index (HDI) stressor indicator. Red line indicates a reference condition cutoff of 1.5 (Ode et al. 2016).

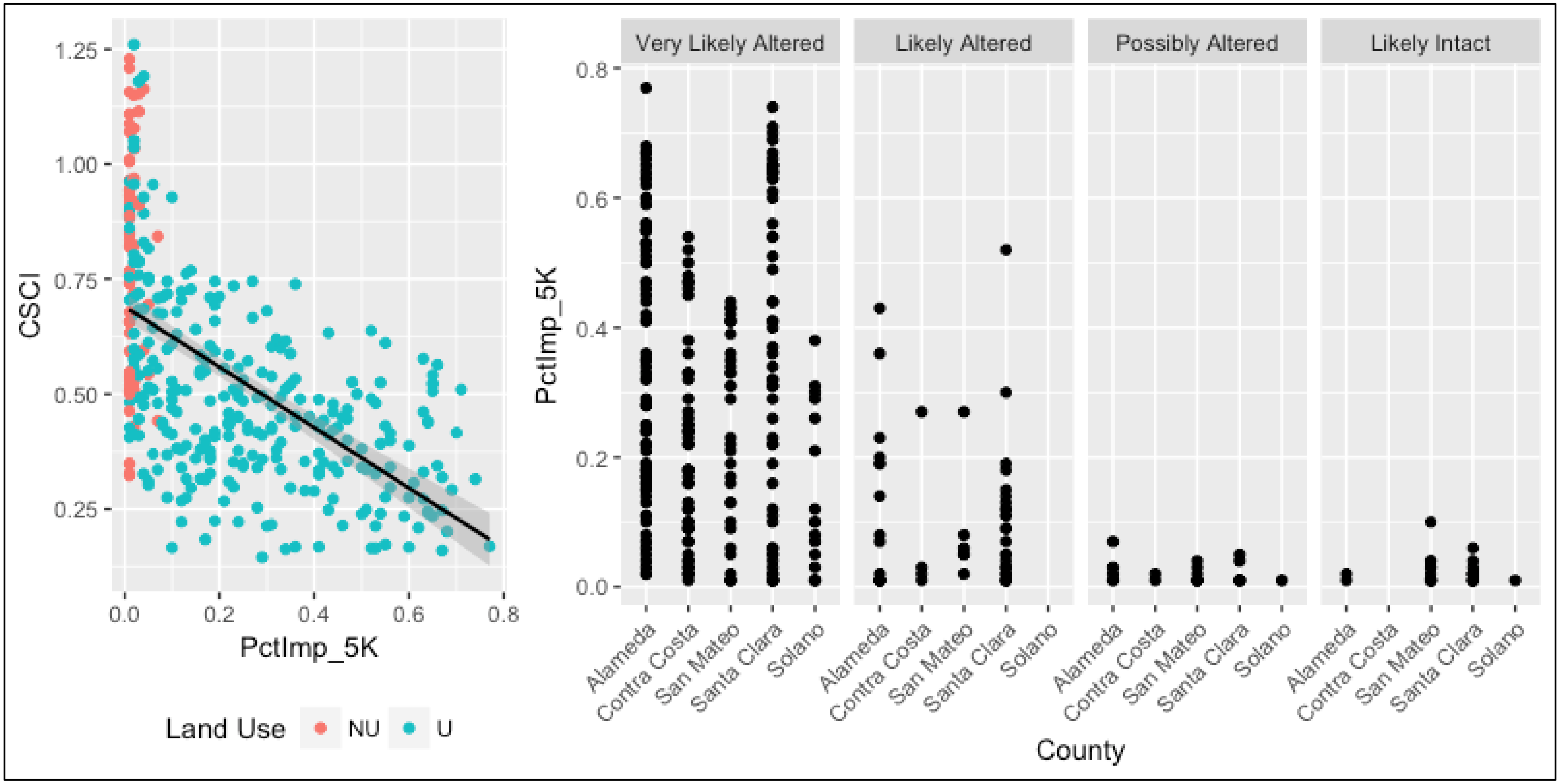

Figure 14. Relationship of CSCI scores to the percentage of land area in a 5 km radius (km^2) around the site that is impervious.

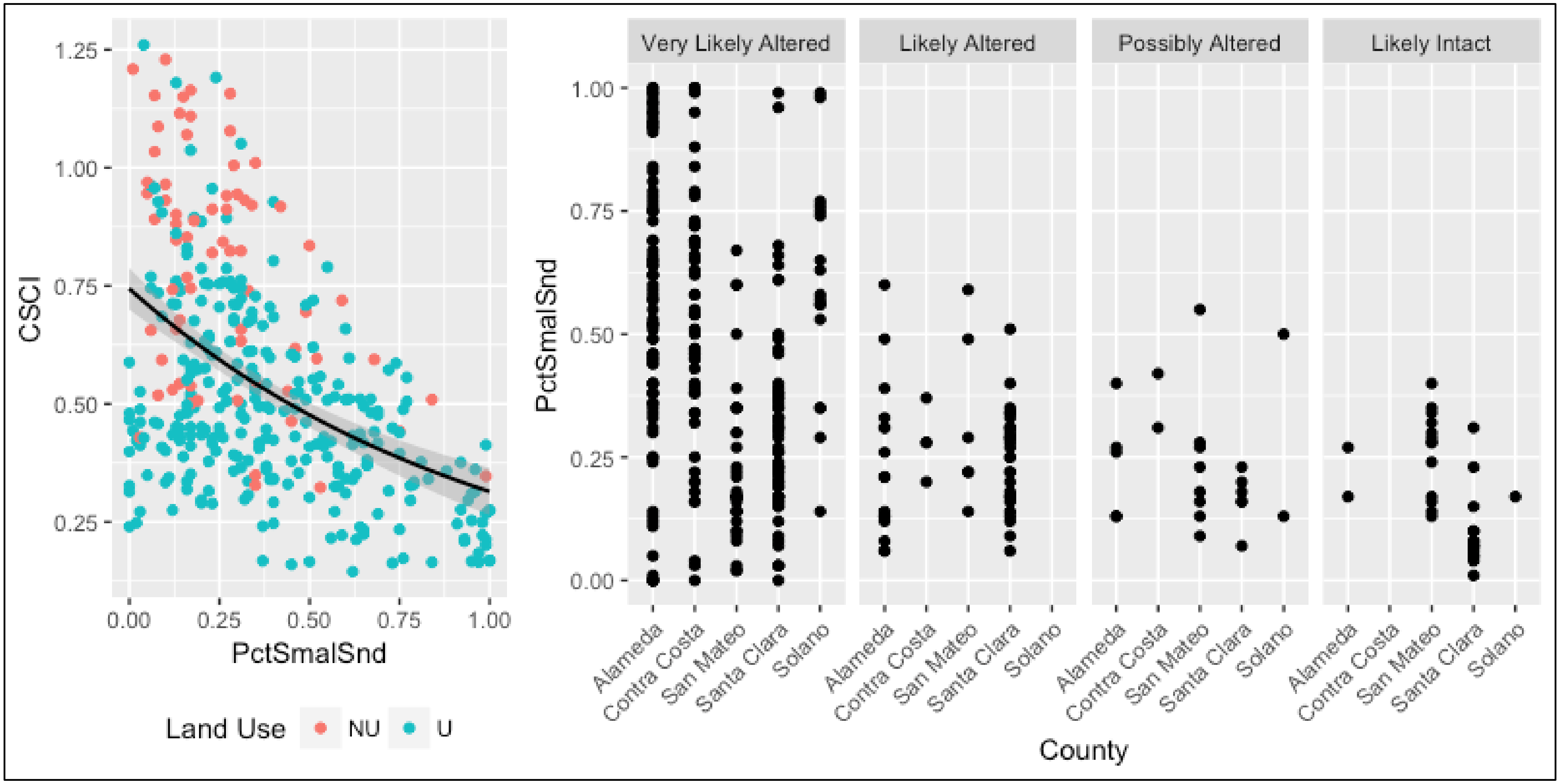

Figure 15. Relationship of CSCI score to the percent of substrate in the stream reach that was smaller than sand.

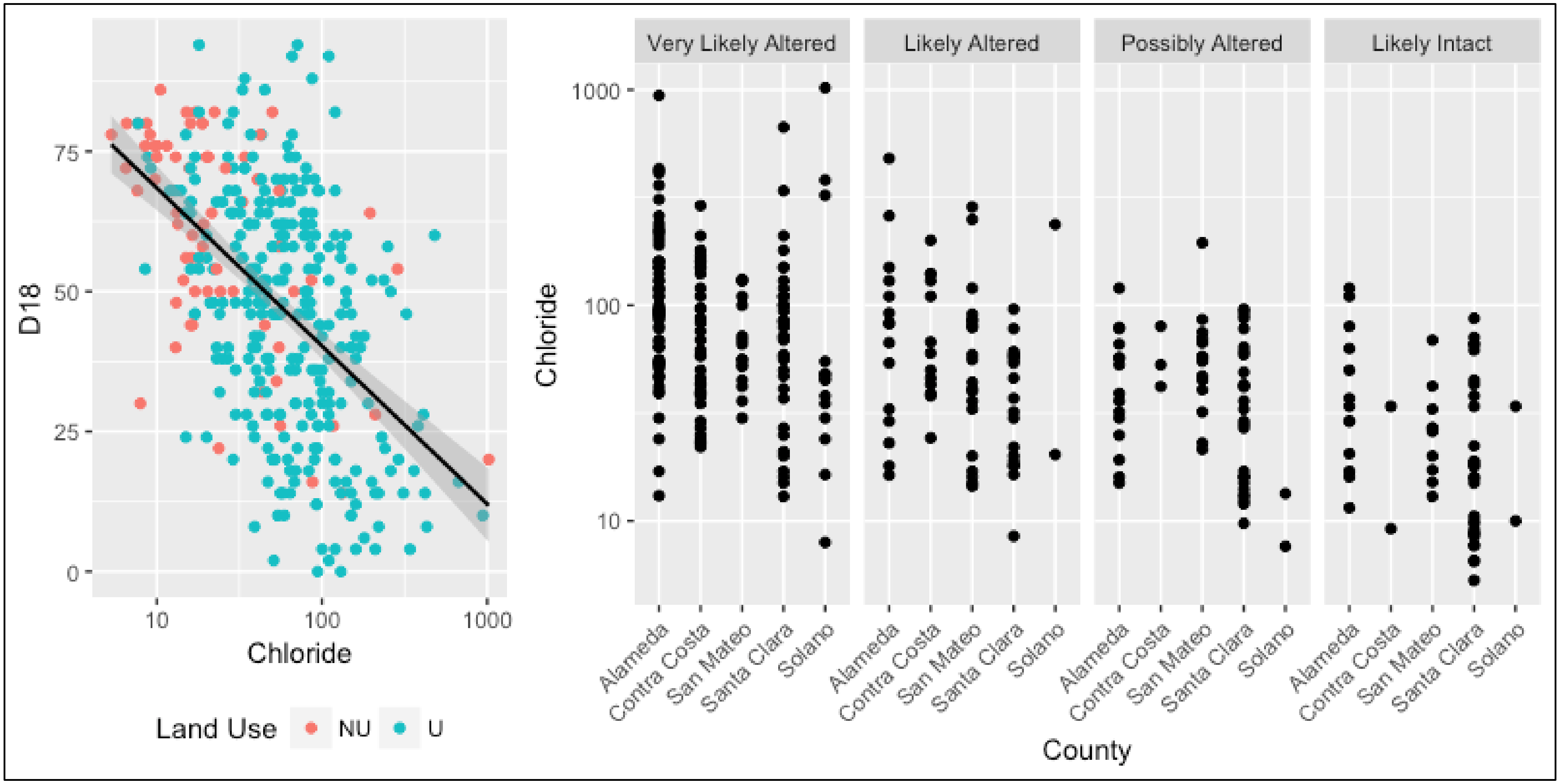

Figure 16. Relationship of D18 score to chloride concentration (mg/L). Note the chloride concentration scale is displayed in log units.

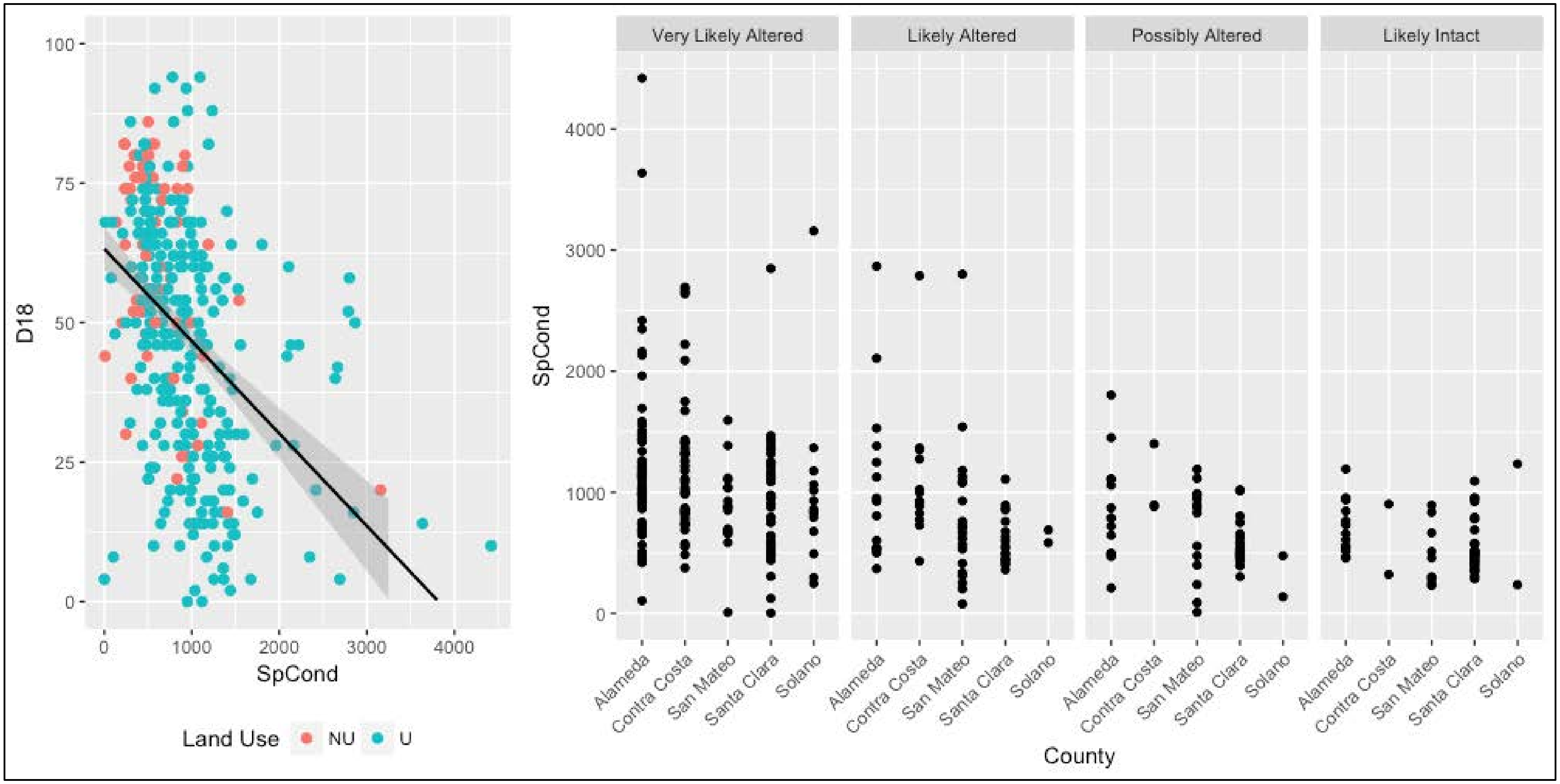

Figure 17. Relationship of D18 score to specific conductivity (µS/cm).

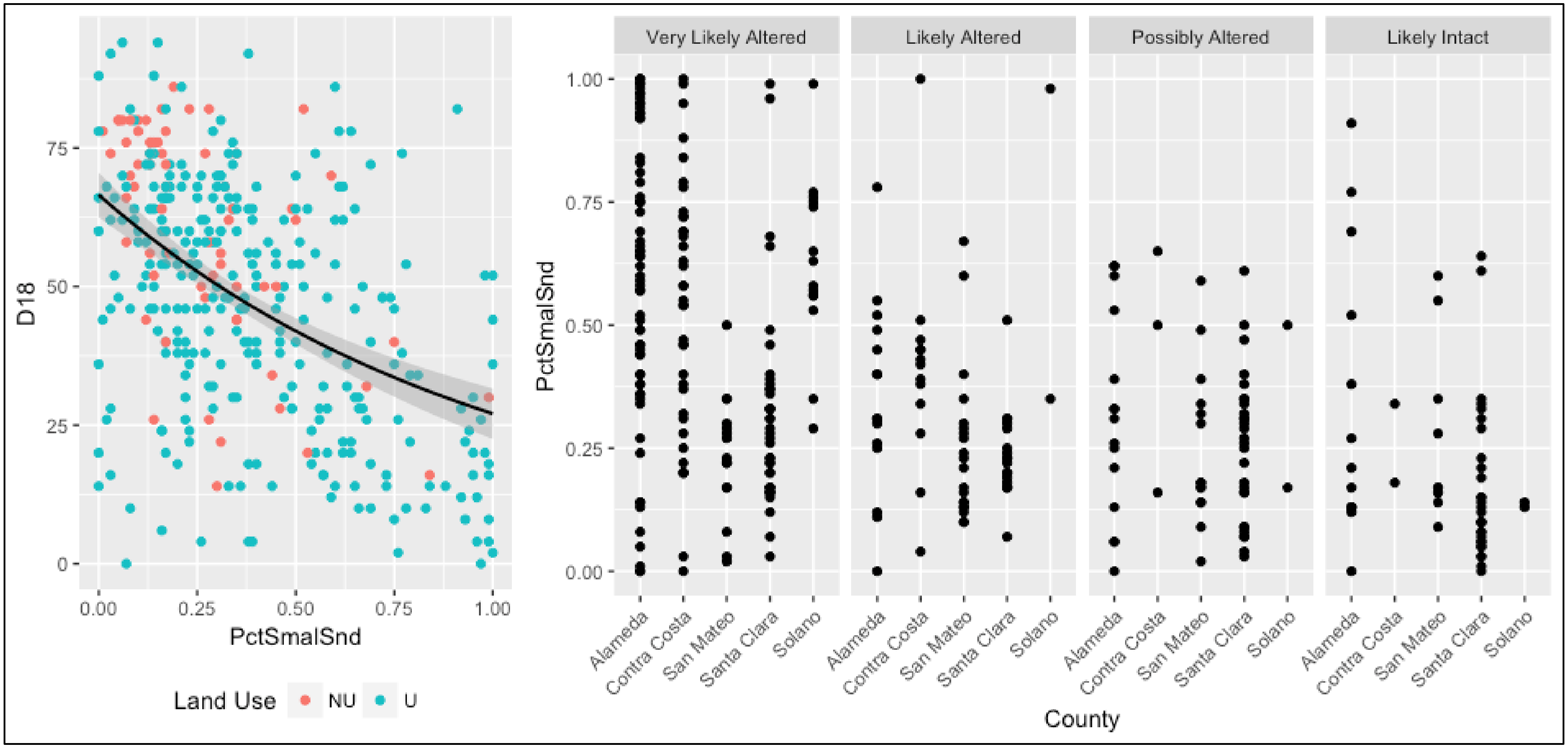

Figure 18. Relationship of D18 score to the percent of substrate in the stream reach that was smaller than sand.

3.3.2 Relative Risk Outputs

The relative risk of several stressors that may impact biological condition (based on CSCI scores) is shown in Figure 19. Definitions of abbreviations and threshold values for relative risk are described in Section 2.4.5. The Human Disturbance Index (HDI) stressor had the strongest relationship (> 3.0) with poor biological condition observed in the RMC dataset. Of the remaining physical habitat stressor variables, percent substrate smaller than sand (SmalSnd) had the strongest relationship (1.56) with poor biological condition. The remaining six stressors evaluated were associated with water quality and water chemistry and had Relative Risk values ranging between 1.26 and 1.51. These results are consistent with the random forest model results presented in the previous section, suggesting that physical habitat variables are more strongly associated with biological condition (based on CSCI scores) in the Bay Area, compared to water quality variables.

The relative risk for the eight stressors evaluated for RMC study were consistent with the results of the relative risk analysis of the same stressors that was conducted by the SMC (Mazor 2015a), with the exception of nutrients. The SMC study showed that relative risk for both Total Nitrogen and Phosphorus slightly under 3.0, while the RMC analysis indicated a much lower relative risk for each of these water quality parameters. The differences in relative risk of nutrients in Northern and Southern California suggest that there may be regional differences in the effects of these water quality parameters on biological condition (based on CSCI). However, it is important to note that the threshold values used by the SMC for Total Nitrogen and Phosphorus were lower than those used in the RMC data analyses.

Please note that the relative risk estimates for the eight stressors illustrated in Figure 19 could not be compared among RMC counties due to the insufficient number of sites with biological conditions above and below stressor thresholds in some counties.

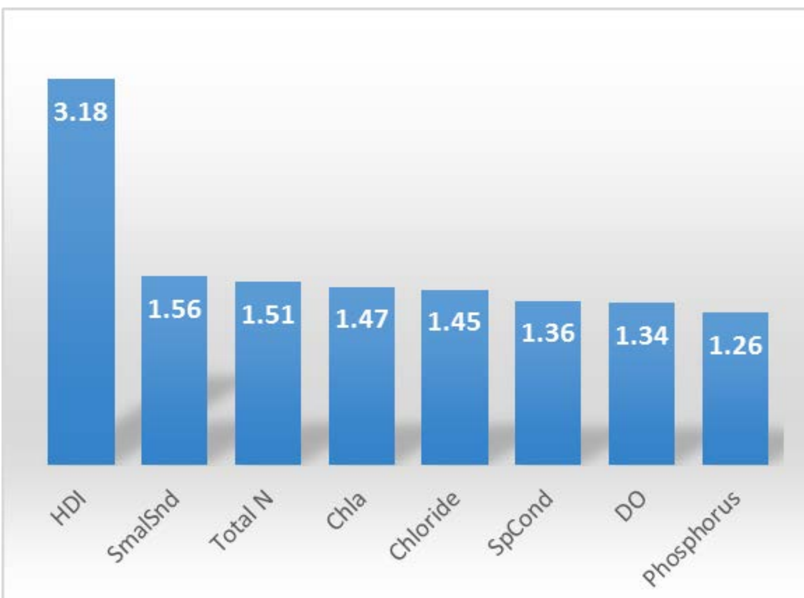

Figure 19. Relative risk of poor biological condition (i.e., scores in the lowest two CSCI condition categories) for sites that exceed stressor disturbance thresholds.

3.4 Trends

During the 2012-2016 monitoring period, there was no obvious temporal trend in biological condition, using either the CSCI, D18 or S2 indices. The median annual CSCI score for non-urban sites fluctuated between 0.518 and 0.931, but estimates in three of five years (2012, 2015, 2016) were only based on data collected at ten sites or less. Estimates were particularly imprecise for 2016, where only five non-urban sites were sampled. In urban areas, the median scores for CSCI had a much smaller range (0.408 to 0.510) than scores at non-urban sites. For urban sites, there was a clear lack of temporal trend, with 2016 exhibiting the highest median of the five years monitored (Figure 20).

D18 and S2 scores in each of the water years followed a similar pattern to CSCI scores. Scores in non-urban areas tended to vary widely depending on the water year and number of sites assessed (Figures 21 and 22). However, the urban sites tended to be relatively consistent, with scores generally being within a similar range each year. One observation to note was that S2 scores at urban sites were generally lower in 2016, compared to the preceding years of the survey, while CSCI scores were higher in 2016.

A comparison of median scores for CSCI each year and accumulated rainfall in each County did not reveal clear patterns on a county-by-county basis (Figure 23). Annual rainfall, as measured at San Francisco International Airport, during the five-year survey period was generally below the long-term average (Figure 5). Regional differences in accumulated rainfall additionally contribute to the lack of discernible changes in condition over time at a regional scale.

Contra Costa exhibited the highest range in accumulated rainfall during the monitoring period (10-20 inches) and generally had consistently low median CSCI scores. Alameda and Santa Clara counties, however, experienced a similar range in accumulated rainfall (5-16 inches), but had very different median CSCI scores in each water year. Given the variations in CSCI scores during different water years in some counties, future analyses to evaluate temporal trends in biological conditions will likely need to consider the influence of climatic variation at the county and regional-scales.

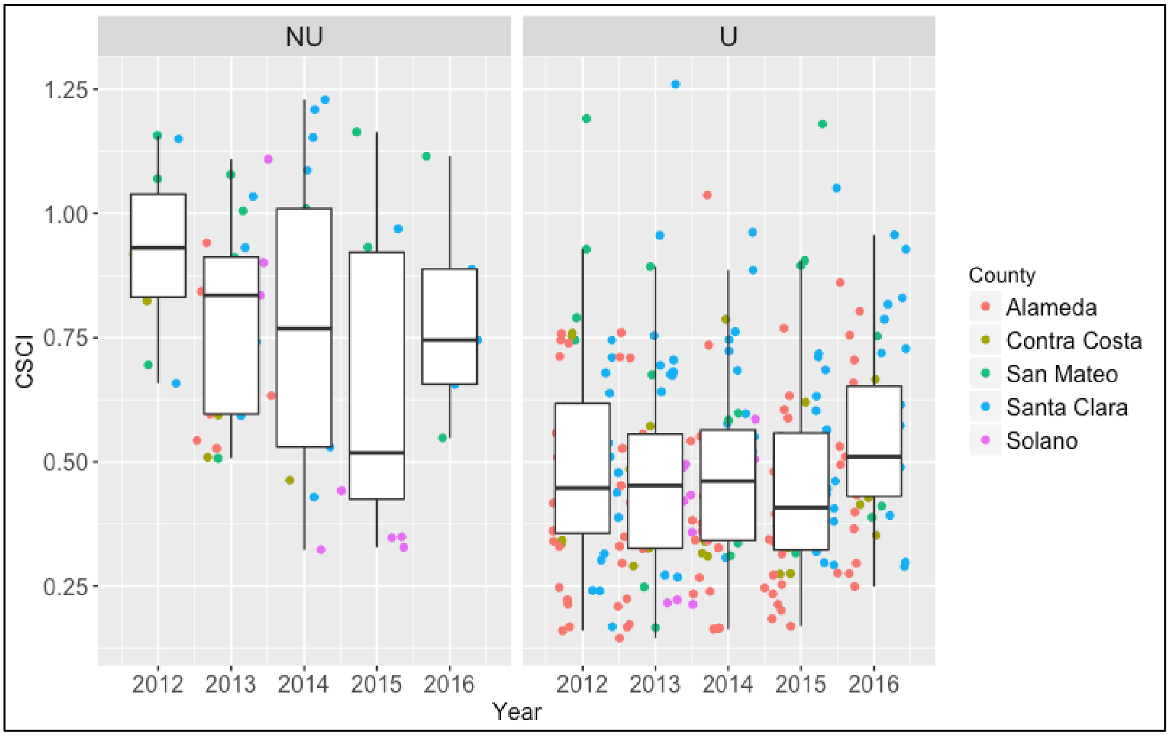

Figure 20. Distribution of CSCI scores during water years 2012-2016. NU = non-urban, U= urban.

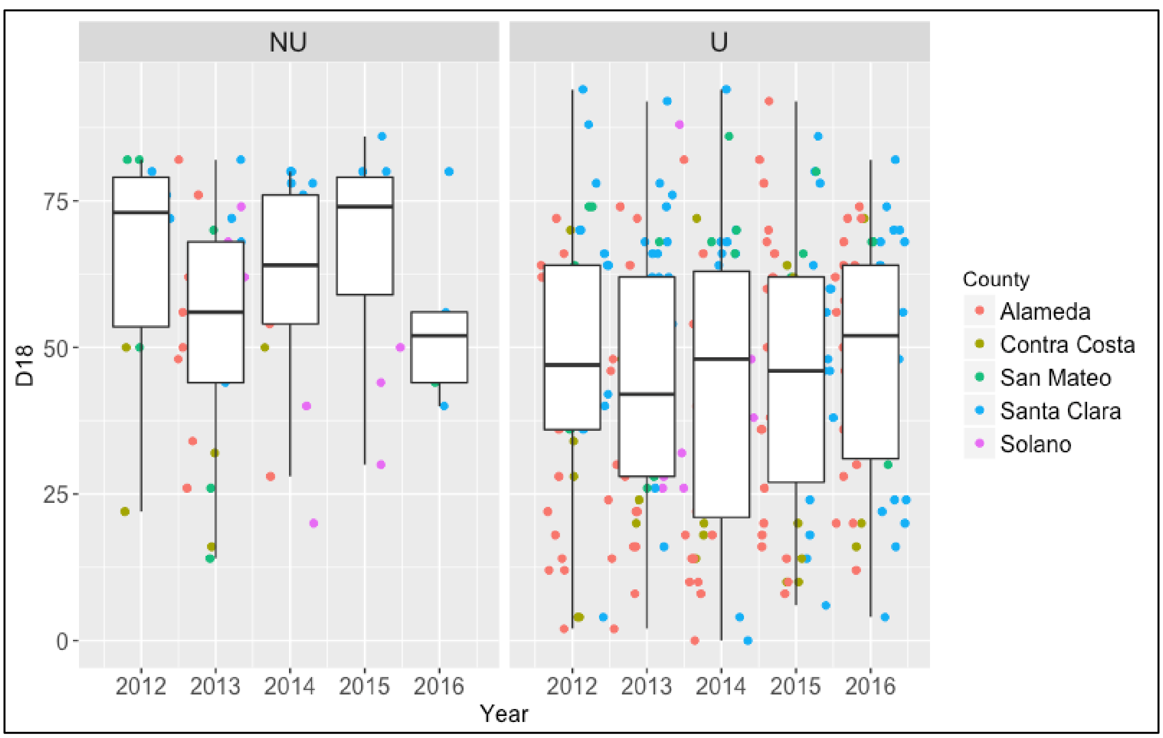

Figure 21. Distribution of D18 scores during water years 2012-2016. NU = non-urban, U= urban.

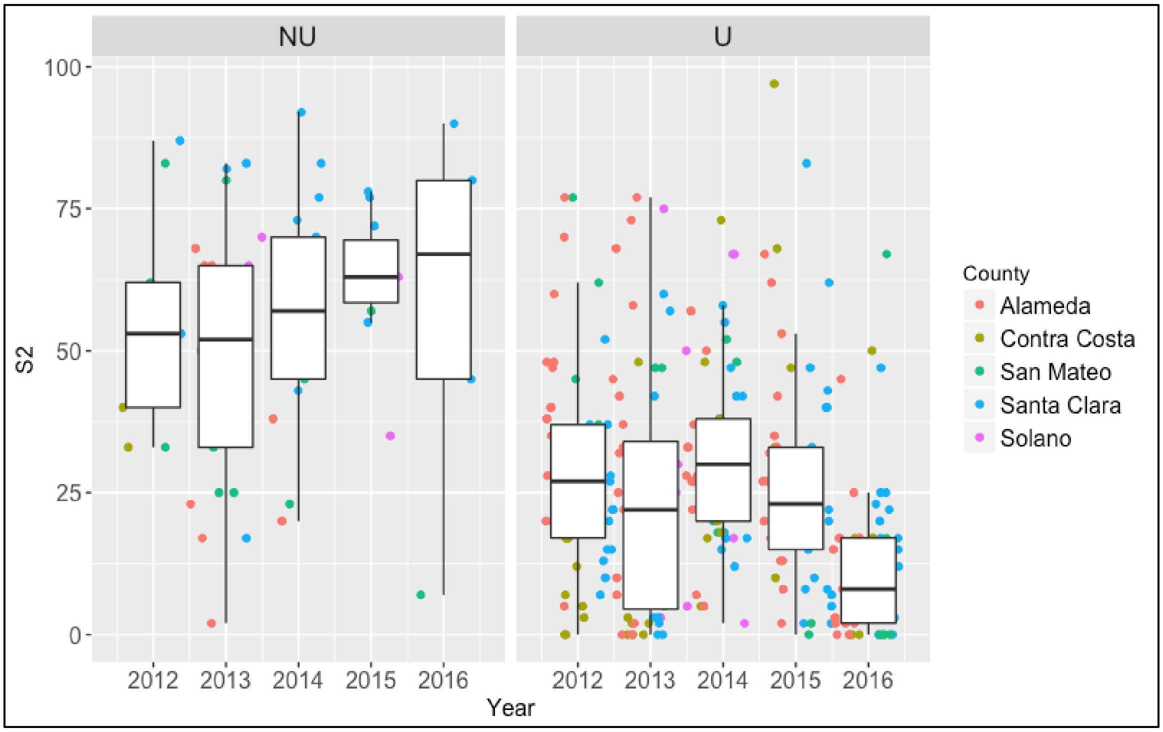

Figure 22. Distribution of S2 scores during water years 2012-2016. NU = non-urban, U= urban.

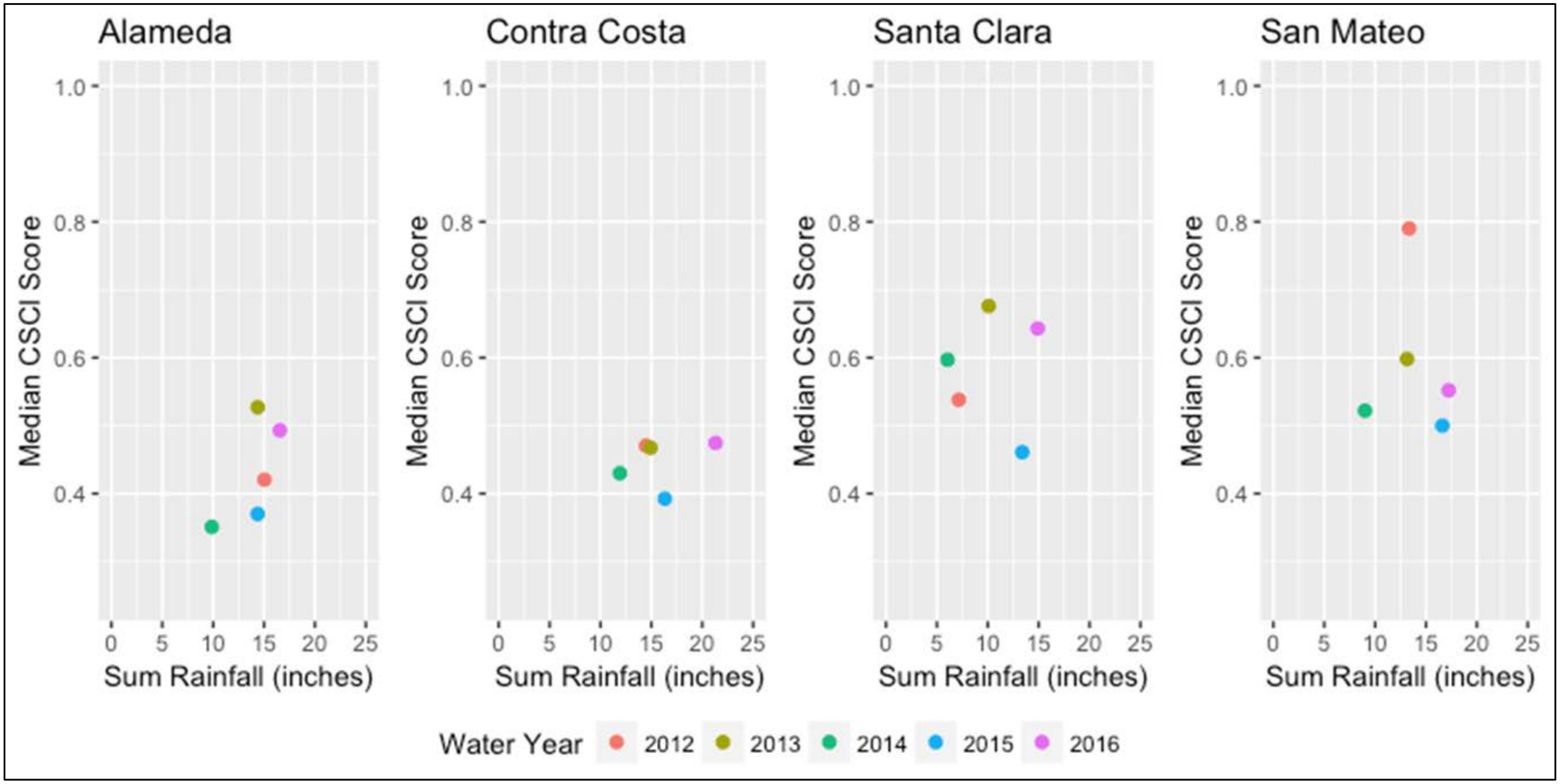

Figure 23. Relationship between median CSCI scores and accumulated annual rainfall in each County during water years 2012-2016. Includes urban and non-urban sites.

4 FINDINGS AND NEXT STEPS

The results and conclusions of the RMC's five-year bioassessment data evaluation are discussed below as they relate to the management questions and goals identified for the project.

4.1 *WHAT ARE THE BIOLOGICAL CONDITIONS OF STREAMS IN THE RMC AREA?*

Regional Conditions

The biological conditions of streams in the RMC area were assessed using two ecological indicators: BMIs and algae. The probabilistic survey design was developed to provide an objective estimate of biological condition of sampleable streams (i.e., accessible streams with suitable flow conditions) at both the RMC area and countywide scale.[7] Results of the survey indicate that streams in the RMC area are generally in poor biological condition:

- The CSCI for benthic macroinvertebrates (BMIs) indicates that 58% of stream length in the region are in the lowest CSCI condition category (Very Likely Altered); 74% of the of the sampled stream length exhibited CSCI scores below 0.795, the MRP trigger for potential follow-on activity.
- Using both algae indices (D18 and S2), stream conditions regionwide appear slightly less degraded than when using CSI, with approximately 40% of the streams ranked in the lowest algae condition category (Very Likely Altered). The algal indices also indicate that greater stream lengths (19-21%) are in the highest condition category (Likely Intact) compared to lengths in this category when the CSCI is used (15%).

These findings should be interpreted with the understanding that the survey focused on urban stream conditions. Approximately 80% of the samples (284 of 354) were collected at urban sites. As a result, the overall condition assessment represents the range of conditions found in the urban area, which is defined in the sample frame as areas classified as "urban" in the US Census (2000), plus all areas within city boundaries. Although the low non-urban sample size precludes making any definitive comparisons, bioassessment scores in the non-urban area were higher than scores in the urban area for each of the RMC counties. In general, the biological condition assessment for the RMC area (with a focus on urban sites) was consistent with the statewide assessment of biological conditions at sites located within urban land uses (PSA 2015), which resulted in more than 90% of urban streams rated in the two lowest biological condition categories using CSCI.

Differences Across Counties

One of the goals for the RMC monitoring design was to compare biological conditions of streams between counties. In general, biological conditions, based on CSCI and D18 scores, appeared better in streams located in Santa Clara and San Mateo counties, compared others. However, Santa Clara and San Mateo counties had proportionally more non-urban sites (with higher CSCI and D18 scores) compared to other

[7] More samples are needed to estimate condition for non-urban land use areas and finer spatial scales (i.e., watersheds).

counties. All counties exhibit higher biological condition scores in the non-urban area compared to the urban area. The difference between urban and non-urban median scores is lower for the D18 index, suggesting that diatoms may respond less to the habitat degradation commonly found at urban sites and may therefore provide better response to changes in water quality conditions.

Higher overall scores in Santa Clara and San Mateo may also be associated with regional differences in rainfall and flow duration. For example, San Mateo County and western Santa Clara County watersheds drain the Santa Cruz mountains, which typically receive higher rainfall, in contrast to Alameda and Contra Costa counties, which primarily contain watersheds that drain the western slopes of the drier Diablo range.

Indicator Tools

The use of multiple indicators provides a broad assessment of ecosystem functions. Streams that show degraded conditions for a single indicator may provide opportunities to identify the stressor and potentially implement management controls to reduce impacts. Alternatively, streams with poor conditions for both indicators (BMI and algae) may have multiple stressors that might be more challenging to address. Watershed managers may also choose to prioritize streams that are in good biological condition, based on both biological indicators, for protection of beneficial uses.

The RMC used existing tools to assess biological condition (CSCI and SoCal Algal IBIs). Although these tools were also used in the regional assessments conducted by the SMC, uncertainty remains as to how well these indices perform for streams within the San Francisco Bay Region:

- The CSCI is a statewide index that was developed for perennial streams. For the RMC project, however, the CSCI was used to evaluate BMI data collected in both perennial and non-perennial streams (note: the RMC assessed flow status by conducting site visits at all sampled sites during the dry season). In addition, CSCI scores appear highly sensitive to physical habitat degradation, which occurs frequently in the many highly modified urban streams monitored by the RMC. It is not clear how well the CSCI tool can show response to stressors associated with water quality, when physical habitat is the primary factor affecting the BMI community.

- For this report, the RMC evaluated algae data using SoCal Algae IBIs for diatoms (D18) and soft algae (S2). The D18 was more responsive to stressor gradients associated with water quality, however, high scores were often found in urban sites with highly degraded physical habitat. The soft algae index (S2) was not a reliable indicator of condition due to overall low taxa richness observed at both disturbed and undisturbed sites throughout the RMC area. In many cases, there was insufficient number of soft algae taxa to calculate S2, resulting in data gaps and lack of utility of the S2 index. Additional testing of soft algae indices is needed to assess the utility of this indicator in the RMC area.

  The State Water Board and Southern California Coastal Water Research Project are currently developing and testing a set of statewide indices using benthic algae data as a measure of biological condition for streams in California. The statewide Algae Stream Condition Indices (ASCIs) are expected to be finalized in 2019. It is anticipated that the RMC will apply the ASCIs to analyze algae data when they become available.

4.2 *What Stressors are Associated with Biological Conditions?*

This question was addressed by evaluating the relationships between biological indicators (CSCI and D18) and stressor data through random forest and relative risk analyses. The study results indicate that each of the biological indicators responded to different types of stressors and therefore the two may be best used in combination to assess potential causes of poor (or good) biological conditions in streams:

- Biological condition, based on CSCI scores, is strongly influenced by physical habitat variables and land use within the vicinity of the site. The percent of the land area within a 5 km radius of a site that is impervious appears to have the largest influence on CSCI scores based on the random forest model results. Based on the relative risk analysis, the degree of human disturbance near a site, as observed via the Human Disturbance Index (HDI), appears to have the greatest relationship with poor biological condition of streams.
- Biological condition, based on D18 scores, is moderately correlated with water quality variables and less associated with physical or landscape variables, such as imperviousness or HDI.

In general, CSCI scores at urban sites were consistently low in all RMC counties, indicating that degraded physical habitat conditions in and around streams do not support healthy in-stream biological communities. D18 scores at urban sites were more variable, indicating that healthy diatom assemblages can occur at sites with poor physical habitat and may be important water quality indicator these sites.

No nutrient variables (e.g., nitrate, total nitrogen, orthophosphate, phosphorus) correlated strongly with CSCI scores in the Bay Area, nor were nutrients ranked as important variables explaining CSCI scores via the random forest model. Phosphorus and ash-free dry mass, which increase in response to biostimulation, were important in predicting algae (D18) index scores, although no statistically significant relationships were observed. This finding suggests that nutrient targets currently under development by the State Water Board as part of their Biostimulatory/Biointegrity Project, should be applied in the context of observed biological conditions, not uniformly based solely on broad relationships that may not apply to the Bay Area streams.

Although results show associations between some stressors and biological condition, they do not establish causation. There are several factors that may affect the strength of the correlation between stressors and biological condition:

- Stressors are not independent of one another and may have synergistic or mediating effects on condition. For example, elevated temperatures reduce the amount of oxygen that can be dissolved in the water column and both stressors may result in adverse effects to aquatic biota.
- Potential variability of stressor concentrations over time may not be represented in a single grab sample. For example, dissolved oxygen can have a wide range of concentrations over a 24-hour period. Drops in DO concentrations typically occur in early morning hours, potentially well prior to the timing of measurements during bioassessment events.
- Many of the physical habitat variables can be highly variable throughout the sample reach. For example, a wide range of substrate grain sizes can occur within a single transect. Thus, degraded habitat conditions that may exist at selected transect(s) of the assessment reach may not be well represented in reach-wide averages used as endpoints for the stressor analysis.

- Stressor impacts may be dependent on other factors (possibly not measured) for negative effects to occur. For example, elevated nutrient concentrations do not necessarily result in eutrophication (i.e., excessive plant and algal growth, reduced oxygen levels). Stream locations that have minimal exposure to sunlight, cooler water and higher flow rates may not develop eutrophic conditions, despite presence of elevated concentrations of nutrients.
- Stressors may have natural sources; prevalence and magnitude may vary by watershed or regionally. For example, naturally occurring nitrogen or phosphorus concentrations may be present in minimally disturbed upper watershed areas.

4.3 *Are Biological Conditions Changing Over Time?*

The short timeframe of the survey (five years) limited the ability to detect temporal trends in bioassessment data. Since new sites are surveyed each year, it is expected that a much longer time period is needed to detect trends at a regional scale over time. The variability in biological condition observed over the five years of the current analysis may have been associated with annual variation in precipitation or other factors. Drought conditions were present during the first four years of the survey. Trends in biological condition are more likely to occur on the decadal timescale. That said, the PSA evaluated trends for unique probabilistic sites sampled over a 13-year period and observed no trends (i.e., consistent directional change over time) (PSA 2015).

It is also important to consider these results within the broader context of the progress made over the past decade to reduce the effects of urbanization on creeks and channels through the mandatory treatment of stormwater and reduction of impervious areas via applicable new and redevelopment projects, and the numerous stream restoration projects that have been put into place. The implementation of mandatory stormwater treatment via green stormwater infrastructure (GSI) and low impact development (LID) began prior to the adoption of the MRP in 2005. These requirements reduce the effects of stormwater from impervious surfaces created via new and redevelopment and likely have positive effects on biological condition in streams, although the responses may be delayed. Bay Area municipalities are currently developing GSI Plans, which will result in the strategic and widespread integration of GSI into Capital Improvement Projects and other co-benefit projects like regional stormwater capture projects, creek restoration and flood control and resiliency projects. These efforts are anticipated to further reduce the impacts of stormwater on local streams. Future creek status monitoring may provide additional insight into the potential positive impacts of GSI and creek restoration on water quality and beneficial uses in urban creeks.

The ability to detect trends would be increased if the sample design included re-visiting sites over multiple years. Multiple surveys at individual sites would provide more site-specific detection of changing biological conditions over time. Should RMC participants intend to use BMIs and algae as long-term indicators, analyses should be conducted to identify the minimum number of samples needed over a specified timeframe to detect trends at a site or within a watershed or county, with a specified level of confidence. The analysis could also be used to optimize the monitoring program by evaluating appropriate sample sizes for detecting trends when considering expected variability in condition for different groups of sites, land use types, or areas where management actions are being implemented.

4.4 Evaluation of Monitoring Design

The information presented below is intended to provide recommendations on potential revisions RMC monitoring procedures that should be considered for future implementation of bioassessment programs in the Bay Area.

4.4.1 Site Evaluations

Over the first five years of monitoring, the RMC evaluated about 25% (1455 out of 5740) of the sites in the sample frame to assess 354 sites. Approximately 46% (873 out of 1896) of the total number of urban sites in the sample frame were evaluated during that time. Additional sites have subsequently been selected from the sample frame and evaluated for sampling in 2017 and 2018. The number of remaining sites for evaluation in the RMC Sample Frame for each county is presented in Table 7.

Table 7. Sites remaining in RMC sample frame before site evaluation in water year 2019.

<table>
<tr><th>County</th><th>Urban</th><th>Non-urban</th></tr>
<tr><td>Alameda</td><td>124</td><td>797</td></tr>
<tr><td>Contra Costa (R2)</td><td rowspan="2">348</td><td>307</td></tr>
<tr><td>Contra Costa (R5)</td><td>331</td></tr>
<tr><td>Santa Clara</td><td>143</td><td>1189</td></tr>
<tr><td>San Mateo</td><td>67</td><td>469</td></tr>
<tr><td>Fairfield-Suisun</td><td>37</td><td rowspan="2">208</td></tr>
<tr><td>Vallejo</td><td>4</td></tr>
</table>

Based on rejection rates from previous years, the sample frame is anticipated to only last two to three years at which time the urban sites in the frame will be exhausted. Revision of the RMC monitoring design could seek to reduce the future rejection rate through re-evaluation of the sample frame to exclude areas of low management interest or regions that would not be candidates for sampling (such as due to lack of permissions or physical barriers to access). This would improve the spatial balance of samples that more closely represents the proportion of the sample frame that can be reliably assessed.

Each countywide stormwater program managed their site evaluation information independently using a standardized database. The site evaluation data were then compiled to conduct the spatial analysis needed to calculate the regional biological condition estimates presented in this report. During the compilation process, inconsistencies in procedures used to conduct site evaluation (BASMAA 2016a) were identified that affect the statistical certainty of the regional estimates. Some sites in the sample draw were skipped over (e.g., challenges in obtaining permissions from private land owners, lack of flow during period of drought) with the intention to re-evaluate the sites at a future date. The skipped sites created sampling bias that affects the spatial balance of the draw and reduces certainty in the condition estimates.

Another issue was the disproportionate sampling of non-urban sites among the counties. The RMC intended to sample twenty percent of the targeted sites each year. Some Programs had difficulty getting access to non-urban sites, or decided to focus on urban sites, resulting in a wide range in number of samples collected at non-urban sites across the counties. As a result, biological condition scores at the county-scale tended to be higher in counties that sampled more non-urban sites.

4.4.2 RMC Sample Frame

Consistent with the PSA, the RMC sample design was created to probabilistically sample all streams within the RMC area, which resulted in a master list of 33% urban sites and 67% non-urban sites. However, because participating municipalities are primarily concerned with runoff from urban areas, the RMC focused sampling efforts on urban sites (80%) over non-urban sites (20%). As a result, non-urban samples are under-represented in the dataset resulting in much lower overall biological condition scores than would be expected for a spatially balanced dataset. In addition, the limited number of non-urban samples (2% sample frame assessed thru-2016) prevented statistical confidence in estimates of biological condition for non-urban land use at the regional scale.

Depending on the goals for the RMC moving forward, the RMC may want to consider developing a new sample draw that establishes a new list of sites that is weighted for specific land uses categories and Program areas of interest. Development of a revised sample frame would result in a new list of sites, associated with different length weights for each land use category. The sample draw could also include a list of sites for oversampling (replacements for sites not sampled) to maintain the spatial balance throughout any timeframe of the draw and allow for a much longer time frame before the list is exhausted.

Re-design of the RMC sample frame could also include new strata based on developed channel classifications created by SCCWRP. The classifications are created using a statistical model that predicts likely ranges of CSCI scores based on landscape characteristics (Mazor et al. 2018). These channel classifications could be integrated as strata into the RMC sample frame to allow varying sampling efforts for urbanized streams.

4.5 Possible Next Steps for the RMC Bioassessment Monitoring

Based on evaluation of data collected during the five years of the survey, several options to revise the RMC Monitoring Design are presented below:

1) Continue to sample new probabilistic sites until the draw is exhausted;
2) Re-visit probabilistic sites in support of assessing temporal trends;
3) Monitor targeted sites for special studies; or
4) Combination of two or more of the above.

Each of these options is discussed in more detail below.

Continue Sampling New Probabilistic Sites

The RMC could continue to sample new probabilistic sites from the current sample frame with the goal to establish baseline conditions over smaller spatial scales. Eventually, statistically significant datasets would be obtained to estimate biological condition for all strata previously considered (i.e., non-urban and countywide), as well as finer scales (e.g., watersheds). Smaller geographic scales of assessments may provide stronger associations between biological conditions and stressor levels. Watershed-level assessments may provide managers more opportunities to evaluate spatial patterns and temporal trends for specific watersheds.

Exclusively sampling new sites would exhaust sites in the current sample draw. It is anticipated that at the current rate of sampling (at same proportion of urban/non-urban sites), some of the Programs would run out of urban sites in two to three years. Solano County has already depleted urban sites from their sample frame. Sampling effort at new non-urban sites should be also be evaluated. Resources to conduct site evaluations (e.g., permission to access private property) are typically much higher at non-urban sites. In addition, the access to non-urban sites appears to be highly variable by county.

If this option is desired, the RMC could develop a new probabilistic sample draw with a list of oversample sites.

Re-visit Probabilistic Sites to Assess Temporal Trends

Re-visiting probabilistic sites previously sampled may provide trend estimates and more refined information to potentially explain causes of observed trends. The most robust trends scenario would involve sampling the same sites each year; however, given the current level-of-effort, this would only be possible at a relatively small number of sites in each county. Thus, the resulting trends assessment could only answer regional questions. Some sites could be sampled for multiple years to evaluate potential variability related to changes in precipitation; non-urban sites may be particularly sensitive to annual variation in precipitation. Integrating site re-visits into the sample design would have the advantage of extending the life of the sample frame (i.e., reduce number of new sites each year).

Targeted Studies

There are several potential objectives for conducting biological assessments at targeted sites, including:

1) Evaluate effectiveness of stream restoration/BMP implementation projects;
2) Determine source/stressor at impaired site (i.e., causal assessment);
3) Evaluate conditions in selected watersheds;
4) Study trends at minimally disturbed sites (e.g., climate change);
5) Assess validity of CSCI in nonperennial streams in the Bay Area;
6) Investigate variability in biological indicator scores within sampling index period.

Targeted studies could be coordinated among RMC participants to evaluate similar objectives at regional scale or could be done independently by each Program. It is anticipated that targeted studies may require more resources with regards to site selection, data needs, detailed analyses, and reporting. However, targeted monitoring could also leverage requirements that Permittees have for other projects.

Combined Approaches

The RMC may consider implementing a combination of all the approaches described above for the future monitoring design.

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APPENDICES

1. Random Forest Analysis
2. Partial Dependency Plots
3. CSCI-Stressor Plots
4. Additional Figures

Appendix 1 Random Forest Analysis

Table 1-A. Variable group, variable code, and description of response variables (condition indices) and explanatory environmental variables (landscape, habitat, and water quality) used for random forest model development.

Variable Group	Variable Code	Description
Response	CSCI	California Stream Condition Index
Response	D18	Soft algae condition score
Habitat	AvAlgCov	Mean Filamentous Algae Cover
Habitat	AvBold	Mean Boulders cover
Habitat	AvWetWd	Mean Wetted Width/Depth Ratio
Habitat	AvWoodD	Mean Woody Debris <0.3m cover
Habitat	ChanAlt	Channel Alteration Score
Habitat	EpiSub	Epifaunal Substrate Score
Habitat	FlowHab	Evenness of Flow Habitat Types
Habitat	NatShelt	Natural Shelter cover - SWAMP
Habitat	NatSub	Evenness of Natural Substrate Types
Habitat	PctBold_L	Percent Boulders - large
Habitat	PctBold_LS	Percent Boulders - large & small
Habitat	PctBold_S	Percent Boulders - small
Habitat	PctFin	Percent Fines
Habitat	PctFstH20	Percent Fast Water of Reach
Habitat	PctGra	Percent Gravel - coarse
Habitat	PctSlwH20	Percent Slow Water of Reach
Habitat	PctSmalSnd	Percent Substrate Smaller than Sand (<2 mm)
Habitat	PctSnd	Percent Sand
Habitat	ShD.AqHab	Shannon Diversity (H) of Aquatic Habitat Types
Habitat	ShD.NatSub	Shannon Diversity (H) of Natural Substrate Types

Variable Group	Variable Code	Description
Land Use	HDI	Combined Riparian Human Disturbance Index - SWAMP
Land use	PctImp	Percent Impervious Area of Reach
Land use	PctImp_1K	Percent Impervious Area in 1km
Land use	PctImp_5K	Percent Impervious Area in 5km
Land use	PctUrb	Percent Urban Area of Reach
Land use	PctUrb_1K	Percent Urban Area in 1km
Land use	PctUrb_5K	Percent Urban Area in 5km
Land use	RdCrs_5K	Number Road Crossings in 5km
Land use	RdCrs_W	Number Road Crossings in watershed
Land use	RdDen_1K	Road Density in 1km
Land use	RdDen_5K	Road Density in 5km
Land use	RdDen_W	Road Density in watershed
Land use	RoadCrs_1K	Number Road Crossings in 1km
Water Quality	AFDM.sub	Ash Free Dry Mass
Water Quality	Ammonia.sub	Ammonia
Water Quality	Chla.sub	Chlorophyll a
Water Quality	Chloride	Chloride
Water Quality	DO	Dissolved oxygen
Water Quality	Nitrate.sub	Nitrate
Water Quality	Nitrite.sub	Nitrite
Water Quality	OP.sub	Orthophosphate
Water Quality	pH	pH
Water Quality	Phosphorus.sub	Phosphorus
Water Quality	Silica	Silica
Water Quality	SpCond	Specific conductivity
Water Quality	Temp	Temperature
Water Quality	TKN.sub	Total Kjeldahl Nitrogen

Variable Group	Variable Code	Description
Water Quality	Total N	Total Nitrogen
Water Quality	UIA.sub	Unionized Ammonia

Table 1-B. Model and cross-validation statistics for random forest models with CSCI and D18 scores using the final set of model variables (Table 2, Table 3)

Index	Model Dataset	Model Statistic	
CSCI	Training	R^2	0.95
	Validation	R^2	0.61
CSCI	Training	CV R^2	0.66
	Validation	CV R^2	0.52
D18	Training	R^2	0.92
	Validation	R^2	0.34
D18	Training	CV R^2	0.35
	Validation	CV R^2	0.33

Training and validation models run with the same variables, *R^2 = adjusted R-squared, CV R^2 = Cross validation R^2

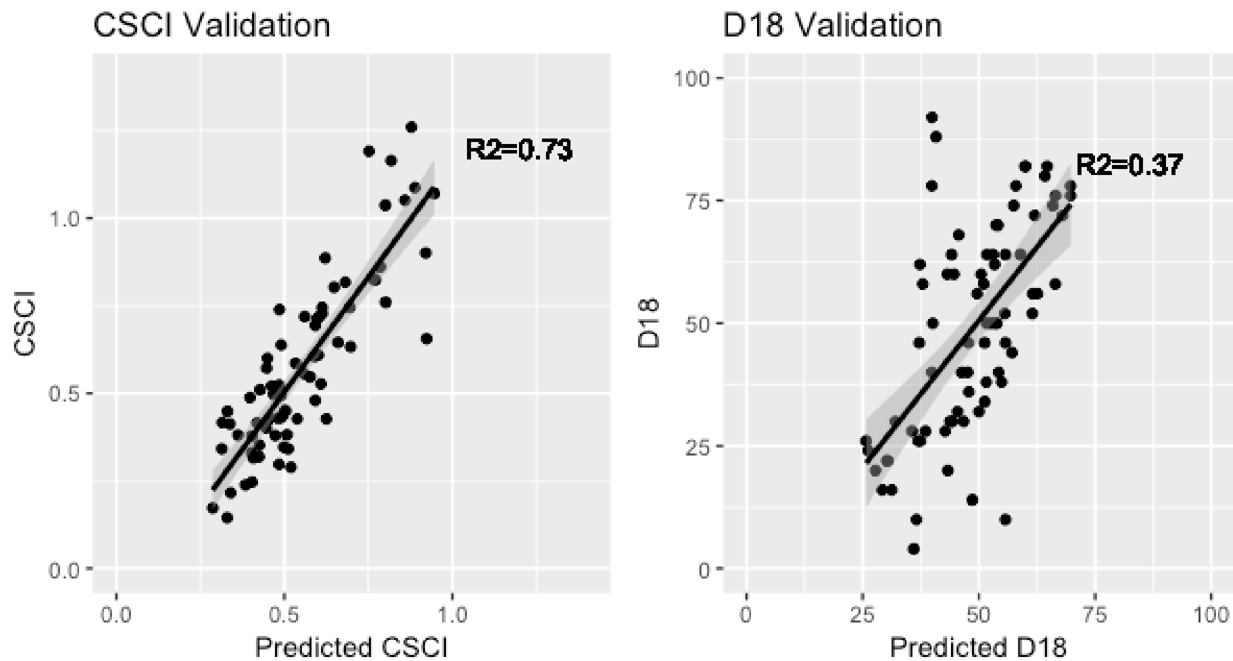

Figure 1-A. Relationship of observed to predicted CSCI and D18 scores in the validation dataset using all 49 explanatory variables in Step 1 of the random forest trial

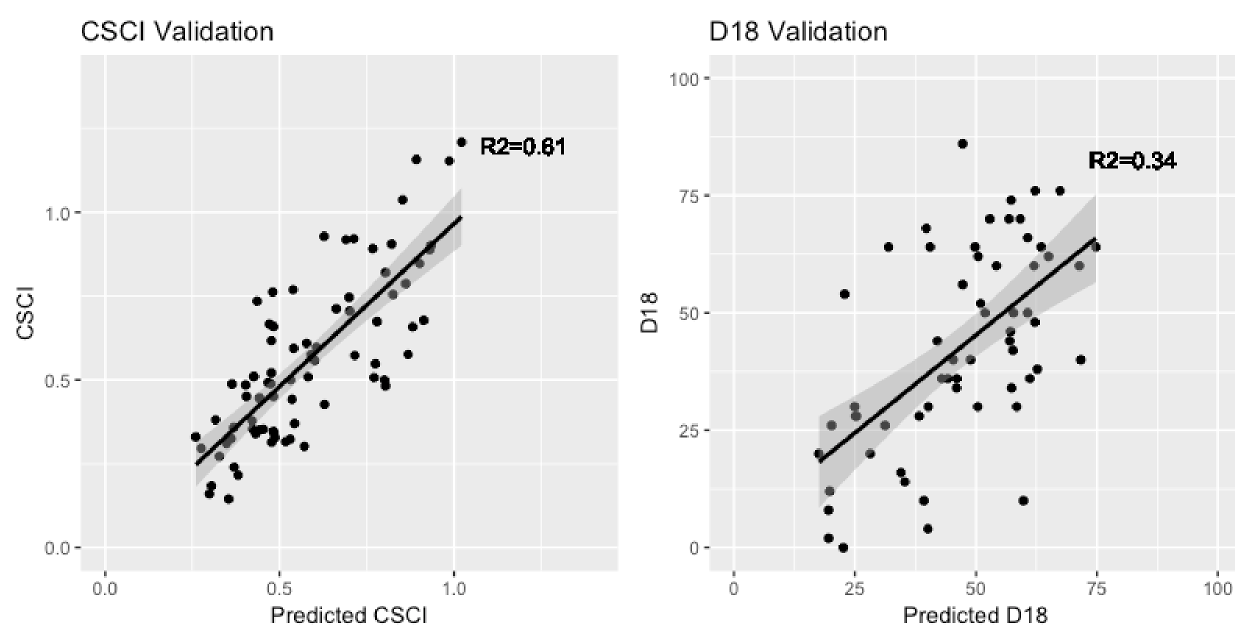

Figure 1-B. Relationship of observed to predicted CSCI and D18 scores in the validation dataset using the final, selected list of explanatory variables in Step 2 of the random forest trial

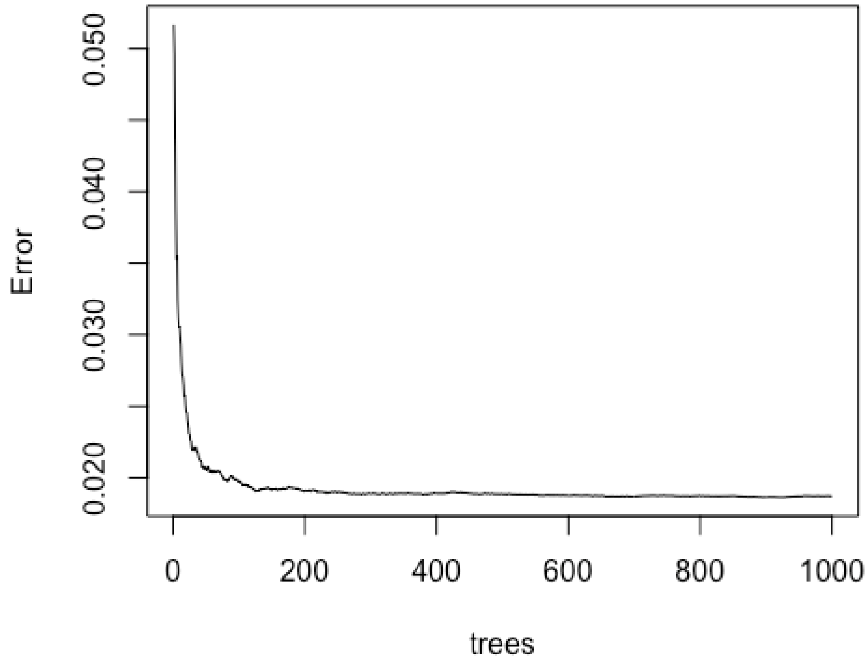

Figure 1-C. Prediction error vs. number of trees in the CSCI model with 49 stressor variables

APPENDIX 2 PARTIAL DEPENDENCY PLOTS

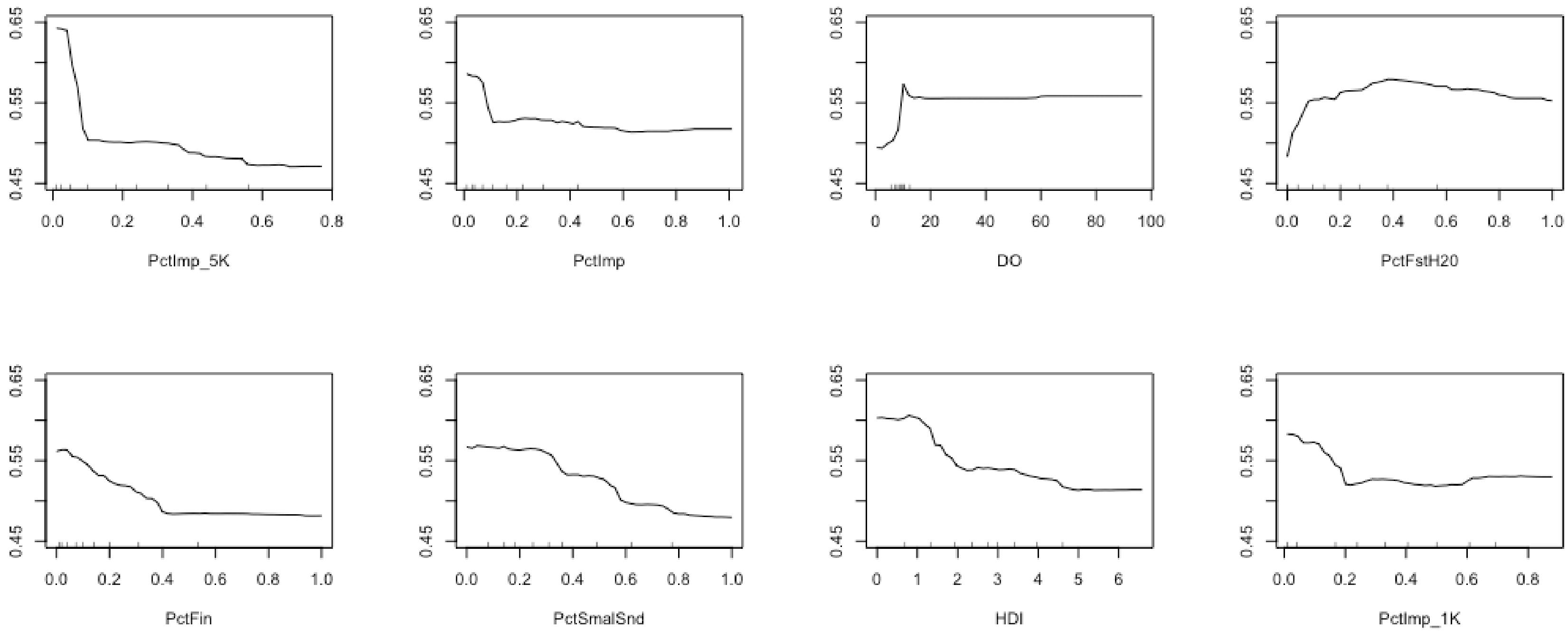

Figure 2-A. Partial dependency plots for stressor variables in random forest model of CSCI condition. Plots show the predicted response of CSCI (y-axis) based on the effect of individual explanatory variables (x-axis) with the response of all other variables removed in the training data set.

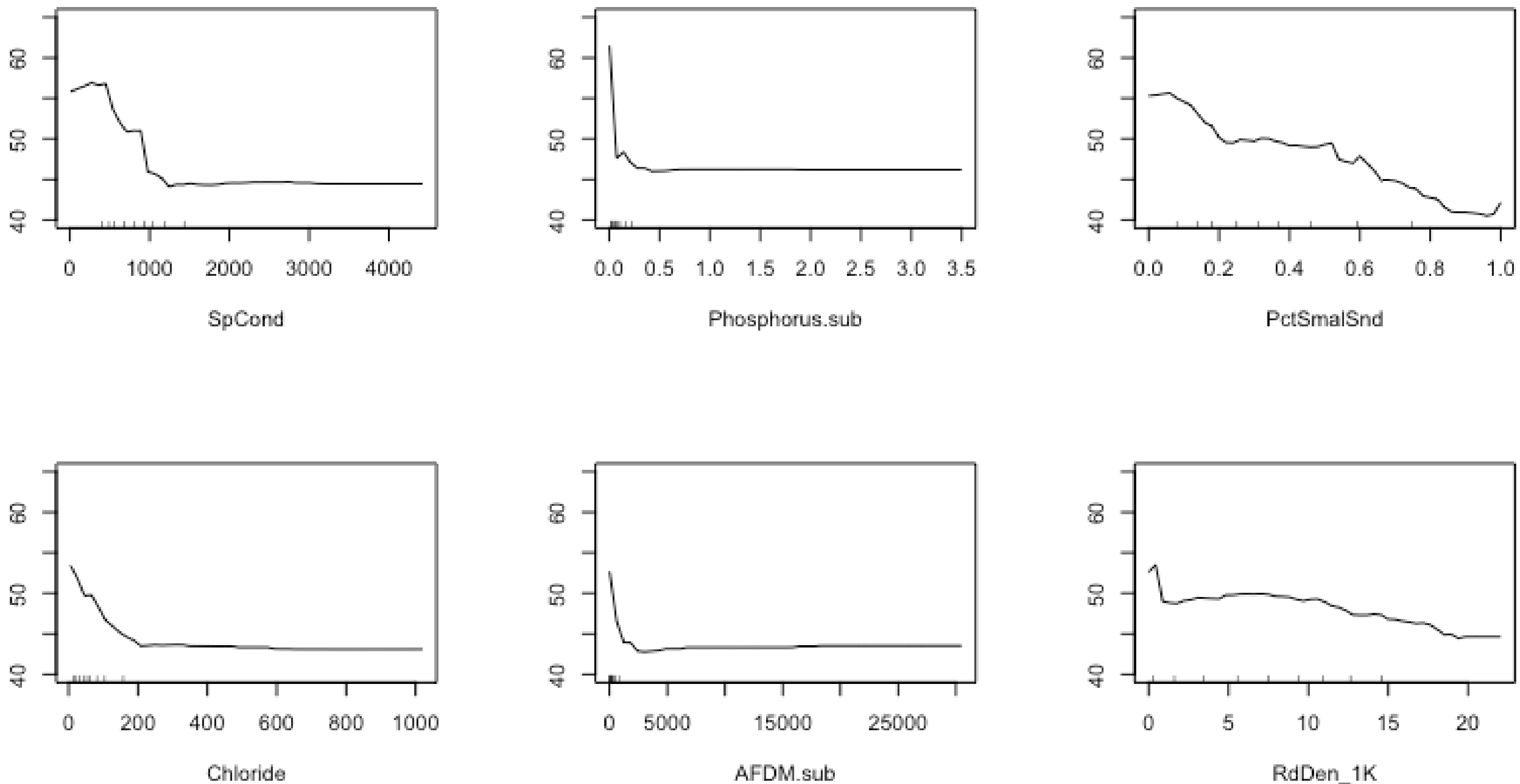

Figure 2-B. Partial dependency plots for stressor variables in random forest model of D18 condition. Plots show the predicted response of D18 (y-axis) based on the effect of individual explanatory variables (x-axis) with the response of all other variables removed in the training data set.

APPENDIX 3 CSCI-STRESSOR PLOTS

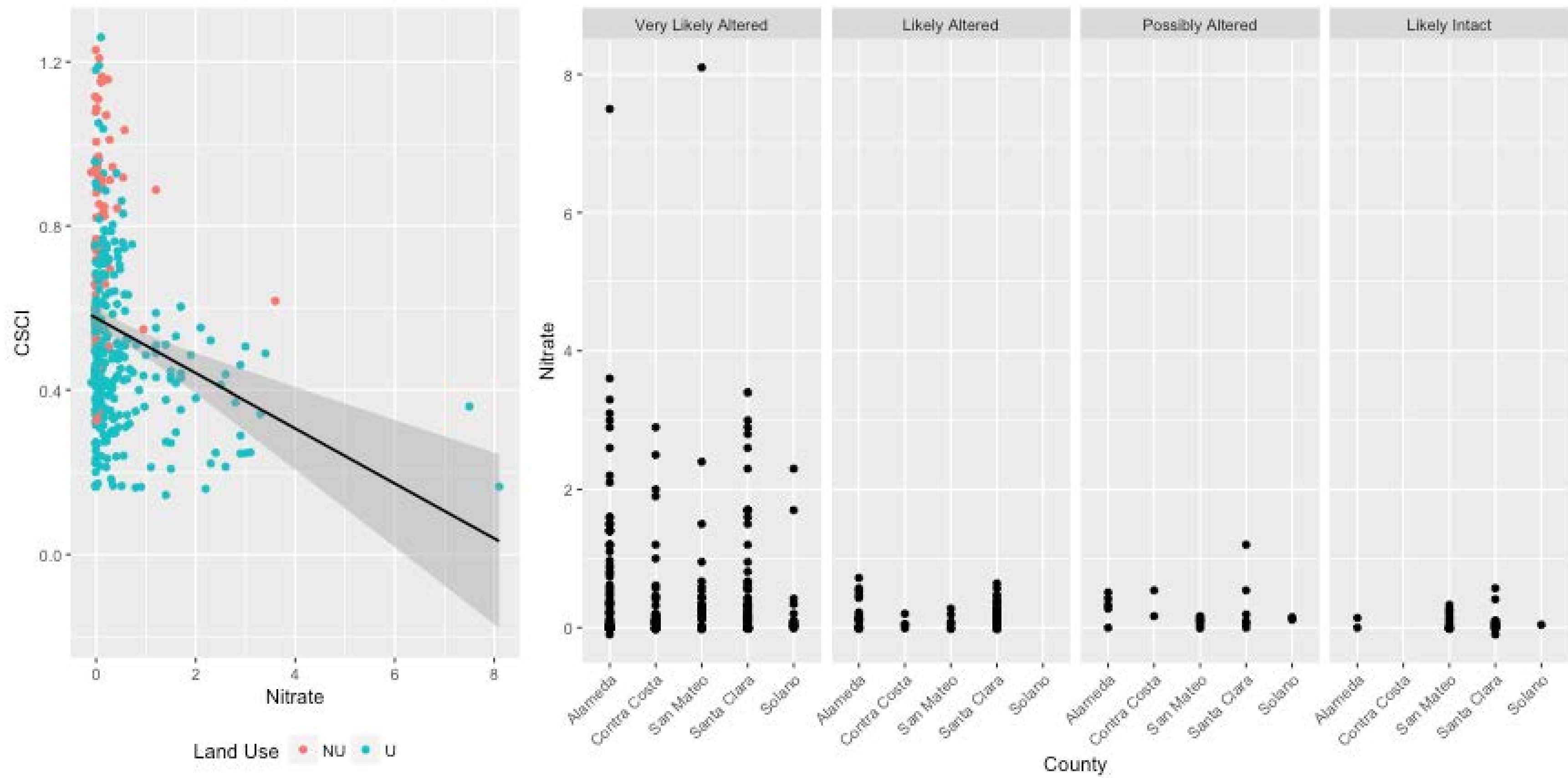

Figure 3-A. Relationship of Nitrate concentration to CSCI scores

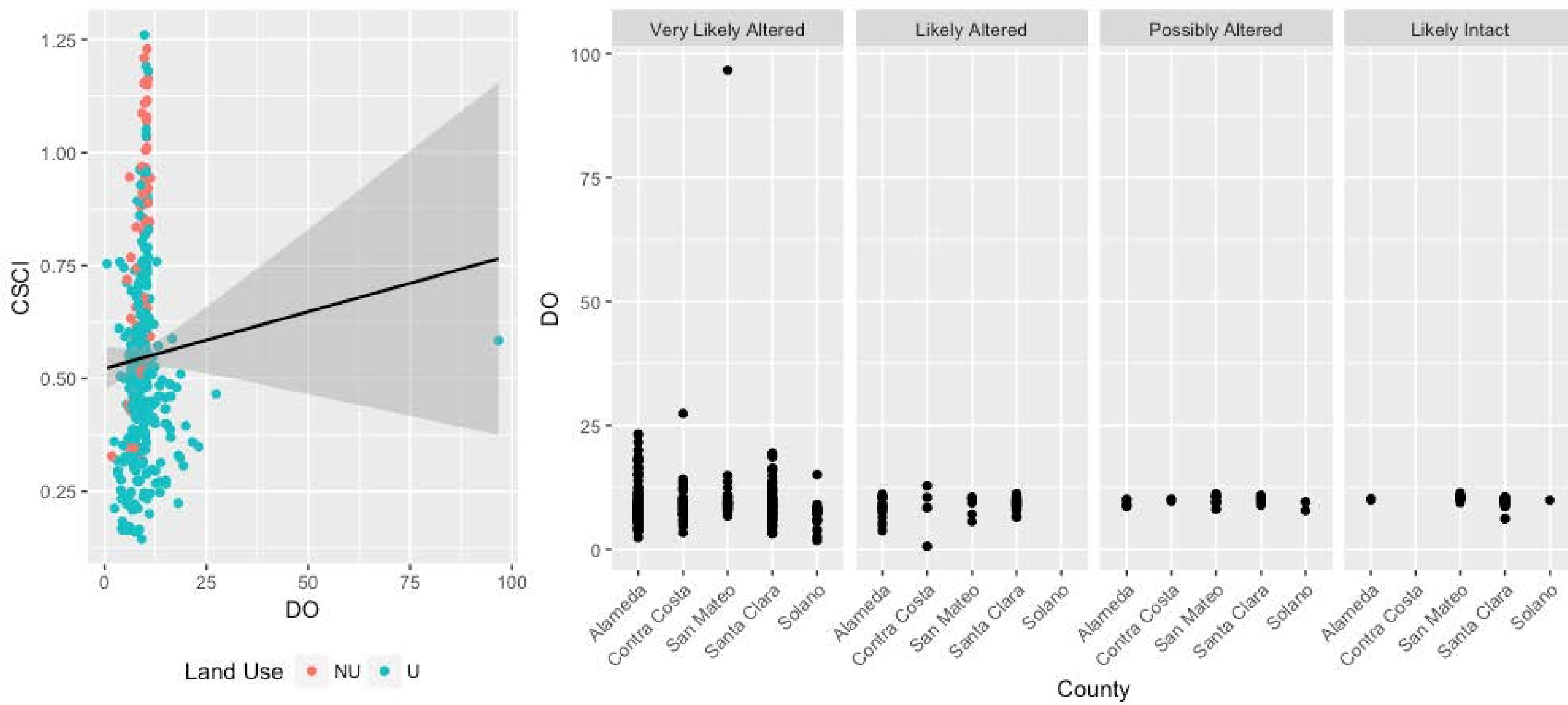

Figure 3-B. Relationship of Dissolved Oxygen values to CSCI scores

APPENDIX 4 ADDITIONAL FIGURES

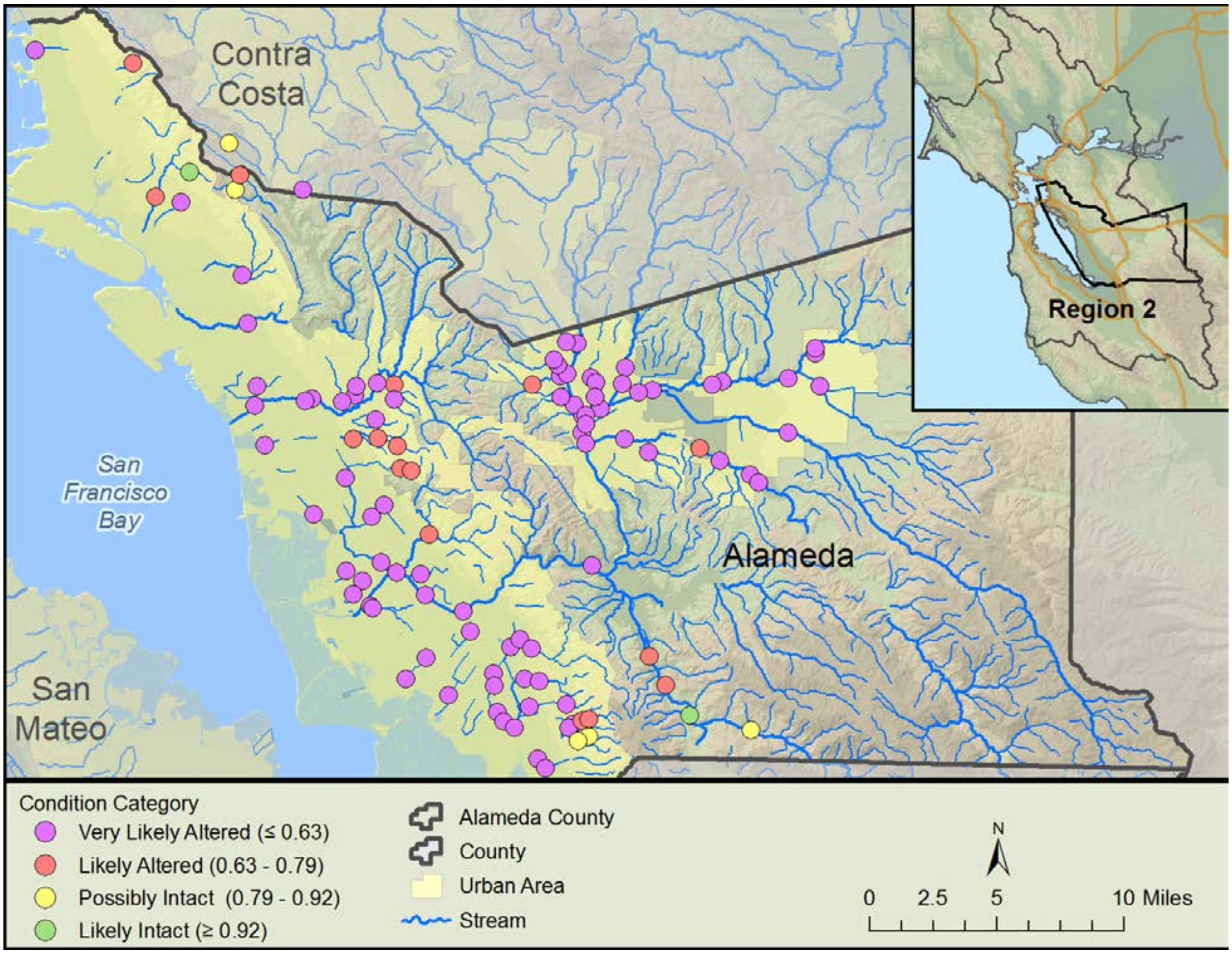

Figure 4-A. Biological condition based on CSCI scores in Alameda County.

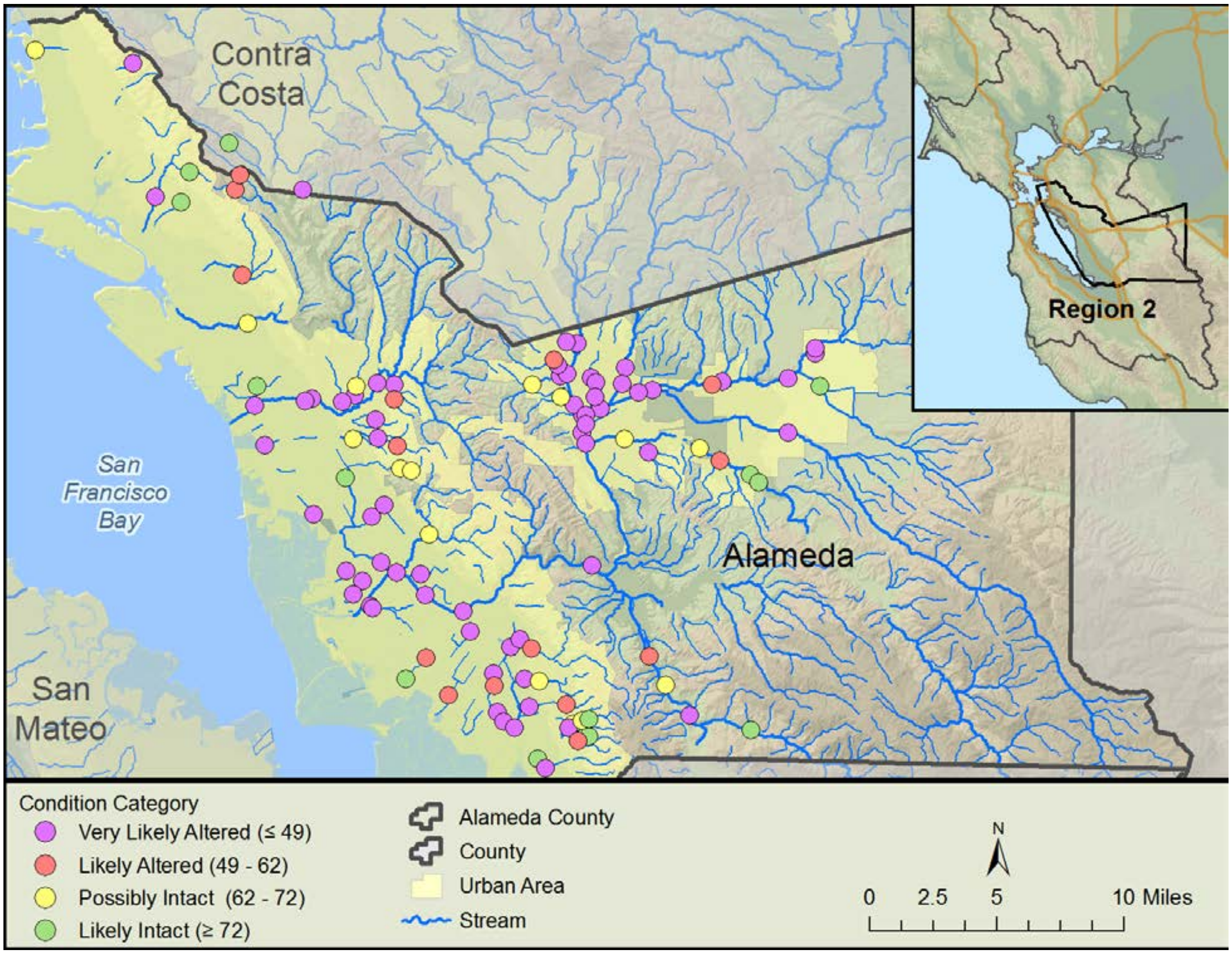

Figure4-B. Biological condition based on D18 scores in Alameda County.

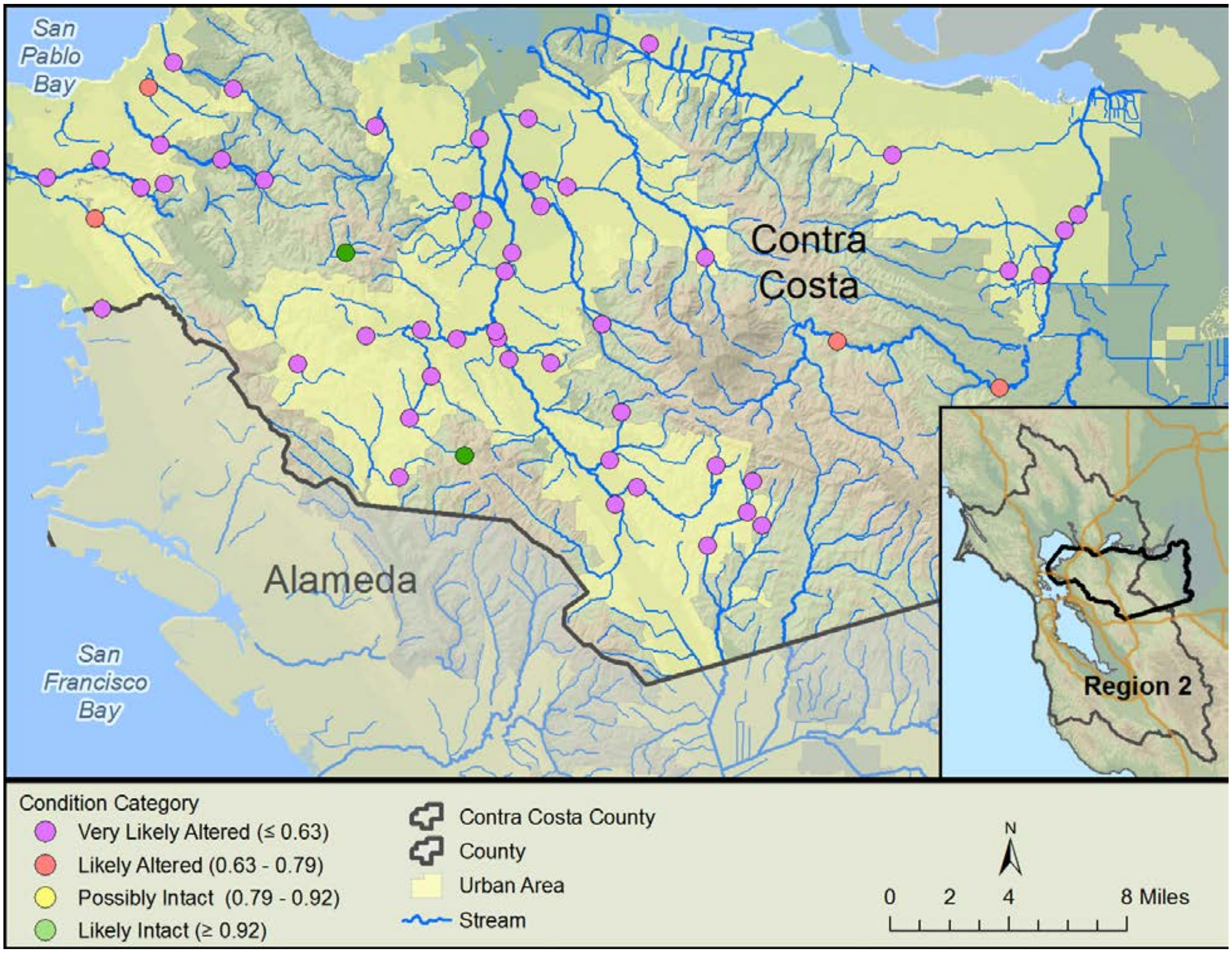

Figure 4-C. Biological condition based on CSCI scores in Contra Costa County.

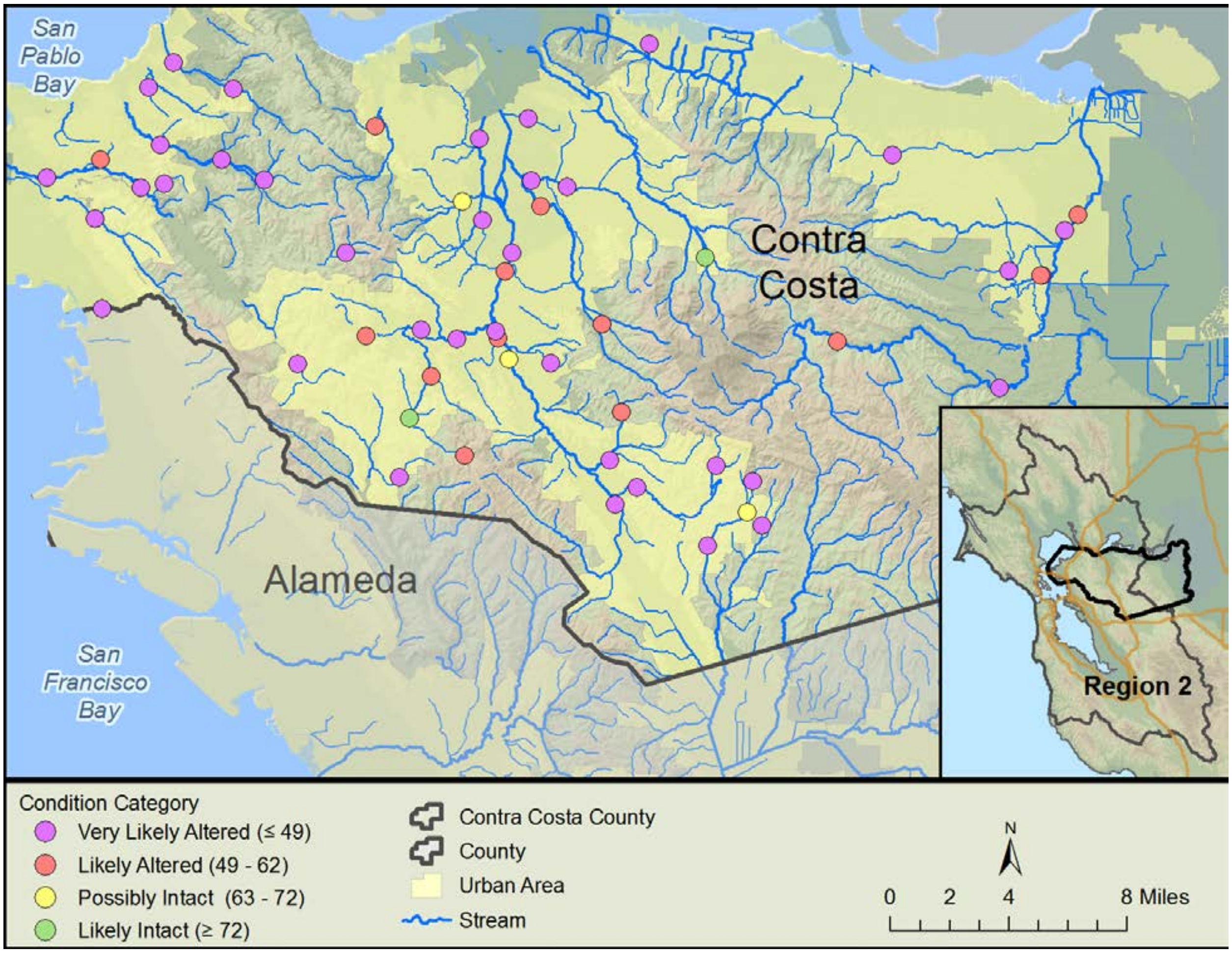

Figure 4-D. Biological condition based on D18 scores in Contra Costa County.

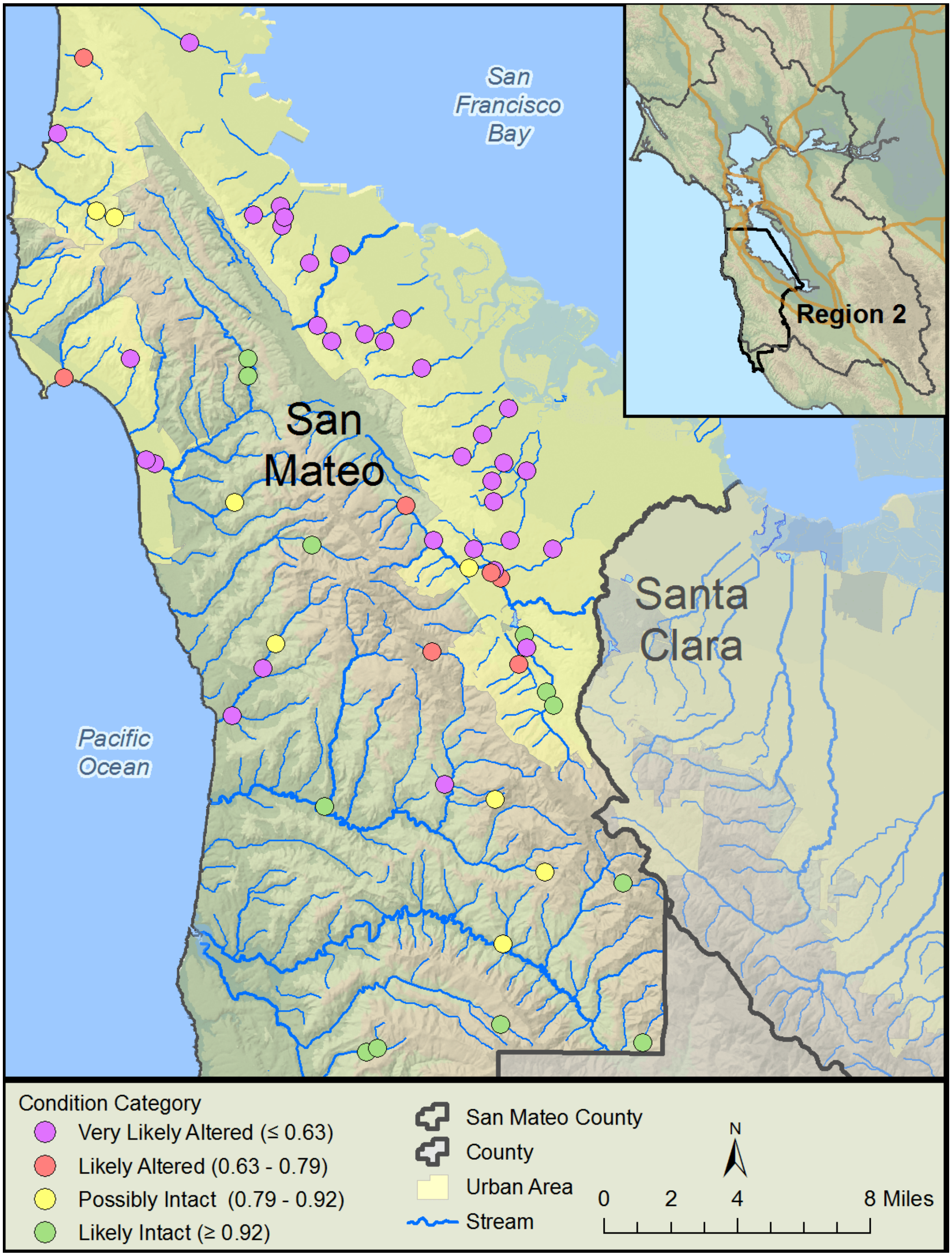

Figure 4-E. Biological condition based on CSCI scores in San Mateo County.

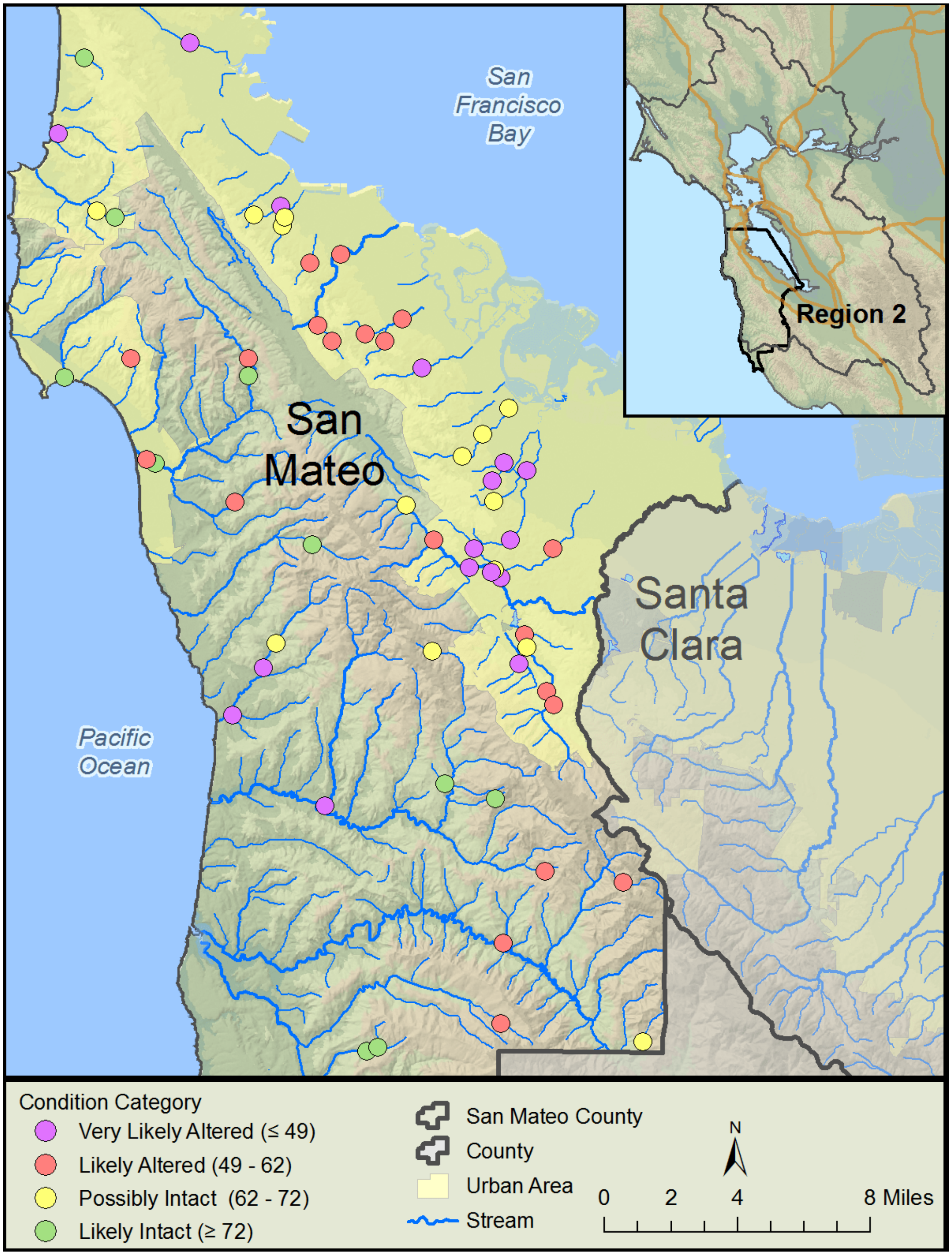

Figure 4-F. Biological condition based on D18 scores in San Mateo County.

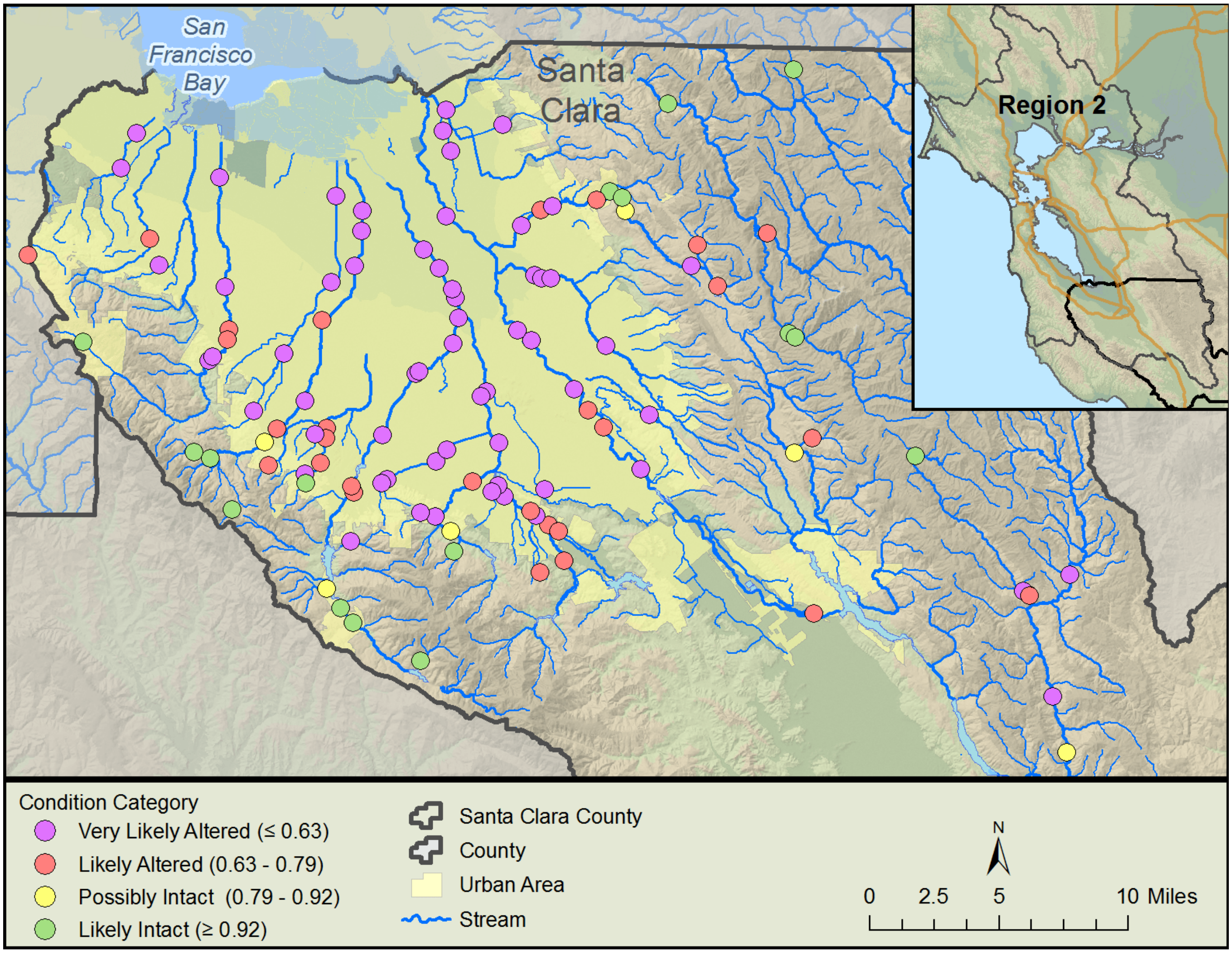

Figure 4-G. Biological condition based on CSCI scores in Santa Clara County.

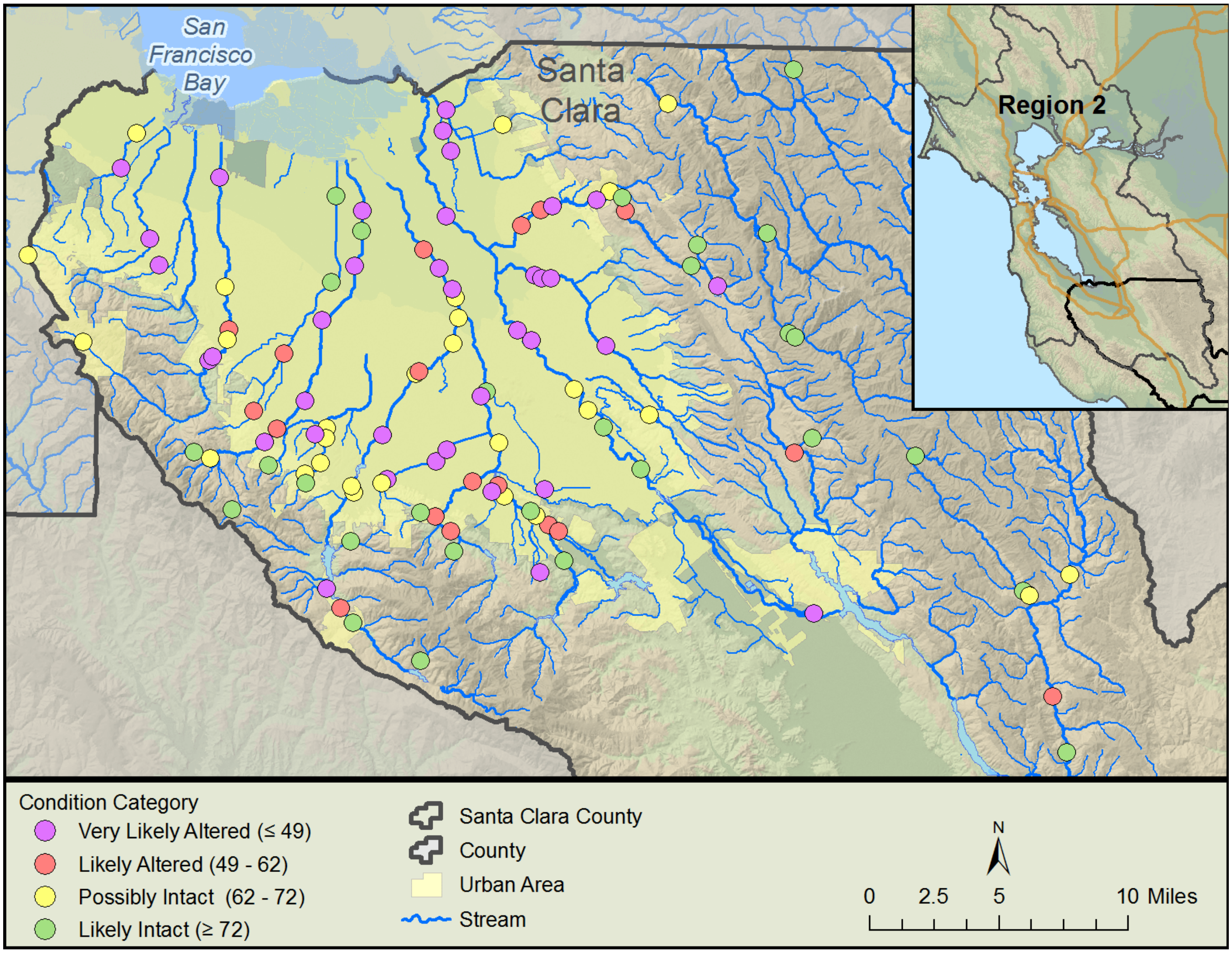

Figure 4-H. Biological condition based on D18 scores in Santa Clara County.

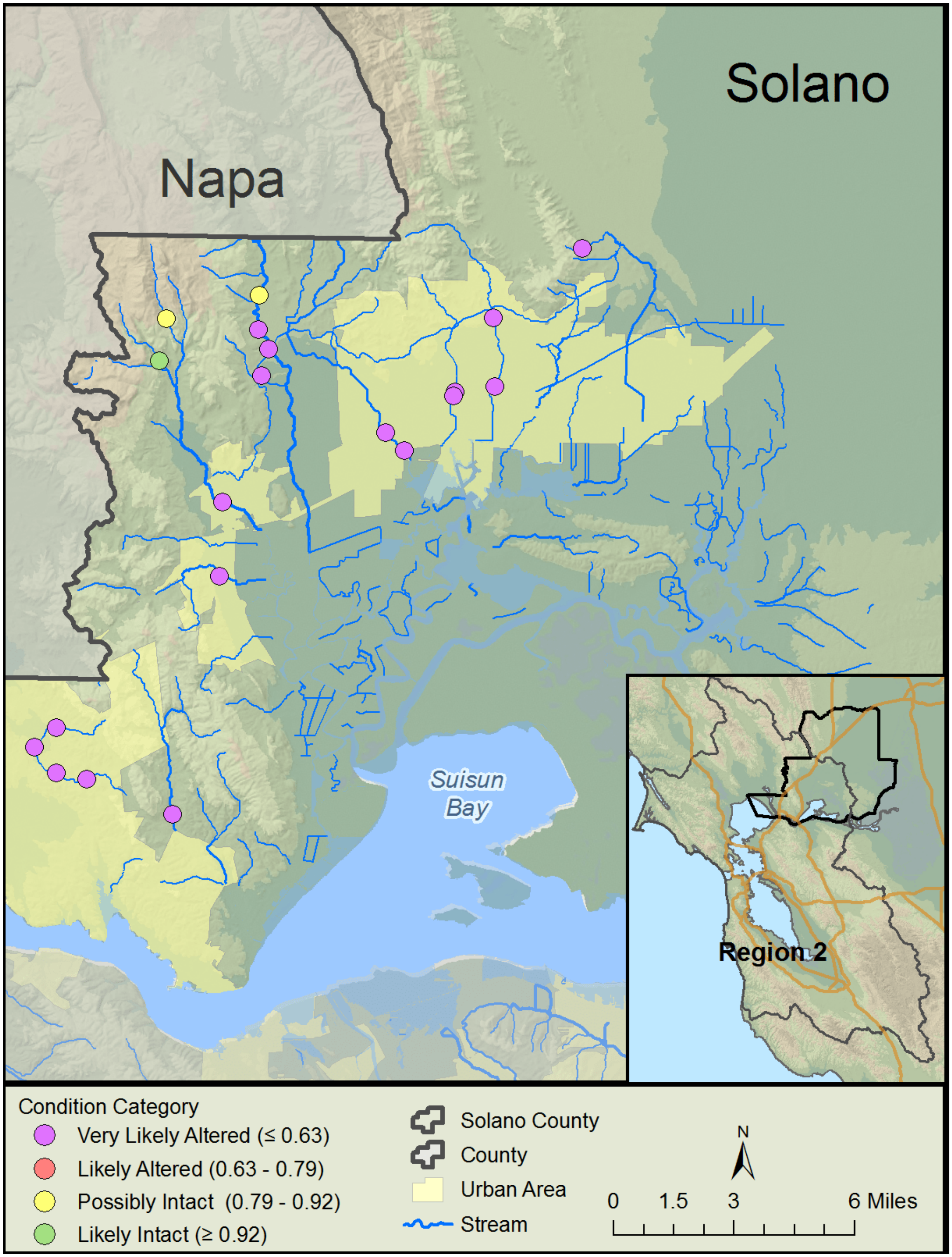

Figure 4-I. Biological condition based on CSCI scores in Solano County.

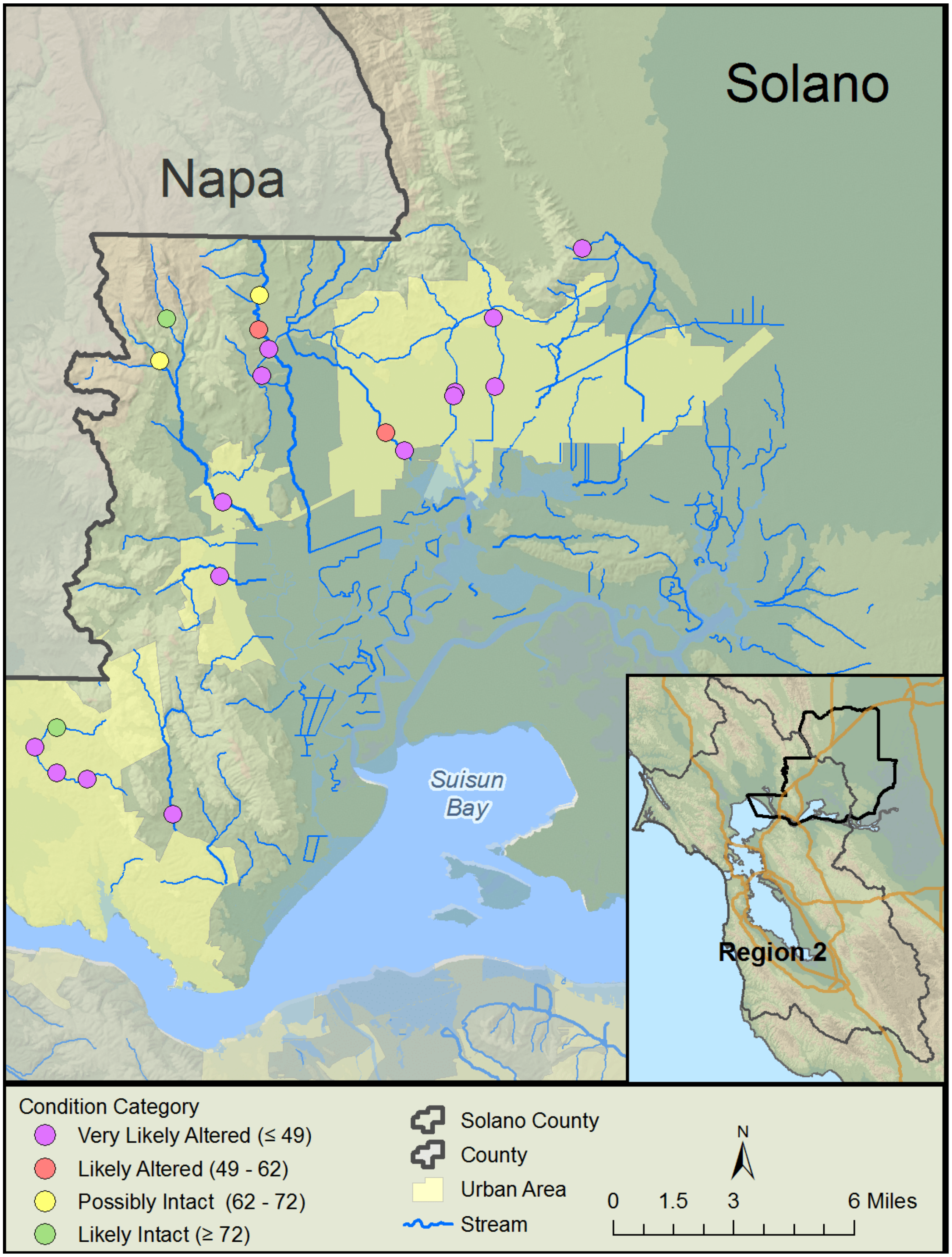

Figure 4-J. Biological condition based on D18 scores in Solano County.