C-11-V.0 URBAN STREAM BIOASSESSMENT MONITORING

C-11-V.1 Introduction

This section reviews results and findings on urban stream bioassessment monitoring, which consisted of field monitoring during the spring of 2016 by the Permittees. Bioassessment monitoring is a means of assessing the biological quality of aquatic habitat by evaluating the assemblage of benthic macroinvertebrates (BMIs). Each site is rated on its ecological structure and taxonomic completeness by using the California Stream Condition Index (CSCI), which is based on a statistical analysis of the distribution of organisms at a site (see the following link for the CSCI Fact Sheet and technical memo: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/883_CSCI-StatewideBioScoringTool.pdf). The CSCI is calibrated so that the score of reference sites is 1, and sites that approach 0 demonstrate a significant departure from reference conditions. **Section C-11-V.2** presents the CSCI scoring for 2015-16 monitoring locations. Bioassessment is one of the multiple lines of evidence performed at each site. Physical habitat and water samples are also collected and analyzed for aquatic chemistry (nutrients, major ions). The 2015-16 chemistry and toxicity data for the bioassessment program can be referenced at the following link: https://ocgov.box.com/v/2015-16-SAR-PEA-C11-Datasets.

C-11-V.2 Regional Monitoring

The Permittees began participating in a regional bioassessment monitoring program sponsored by the Southern California Stormwater Monitoring Coalition (SMC) and managed by the Southern California Coastal Water Research Project (SCCWRP) in 2009. This program was designed to assess stream health using the resident stream benthic macroinvertebrates to determine the water quality conditions within a stream reach. The "SMC Program" as it is known, is based on a probabilistic sampling design that allows the ambient condition of streams in southern California to be assessed and compared to stream systems in watersheds with similar conditions and land use. The original five year study spanned 2009-13 with 2014 acting as a transitional year. The goal of this multi-agency program is to:

1. Determine the status of macroinvertebrate conditions across southern California streams;
2. Identify key stressors that affect stream macroinvertebrate conditions; and,
3. Monitor receiving water stressors over time.

Stream monitoring sites are stratified by urban, open space, and agricultural land uses to provide a better assessment across stressor gradients from chemical, biological, and physical influences.

The 2014 sampling effort was the sixth year of the original five year study to assess stream macroinvertebrate conditions across southern California, which represented a transitional year for the regional program by expanding the original five year period and preparing the program for its next five year monitoring cycle. The report on the first 5 years of the SMC Program can be found at the following link:
http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/844_SoCalStrmAssess.pdf

The second SMC Program five year study began in 2015 and will span until 2019. The core questions from the original study have carried over with modifications to the program that reflect what was

learned and what still needs more understanding from the first five years. There has been a reduction in water quality analysis by eliminating metals, pesticides, and toxicity since these have not been correlated to the health of BMI assemblages. The new study emphasizes nutrients and elevated ions as these have statistically shown to be drivers of impaired biology. The technical report for the current five year study can be found at the following link:
http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/849_SMCWorkplan2015.pdf

There has been an introduction of several new methods of quantifying biological integrity beginning in 2015. New field components include channel modification, hydromodification, vertebrate identification, and flow regime, which are reported to SCCWRP through the SMC Stream Data Submission webpage. Contaminants of emerging concern (CECs) are sampled at the trend sites as a means of bioanalytical screens. Furthermore, a new experimental procedure was introduced in 2016 to assess algae taxonomy. DNA extractions were performed in coordination with SCCWRP and California State University, San Marcos as a potentially new taxonomic method. SCCWRP has also generated a new probabilistic site draw to use for this study. For the first time, non-perennial and first order streams have been included in the site draw. The SMC Program requires three condition sites to be sampled every year in the Santa Ana Region, with a new set of three sites changing each season. There is also a requirement for two developed trend sites and one open trend site to be revisited each year of the study. These sites are intended to be static and not change unless there are undesirable flow conditions or accessibility issues. It is important to note that trend sites are not necessarily limited to the Santa Ana Region of Orange County as the probabilistic site draws for trend sites are shared with the San Diego Region of the SMC Program. For 2016, the Santa Ana Region had the one open trend site (station SMC00105, see **Table C-11-V.1** and **Figure C-11-V.1** below). Conversely, both developed trend sites were in the San Diego Region for 2015 and 2016, and likely will be for the remainder of the five year study based on their seasonal flow condition and accessibility.

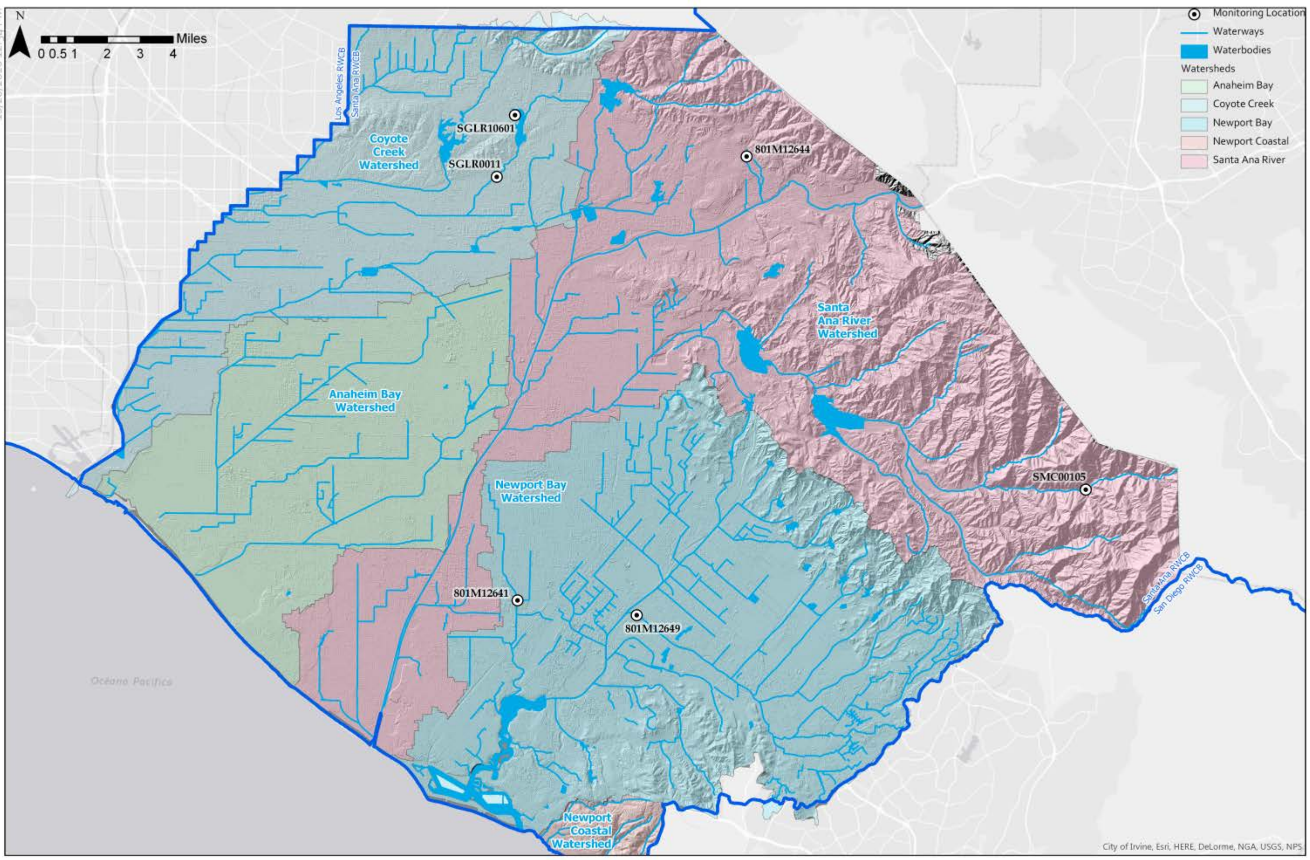
In addition to the SMC Program, the Permittees also participate in the San Gabriel River Regional Monitoring Program (SGRRMP). This program is designed to assess and improve the water quality impairments in the San Gabriel River Watershed, and contains a bioassessment component that follows both SWAMP and SMC protocols. Two stations on Fullerton Creek were selected for 2016, with station SGLR0011 being revisited on an annual basis. Station SGLR10601 will change in the 2016 sampling season. In addition to the SMC suite for water chemistry, the SGRRMP also monitors for metals, pyrethroids, organic carbon, and CECs. Toxicity is also monitored and tested for *Ceriodaphnia dubia* using a two dilution test for survival and reproduction.

Table C-11-V.1 and **Figure C-11-V.1** below describe the bioassessment monitoring sites sampled during the April to May 2016 index period. A total of six sites were visited in 2016: four as part of the SMC Program, and two sites (SGLR10601, SGLR0011) as part of the Permittees participation in the SGRRMP. A contract laboratory conducts the bioassessment sampling and taxonomic analyses on behalf of the Permittees.

Table C-11-V.1: Receiving Water Locations for Bioassessment Monitoring Program Table. The table displays 2016 monitoring stations, stream name, coordinates, and sample date.

Station	Station Description	Sample Date	Latitude	Longitude
801M12641	Santa Ana Delhi Channel	19-May-16	33.69422	-117.88293
801M12644	Esperanza Channel	28-Apr-16	33.89118	-117.76562
801M12649	San Diego Creek	11-May-16	33.68850	-117.81997
SGLR10601	Craig Park	19-May-16	33.90791	-117.88829
SGLR0011	Fullerton Creek	19-May-16	33.88054	-117.89743
SMC00105	Silverado Creek	28-Apr-16	33.74651	-117.58423

Figure C-11-V.1: Receiving Water Locations for Bioassessment Monitoring Program Map. The map depicts 2016 monitoring stations in the Santa Ana Region within each watershed boundary.

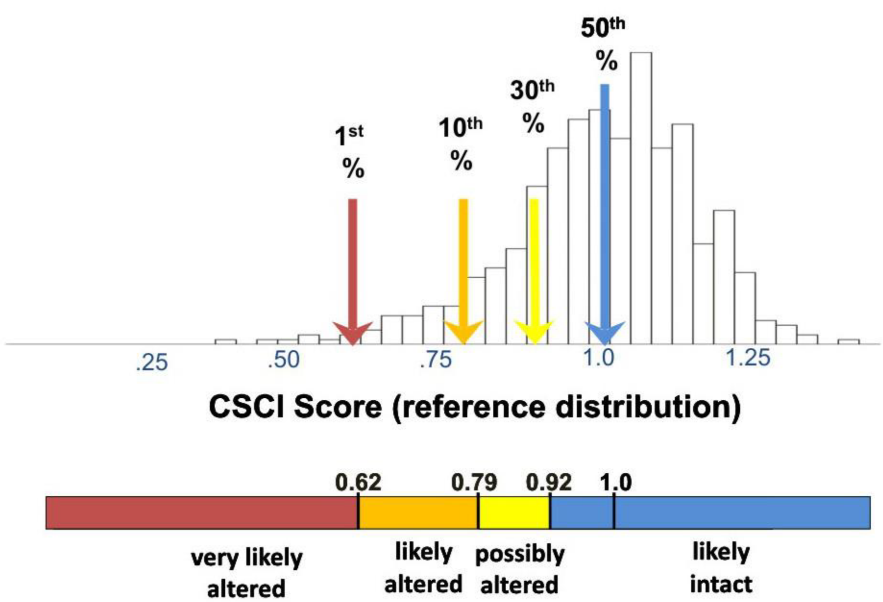


Data analysis was conducted for the 2015-16 monitoring activities by using the CSCI. The following section details the CSCI scores for the six sites monitored as part of the Regional SMC Program in 2015-16. **Attachment C-11-I** includes additional information on the methods used to develop this analysis.

CSCI Results

The CSCI was created to address some of the limitations of previous biological indices, such as the Southern California Index of Biotic Integrity (SoCal IBI). Several stream types exist within California, and regional indices like the SoCal IBI did not accurately represent the wide variation of reference conditions. The CSCI was developed with a robust dataset of these reference conditions to allow for representative biological benchmarks. Two indices are combined to create the CSCI, each quantifying different biological conditions of a stream: a multi-metric index (MMI) that measures ecological structure and function, and an observed-to-expected (O/E) index that measures taxonomic completeness. These indices are averaged to provide more comprehensive lines of evidence. Scoring of reference conditions has been calibrated to 1, and sites that begin to approach 0 demonstrate a significant departure from reference condition. A minimum threshold has not been established. **Figure C-11-V.2** displays the CSCI scoring distribution with thresholds and condition categories. A SWAMP technical memo is available detailing the creation, scoring, and calculations of the CSCI at the following link: http://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/docs/csci_tech_memo.pdf

Figure C-11-V.2: CSCI Scoring Distribution. This figure displays the scoring distribution of reference sites that were used to create the CSCI. Scoring thresholds and condition categories are included.



The CSCI score, component observed-to-expected (O/E) index, and the multi-metric index (MMI) scores for the six sites collected in 2016 are presented in **Table C-11-V.2** and **Figure C-11-V.3**. **Table C-11-V.3** explains the six metrics that constitute the MMI. CSCI scores ranged from 0.39 at station 801M12641 located in a highly modified concrete-lined flood control channel (Santa Ana Delhi) to 0.72 at station SGLR10601 located in Fullerton Creek in Craig Regional Park in a flood control managed stream with an earthen bottom and earthen banks fed by urban runoff. Other than station SMC00105 in Silverado Canyon (CSCI score 0.68), each of the other sites was located in cement lined channels or in soft bottom streambeds with heavily shored banks, and CSCI scores did not exceed 0.62 (801M12644, Esperanza Channel).

It should be noted that the CSCI score at SMC00105 (0.68) does not necessarily mean that the benthic communities were more impaired than SGLR10601 (0.72). In fact, in looking at the MMI (**Table C-11-V.2**), SMC00105 was much higher (0.74 to 0.55). Thus, the physical composition of the benthic community scored better. However, the O/E index is relative to the watershed scale, and this is where SGLR10601 performed better (0.89 to 0.63). In other words, this site scored relatively higher for an urban stream. The habitat is also relatively complex, and this is captured in the physical habitat section below in **Figure C-11-V.4**.

It is important to stress there is not an established minimum disturbance threshold for the CSCI, however low values should be considered indicative of degradation. Furthermore, the CSCI percentiles show how similar the biological condition is for a given site compared to the distribution of reference sites it was compared against. For example, station SGLR10601 was similar in biological condition to 4% of sites in the reference distribution to which it was compared. In contrast, four of the other five stations were located in heavily shored or concrete lined channels and fell outside the reference distribution (percentile scores ≤ 0.01). The exception was station SMC00105 which was comparable to 2% of the reference distribution and is mostly a natural riparian area.

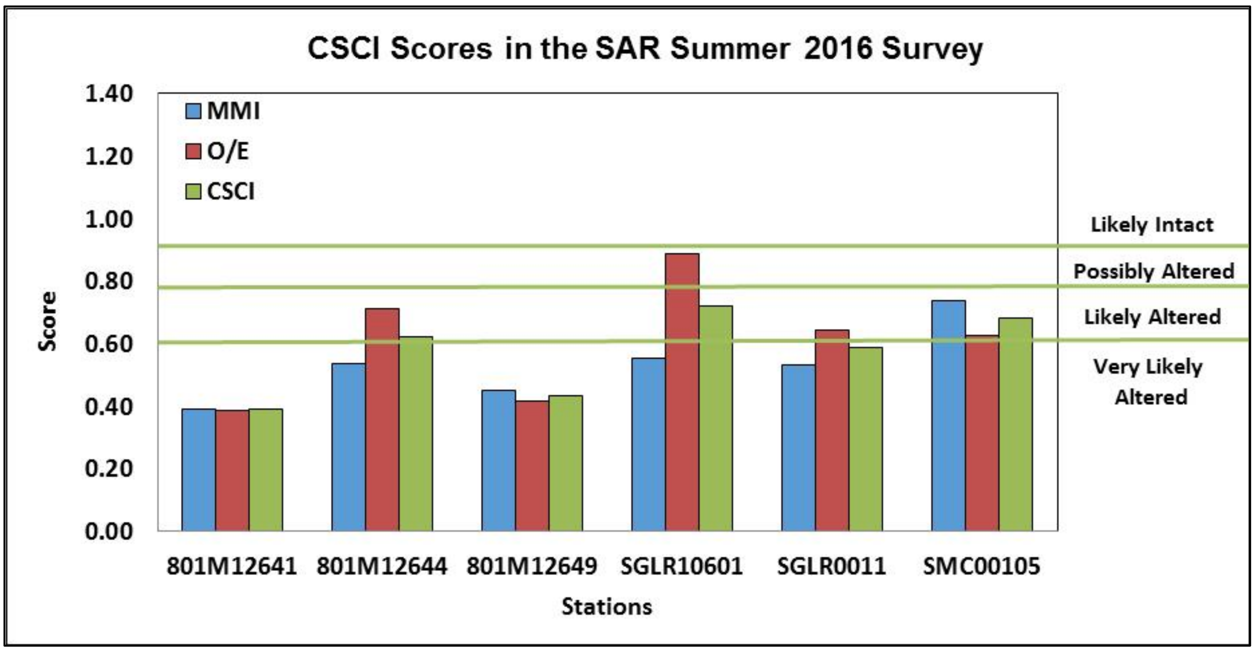
Table C-11-V.2: CSCI Scores and Metrics for Sites Monitored in the Santa Ana Region, 2016. The CSCI is the average of the O/E and MMI indices. The percentile of the CSCI scores is relative to the reference distribution sites they were compared to for the analysis.

CSCI	801M12641 Santa Ana Delhi	801M12644 Esperanza Channel	801M12649 San Diego Creek	SGLR10601 Fullerton Creek	SGLR0011 Fullerton Creek	SMC00105 Silverado Creek
CSCI						
CSCI Score	**0.39**	**0.62**	**0.43**	**0.72**	**0.59**	**0.68**
CSCI Percentile	**0.00**	**0.01**	**0.00**	**0.04**	**0.01**	**0.02**
CSCI Category	**Very Likely Altered**	**Likely Altered**	**Very Likely Altered**	**Likely Altered**	**Very Likely Altered**	**Likely Altered**
MMI Metric						
% Clinger Taxa	26	27	17	19	18	16
% Coleoptera Taxa	0	0	0	0	0	24
Taxonomic Richness	9	12	11	17	10	15
% EPT Taxa	18	13	18	17	39	22
Shredder Taxa	0	1	0	2	0	0
% Intolerant	0	0	0	0	0	1
MMI Score	**0.39**	**0.54**	**0.45**	**0.55**	**0.53**	**0.74**
MMI Percentile	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.07**
O/E						
Mean Observed Taxa	3	6	3	7	7	5
Expected Taxa	8	9	8	8	11	8
O/E	**0.39**	**0.71**	**0.42**	**0.89**	**0.64**	**0.63**
O/E Percentile	**0.00**	**0.07**	**0.00**	**0.28**	**0.03**	**0.02**

Table C-11-V.3: Descriptions of the Six MMI Metrics. The MMI's six metrics represent different aspects of BMI assemblage composition and function. All of the taxa associated with each metric respond poorly to impaired habitat.

MMI Metric	Description	Response to Impairment
% Clinger Taxa	Percent of taxa that are adapted for attachment to surfaces in flowing water.	Decrease
% Coleoptera Taxa	Percent taxa from the insect order coleoptera.	Decrease
Taxonomic Richness	Total number of individual taxa.	Decrease
% EPT Taxa	Percent taxa in the orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly).	Decrease
Shredder Taxa	Number of taxa that shreds coarse particulate matter.	Decrease
% Intolerant Individuals	Percent of organisms in the sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1, or 2.	Decrease

Figure C-11-V.3: CSCI, O/E and MMI Scores for Sites Monitored in the Santa Ana Region, 2016. This figure displays the tabular data for O/E, MMI, and CSCI from **Table C-11-V.2**. Green lines denote scoring thresholds.



Research and usage of the CSCI scoring system is expected to increase in the future as it has become the standard scoring index used by the Stormwater Monitoring Coalition. Additional context and historical analysis using the CSCI can be found in **Section C-11-V.3 Spatial Pattern Analysis**.

Physical Habitat and CRAM Methods

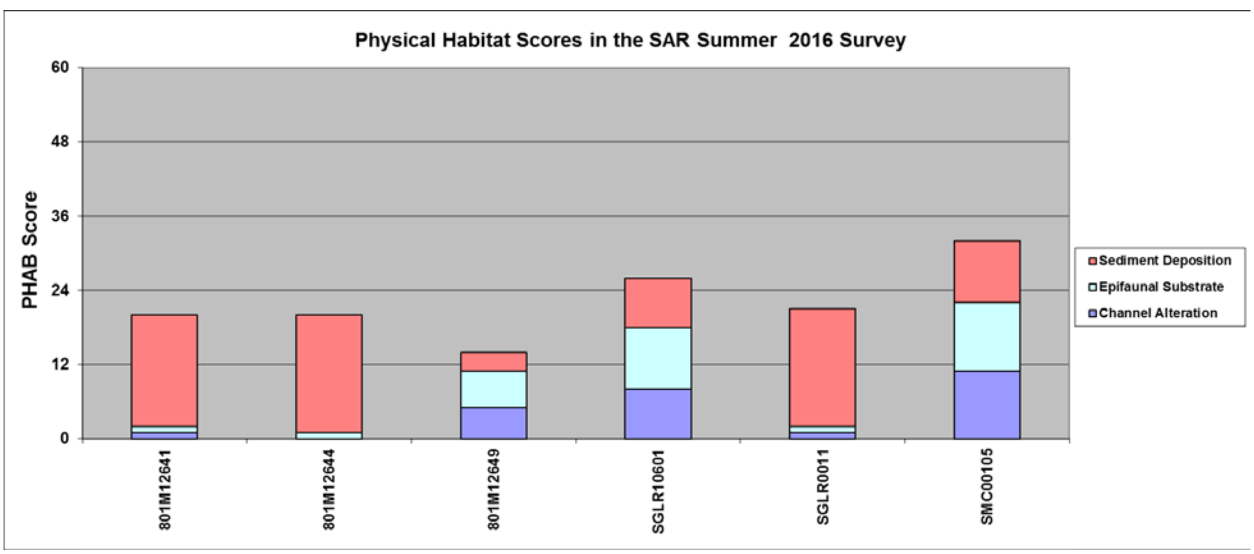
The bioassessment field data collection (benthic macroinvertebrates, algae, physical habitat) were conducted according to SWAMP protocols which can be found at the following link: http://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/docs/combined_sop_2016.pdf

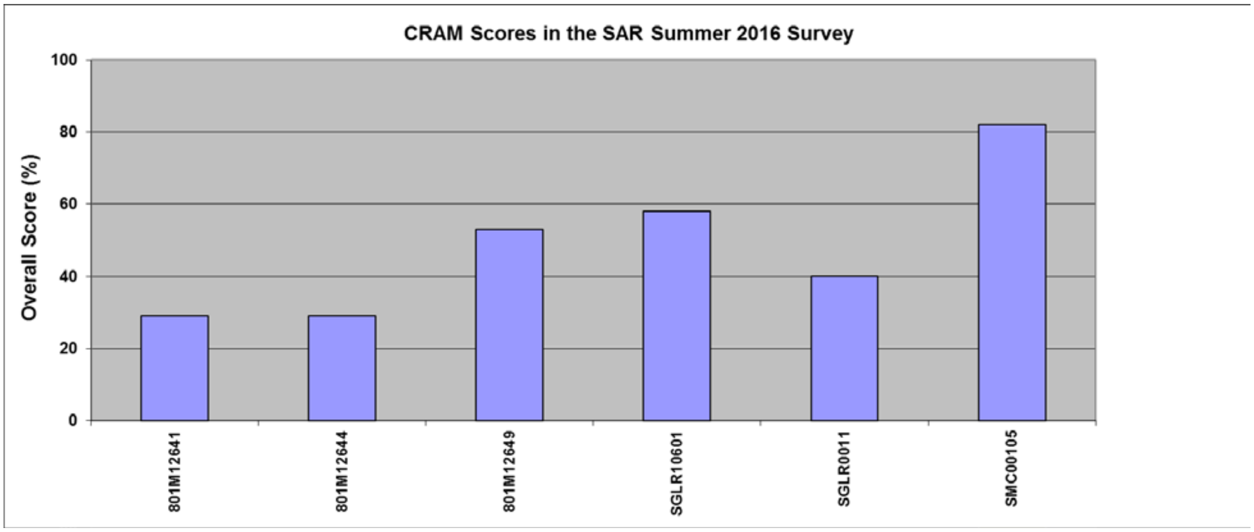
In addition to the SWAMP in-stream physical habitat condition measurements, the SMC Program also specifies that the California Rapid Assessment Method (CRAM) be conducted at each site. This protocol provides an assessment of not only the instream habitat condition, but also of hydrology and the buffer zone surrounding the site, including the biotic structure of the riparian zone. Details of the CRAM assessments can be found at the following link: http://www.cramwetlands.org/

Physical Habitat and CRAM Scoring

Monitoring results are presented in **Figure C-11-V.4** below.

Figure C-11-V.4: Physical Habitat and CRAM Scores in 2016 (Continued on Next Page). The first chart includes physical habitat condition, which is important to the biological condition. Physical habitat is assessed at each site by determining how much sediment deposition there is in the stream bed (more is detrimental), the amount of epifaunal substrate cover (more is better), and the amount of channel alteration that has occurred (more is detrimental). Site SMC00105 had the best overall physical habitat condition which was reflected in a relatively higher CSCI score. As portrayed in the site location map (**Figure C-11-V.1**), this site is located in the upper watershed where habitat conditions are the most favorable. The other sites had poorer physical habitat conditions, with the exception to SGLR10601. California Rapid Assessment Method (CRAM) scores are included in the second chart. CRAM provides a measure of streambed, riparian, buffer zone, hydrologic, and biotic condition, thus providing a wider assessment of physical habitat. The trend for this measure was slightly different than the physical habitat assessment, but tracked with the CSCI scores.





The physical habitat conditions for each of the SMC Program sites were assessed using three attribute scores (sediment deposition, epifaunal substrate, channel alteration) that, together, are summed to a total score ranging from zero (poorest condition) to 60 (best condition). SMC00105 had the highest score of 31. Despite being an upper watershed station, it is located next to single family homes and a parking lot at the lower end of the sampling reach. These factors are suppressing the physical habitat score, and are likely driving the relatively low CSCI score of 0.68. The SGLR10601 score of 26 is relatively high for an urban site, which correlates to the CSCI score 0.72.

CRAM scores for each site were somewhat consistent with the CSCI and physical habitat scores. Of note is that site SMC00105 had a CRAM score of 82, which is just within the excellent range and indicates very good habitat condition. The rest of the CRAM scores had some variance, ranging from 29 to 58, nearly spread out over the entirety of the poor to fair ranges. These sites share similar characteristics due to their channel engineering and/or flood control influences. CRAM assessment is important in determining stream health since it evaluates not only the condition of the stream bed habitat, but also the condition of the buffer zones surrounding the riparian zone out to 250 meters on either side of the stream. The higher CRAM score for Silverado Canyon coincided with a fairly lower CSCI score, which could be pointed to a seasonal anomaly or the persistent drought.

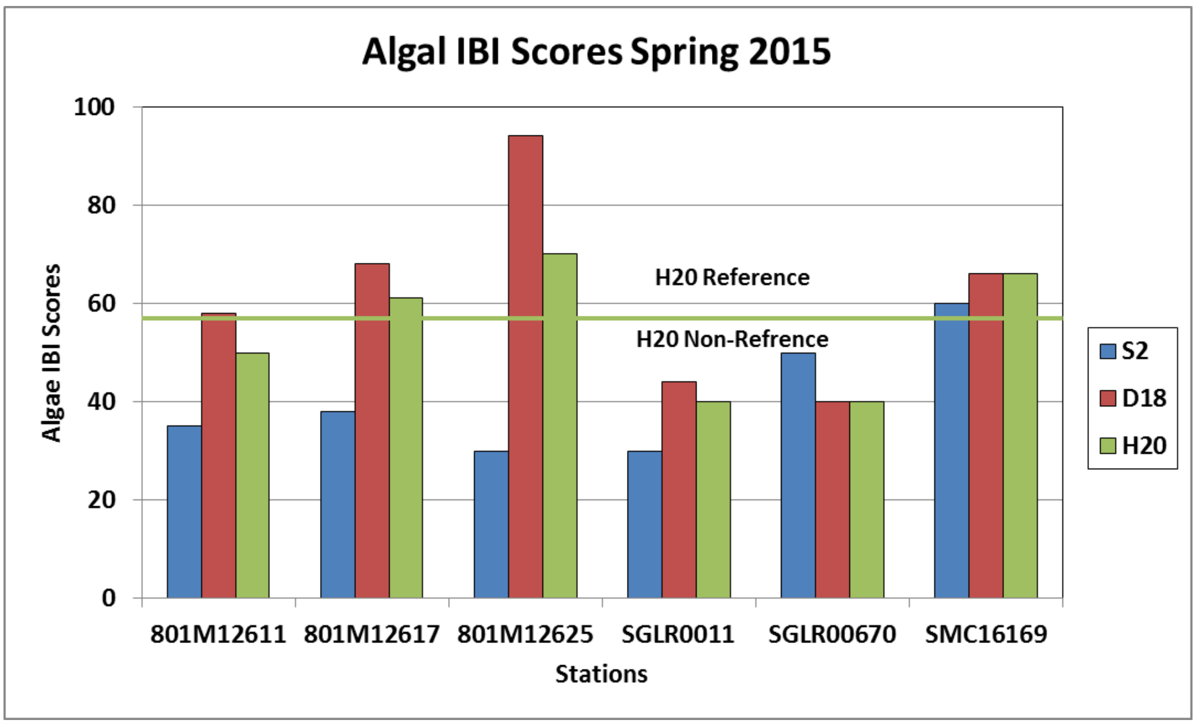
Attached Algae

Soft-bodied algae and diatom community structure can be used to assess many aspects of stream water quality including the effects of nutrient loading and other contaminants, such as dissolved metals and trace organics. The Southern California Coastal Water Research Project (SCCWRP) scientists have created the Southern California Algae Index of Biotic Integrity (SoCA Algal IBI) which is similar to the index used for BMIs to assess anthropogenic impacts. Algae samples were collected from 2007 through 2010 at a total of 451 distinct southern California stream reaches to develop the IBI scoring system. The SoCA Algal IBI is composed of three indices: 1) a diatom IBI (D18) is based solely on diatom metrics, 2) a soft algae IBI (S2) is based solely on non-diatom (soft) algae metrics, and 3) a hybrid (H20) of both diatom and soft bodied algae metrics. IBIs are composed of metrics chosen for their ability to differentiate between reference and non-reference stream conditions. The SoCA Algal IBI metrics, IBI score, and quality control results were calculated using the SCCWRP SoCA Algal IBI calculator and its underlying R script.

Figure C-11-V.5 below contains algae data from the three indices for the bioassessment sites sampled in 2015. The 2016 data is still being analyzed by the State and should be ready in early 2017. The H20 boundary chosen to delineate between reference and non-reference condition (57 on a scale from 0 to 100) was based purely on statistical grounds, and was calculated as two standard deviations below the mean distribution of reference sites. As a result, it does not represent an ecologically meaningful change point in community composition and cannot be used in a regulatory framework. An H20 score above 57 is considered reference condition, and below 57 is considered non-reference. The S2 and D18 indices do not have accepted scoring thresholds to date. There is an algae CSCI in production and may be ready for use by the end of 2017.

The figure demonstrates that both reference location sites (SMC16169, Silverado Creek) and urban locations (801M12617, 801M12625) can score well with the H20 index. Further study and trend analysis should be completed before any conclusions can be made from these assessments. The algal CSCI could assist with this effort in the future.

Figure C-11-V.5: Algal IBI Scores, Spring 2015. The figure displays the 2015 SoCA Algal IBI and the three indices for the six monitored stations. 2016 results should be available in early 2017.



C-11-V.3 Spatial Pattern Analysis

In addition to describing patterns and trends in benthic invertebrates, a further purpose of the SMC Program is to evaluate the triad of monitoring indicators to determine whether physical habitat, aquatic chemistry, and toxicity (where sampled) are correlated with CSCI scores. If strong correlations exist, then this would suggest the presence of a causal relationship between the various stressors and biological integrity. Previous analysis conducted by the SMC has shown that water chemistry and toxicity data does not have a strong correlation with impaired biology, thus the suspension of metals, pesticides, and toxicity collection (except with the SGRRMP). Physical habitat remains the strongest driver of low CSCI scores. The spatial pattern analysis of biotic integrity consists of three elements:

1. Spatial Distribution;
2. Relationship to Aquatic Chemistry and Toxicity; and,
3. Biological Cluster Analysis

Spatial Distribution

Broad patterns exist in 2016 for interrelated indicators (i.e., CSCI and CRAM) and were mapped in **Figure C-11-V.6** below. As with other years, impaired physical habitat is linked with undesirable benthic assemblages. **Figure C-11-V.7** shows consistently low CSCI scores across the urbanized portion of the County (CSCI ≤ 0.80). Some sites in the upper watershed, east of Irvine Lake had CSCI scores that were ≥ 0.80 indicating the biological communities found there were similar to those found at reference sites in the southern California region. The physical habitat and surrounding riparian zones tend to be of better quality in these areas.

Figure C-11-V.6: Summary of Overall Conditions in Spring 2016. The map depicts overall conditions observed at sites monitored in 2016. For this analysis, physical habitat was measured using the comprehensive California Rapid Assessment Method (CRAM).

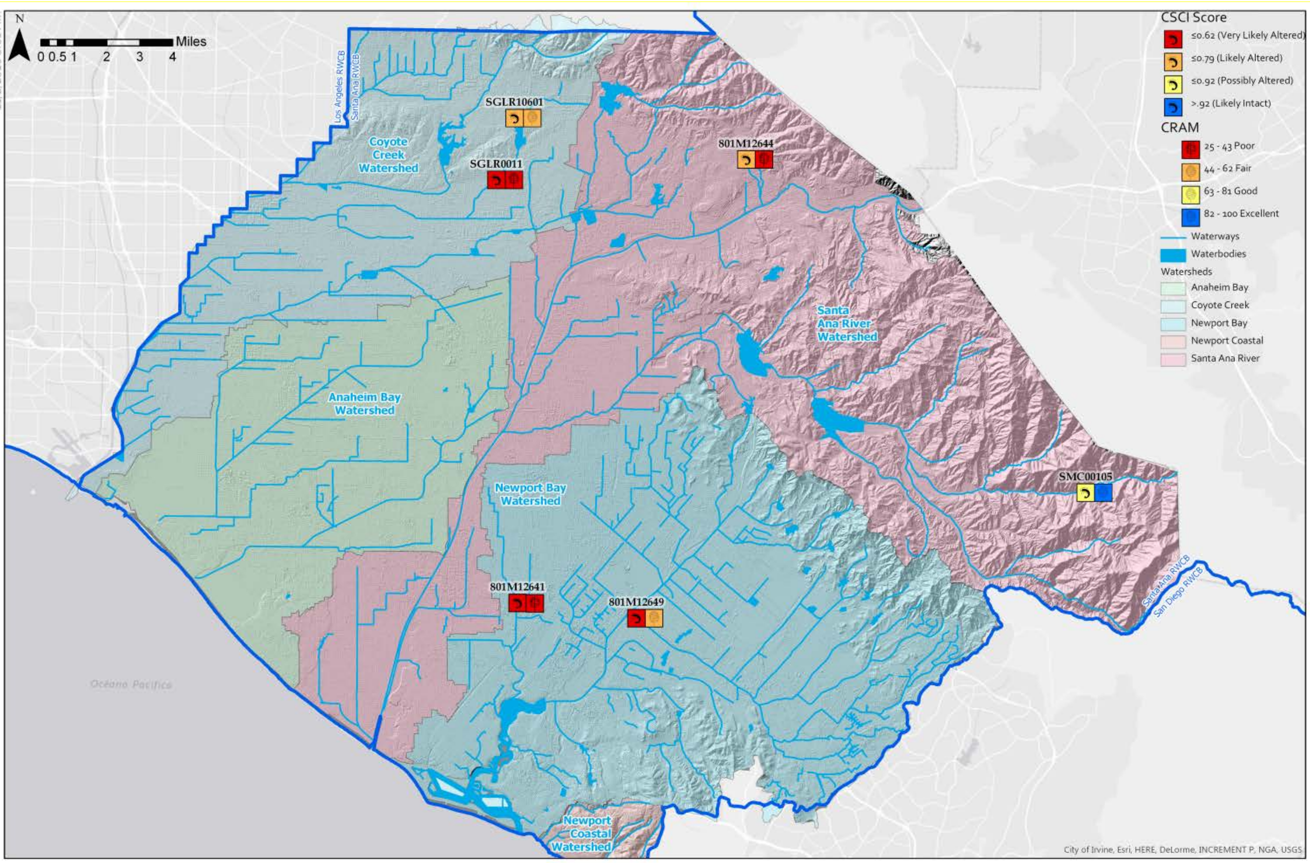
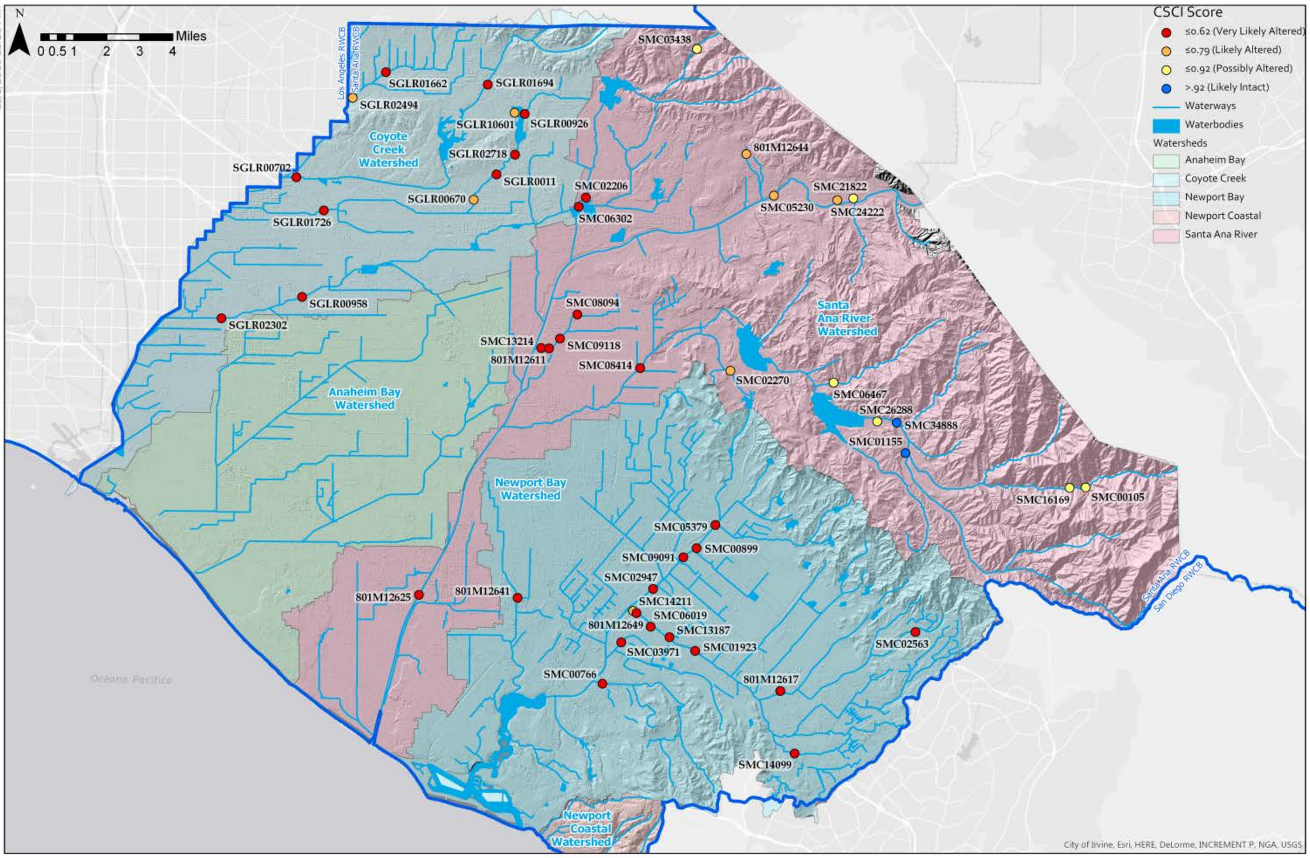


Figure C-11-V.7: Patterns of CSCI Scores for the SMC Program, 2009 - 2016. This map shows regional CSCI scores observed as part of this SMC monitoring program since inception in 2009. The color scheme for the scores has been adjusted from **Figure C-11-V.2** to match the CSCI scale used in the referenced SWAMP technical memo.



The CRAM scores for these same sites showed a very similar pattern, with the poorest habitat scores associated with sites in the highly urbanized lower watershed and highest scores associated with sites in the upper watershed, especially east of Irvine Lake as shown in **Figure C-11-V.8**. There was a strong association between CSCI and CRAM scores (R^2 = 0.54) in these watersheds as shown in **Figure C-11-V.9**.

Figure C-11-V.8: Patterns of CRAM Scores for the SMC Program, 2009 - 2016. This map shows overall CRAM scores observed in the SMC monitoring program since inception in 2009.

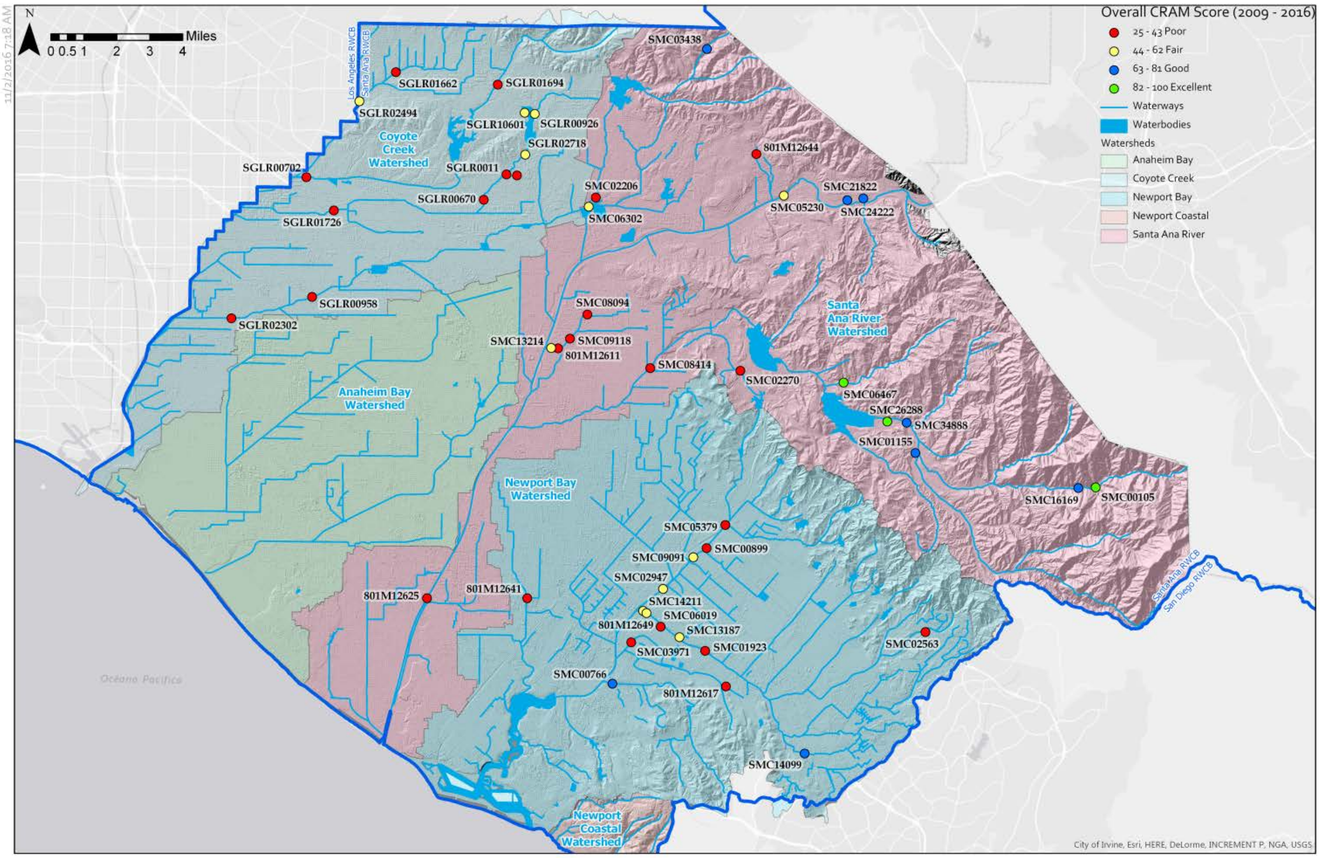
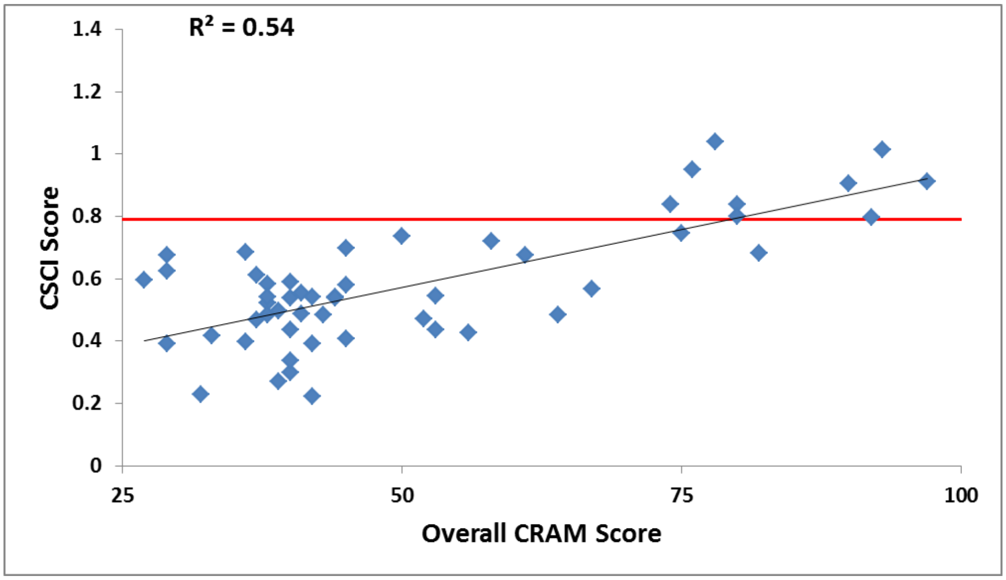


Figure C-11-V.9: CSCI Score versus Overall CRAM Score. This graph shows the correlation between CRAM scores of the riparian and buffer zones surrounding a stream reach and the biological condition (CSCI score). Correlations with biological condition of 0.4 or greater ($R^2 = 0.54$) are considered to be reasonably strong for this assessment. The red horizontal line indicates the 30th percentile, and scores below this line are either fall in the likely or very likely altered condition categories.



Relationships to Aquatic Chemistry and Toxicity

Detailed monitoring data for aquatic chemistry and toxicity (at the two SGRRMP stations) were examined to determine whether there are any clear relationships to biotic integrity at a finer level of detail. No definitive relationships could be made between nutrient concentrations and CSCI scores. However, stations on streams with known groundwater sources (801M12641, 801M12644, 801M12649) did have elevated dissolved solids, which more than likely contributed to the lower CSCI scores at these stations. It should be mentioned that these three stations are also in highly modified concrete channels, so their physical habitat is also significantly impaired and certainly driving down the biological integrity. Trying to determine the extent to which these factors have contributed to impaired biology is difficult to assess. Causal analysis may be needed to tease out the impairments in these types of stream habitats. CTR exceedances of metals were not observed for the dissolved fraction for both acute and chronic concentrations. No aquatic toxicity was observed at the two SGRRMP stations using a two dilution test for *Ceriodaphnia dubia*, and the SGRRMP has decided that aquatic toxicity will not be evaluated in 2017.

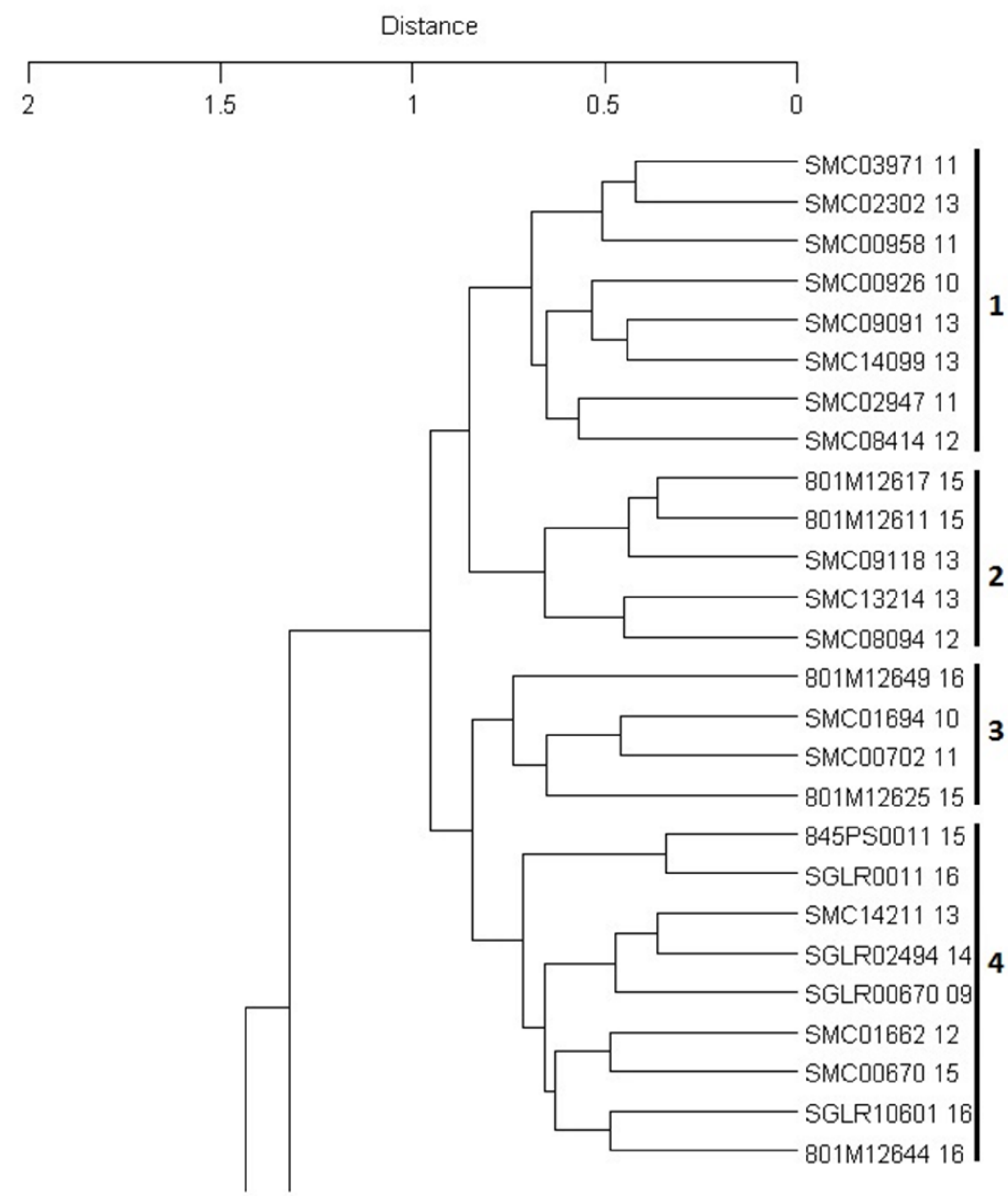
A more detailed analysis of the individual parameters monitored with a historical perspective can be seen in the Correlation with Parameters section with **Figure C-11-V.14** through **Figure C-11-V.18**.

Biological Cluster Analysis

A more powerful set of analyses was used to discern relationships between the biological patterns in the benthic community and patterns in potential explanatory variables in the physical habitat, aquatic chemistry, and aquatic toxicity, where available.

As a first step, the species data from all surveys were clustered to identify groupings of sites that were similar in terms of their community composition. The dendrogram in **Figure C-11-V.10** below shows the cluster analysis of all sites during surveys conducted from 2009 to 2016. Cluster analysis arranges sites that are similar to one another based on species composition and abundances. Sites that are near one another on a dendrogram node are similar to one another in terms of the species found there. The clusters have years fairly evenly spread between them indicating that annual variation (i.e., drought vs. wet years) was not as great a factor as location and habitat condition. The sites in Group 7 were located in the upper watershed (especially Santiago Creek) and have some of the best CSCI scores. **Figure C-11-V.11** is the two-way coincidence table of the relative distribution of species at each site during each monitoring event. Horizontal and vertical lines on the two-way coincidence table identify major groupings of species and sites, respectively. Sites are identified by their station number and year of sampling. Relative species abundances are shown as symbols. Smaller symbols represent a lower proportion of maximum abundance and larger symbols a larger proportion. The abundance of each species was standardized in terms of its maximum at each site over all surveys. Again, Group 7 is dominated by upper watershed site locations.

Figure C-11-V.10: Dendrogram Analysis of Sites Surveyed in the Santa Ana Region, 2009 – 2016 (continued on the next page). Cluster analysis arranges sites that have similar BMI assemblages. Seven cluster groups represent the eight years of the SMC Program. Data were square root transformed. Distances between groups were calculated using the Bray-Curtis Similarity Index. Groups were defined by cluster analysis using a trimmed species list that excluded rare species.



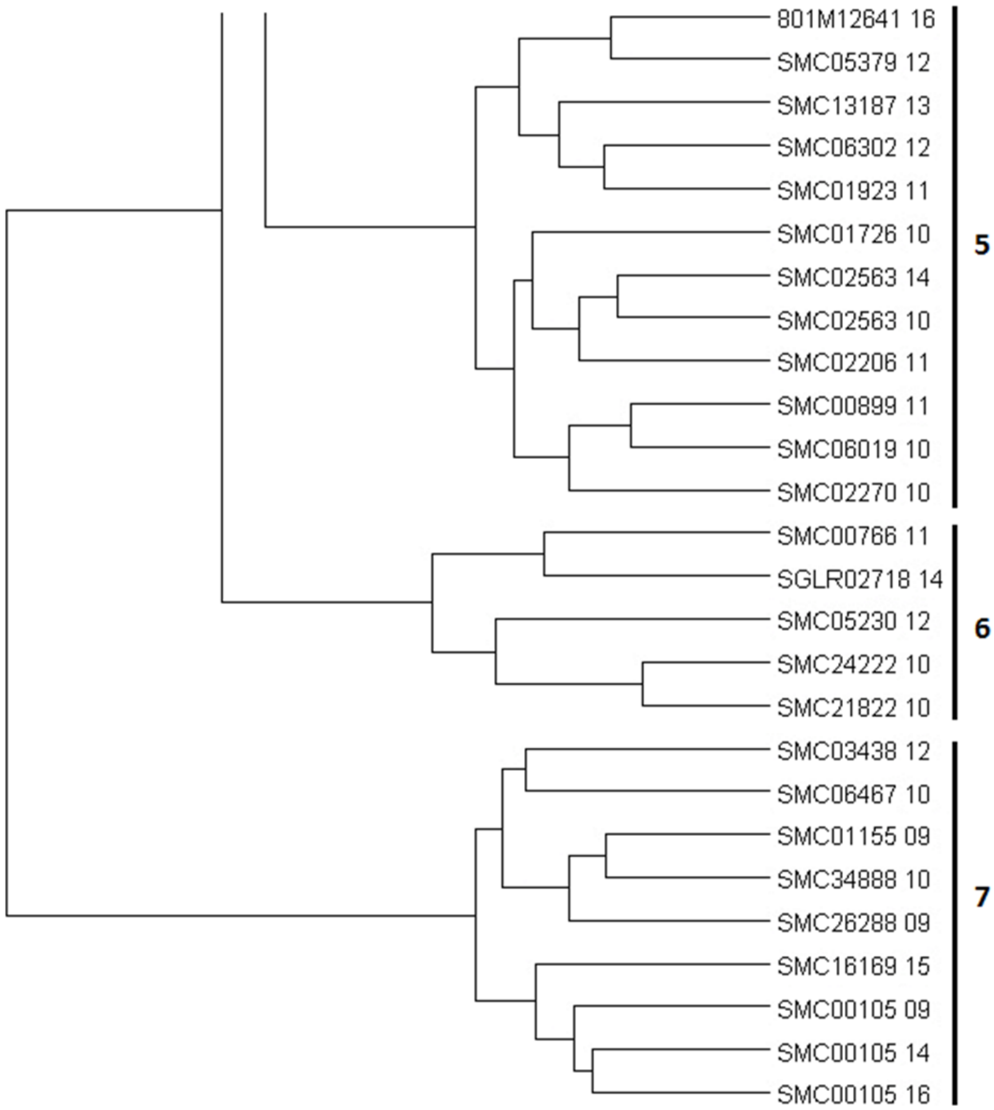
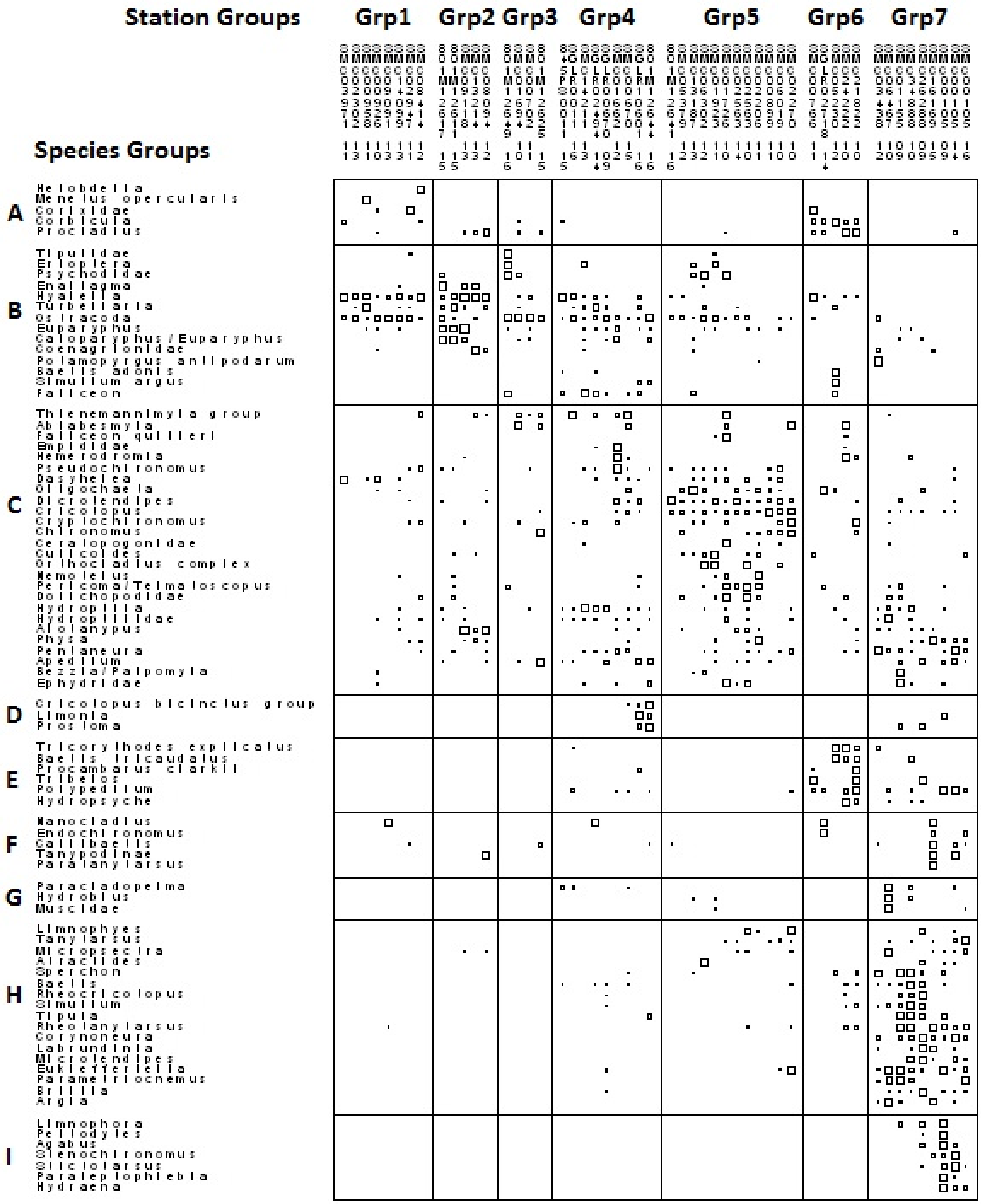


Figure C-11-V.11: Two Way Coincidence Table of Sites Surveyed in the Santa Ana Region, 2009 - 2016. The two way coincidence table is simply a different way of looking at the cluster analysis. The same 7 station cluster groups are depicted along the top axis, while the species clusters are depicted along the vertical axis. The symbols in the graph show the relative abundance of each species and how important they are at a given site. Group I includes species that are more sensitive to pollution and are dominant in sites in the upper watershed.

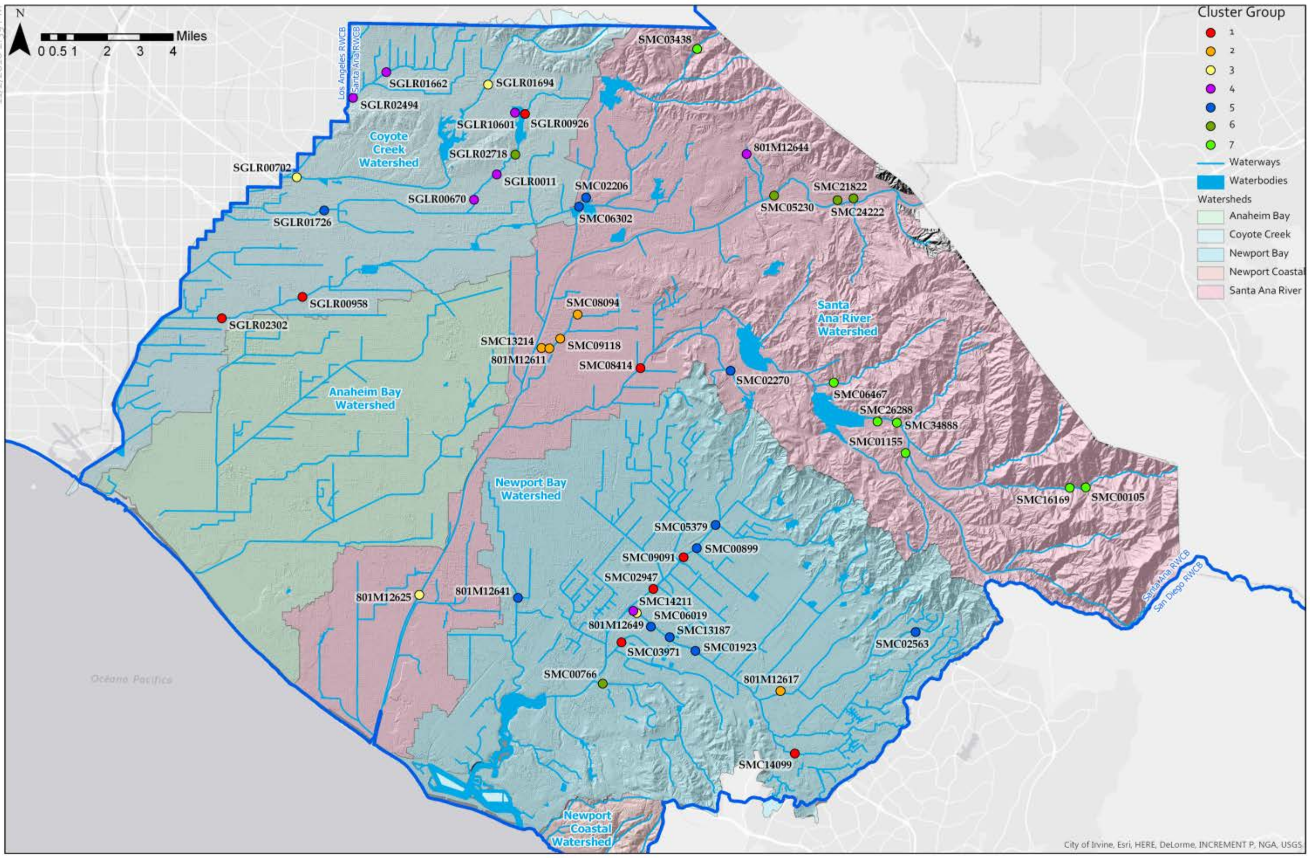

Station Groups
Grp1
Grp2
Grp3
Grp4
Grp5
Grp6
Grp7
Species Groups
A
Helobdella
Menetus opercularis
Corixidae
Corbicula
Procladius
B
Tipulidae
Erioptera
Psychodidae
Enallagma
Hyalella
Turbellaria
Ostracoda
Euparyphus
Caloparyphus/Euparyphus
Coenagrionidae
Potamopyrgus antipodarum
Baetis adonis
Simulium argus
Fallceon
C
Thienemannimyia group
Ablabesmyia
Fallceon quilleri
Empididae
Hemerodromia
Pseudochironomus
Dasyhelea
Oligochaeta
Dicrotendipes
Cricotopus
Cryptochironomus
Chironomus
Ceratopogonidae
Culicoides
Orthocladius complex
Nemotelus
Pericoma/Telmatoscopus
Dolichopodidae
Hydroptila
Hydroptilidae
Alotanypus
Physa
Pentaneura
Apedilum
Bezzia/Palpomyia
Ephydridae
D
Cricotopus bicinctus group
Limonia
Prostoma
E
Tricorythodes explicatus
Baetis tricaudatus
Procambarus clarkii
Tribelos
Polypedilum
Hydropsyche
F
Nanocladius
Endochironomus
Callibaetis
Tanypodinae
Paratanytarsus
G
Paracladopelma
Hydrobius
Muscidae
H
Limnophyes
Tanytarsus
Micropsectra
Atractides
Sperchon
Baetis
Rheocricotopus
Simulium
Tipula
Rheotanytarsus
Corynoneura
Labrundinia
Microtendipes
Eukiefferiella
Parametriocnemus
Brillia
Argia
I
Limnophora
Peltodytes
Agabus
Stenochironomus
Stictotarsus
Paraleptophlebia
Hydraena

These two figures clearly show several dominant patterns. First, sites that are at or near reference conditions based on the CSCI are concentrated at the lower end of the dendrogram, which is equivalent to station Groups 6 and 7, located on the right side of the two-way coincidence table. These sites are mostly located in the upper watershed above and east of Irvine Lake (see **Figure C-11-V.11** above and **Figure C-11-V.12** below).

Secondly, there is no clear clustering of sites based on the sample year. This suggests that annual variability in weather conditions is not driving the composition and abundances of taxa in the watersheds. Rather, it is predominantly based on habitat conditions (**Figure C-11-V.9**), as well as some geographic correlations as well (**Figure C-11-V.12**). Cluster Groups 2, 4, 6, and 7 tend to be gathered in tightly assembled geographical areas. This suggests that similar habitat conditions are found in each of the respective cluster groups. It is also interesting to note than Cluster Group 5 has two different groupings, implying there could be habitat similarities to support similar taxa dominance.

Lastly, species with broader spatial and temporal distributions are concentrated in the upper three species groups (Groups A, B, and C) on the two-way coincidence table. Species with such extensive distributions tend to be more pollution and/or disturbance tolerant. In contrast, species in the lower two species groups (Groups H and I) have much more restricted distributions, and in fact are found primarily at the upper Santiago Creek watershed and upper Santa Ana River sites where anthropogenic impact is relatively minimized. A closer examination of the species groups in the two-way coincidence table shows that species Group H contains a diverse assemblage of several sensitive types of organisms. Species Groups A, B and C (at the top of the two-way table) include moderately to very tolerant species characteristic of disturbed sites. Moreover, many of the dominant taxa at the upper and lower vertical ends of the two way coincidence table are characterized by larger symbols, thus a larger proportion of species abundance. **Figure C-11-V.12** is effective at spatially capturing these patterns.

Figure C-11-V.12: Map of the Cluster Group Distribution across the Santa Ana Region. This map includes historical and current year bioassessment data and is intended to show the locations of cluster group sites. As indicated above, Group 7 is primarily found in the upper watersheds, particularly in the Santiago Creek watershed in the vicinity of Irvine Lake.

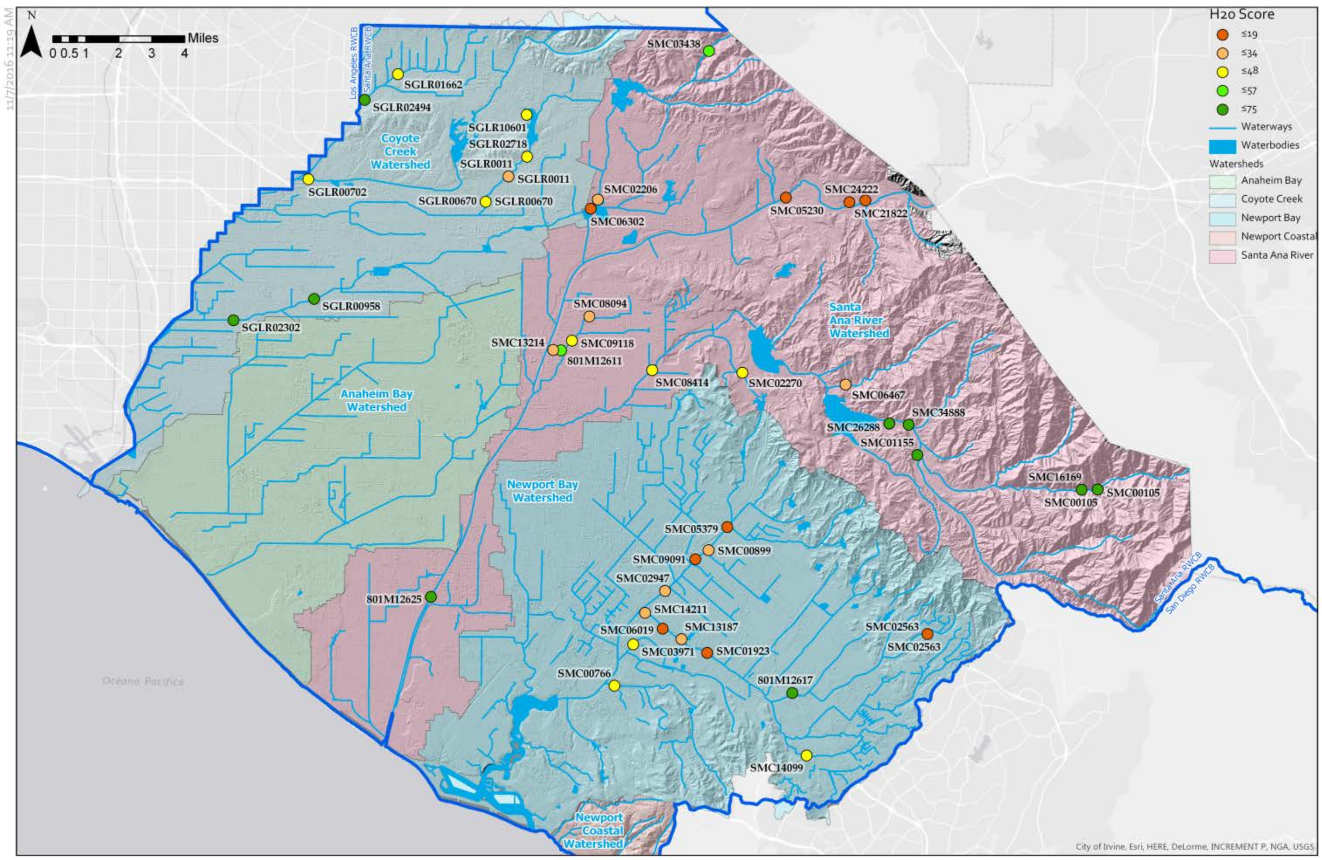


Correlation with Algae

Historical spatial analysis was completed for algae using the soft algae and diatom hybrid H20 index. **Figure C-11-V.13** shows the H20 scores for all SMC stations through 2015 and SGRRMP stations through 2016. A score ≥ 57 indicates reference condition and less than 57 is considered non-reference. The rest of the scoring range is arbitrary without corresponding condition categories, but it assists in providing some spatial context. H20 scores do not always reflect the CSCI scores for the seven cluster groups, however sites in the Santiago Creek watershed east of Irvine Lake score 75 or higher. It is interesting that despite known legacy nutrient issues in the Newport Bay watershed, the H20 scores demonstrate impairment despite this abundant food source. Also of note is that some of the highly modified urban sites (e.g., 801M12625) score very well with the H20 index. Although further analysis is needed to definitively understand these scenarios, it is presumed that nutrient availability, ample sunlight, higher ambient temperatures, and surfaces for diatoms to grow combine for a beneficial habitat.

The 2016 SMC algal scores should be available in early 2017 once they are analyzed by the State. 2016 marked the beginning of a DNA extraction method, which is intended to assist in future algal taxonomy studies and analysis. However, greater study and analysis is needed to understand algal taxonomy in urban watersheds. To date there is not an accepted scoring threshold for the soft algae (S2) and diatom (D18) indices. There is currently an algal CSCI in production at SCCWRP which is scheduled to be launched towards the end of 2017. Next year's reporting period will include this new algal index if it is ready for use.

Figure C-11-V.13: Historical Algal H20 Index, 2009 – 2015. This map shows the 7 cluster groups with their corresponding H20 scores. The scoring range is arbitrary, but 57 or greater is considered reference. The two 2016 SGRRMP stations are included in this map. 2016 SMC algae data should be available in early 2017.



Correlation with Parameters

Variables measured during the surveys conducted from 2009 to 2016 were then grouped into biotic condition (e.g. CSCI scores), physical habitat parameters (e.g. channel alteration), water quality physical measurements (e.g. pH, dissolved oxygen), nutrients, potential pollutant parameters (e.g. dissolved metals) and ions (e.g. sulfate). The median values of each parameter were then plotted for each cluster group using box and whisker plots. "Cluster Group" on the x-axis of the box and whisker plots refers to the site groupings based on taxa from the dendrogram and two way coincidence table.

The box and whisker plots show the condition of each cluster group as determined by the scoring mechanism for the respective analysis (**Figures C-11-V.14** to **C-11-V.18**). Median CSCI scores (**Figure C-11-V.14**) were above the "likely intact" condition category threshold of 0.92 for Group 7 (median CSCI 0.95), which were the sites located in the upper watershed east of Irvine Lake. Median CSCI scores were below the 0.79 threshold in Groups 1 through 6, placing these groups in the "likely altered" or "very likely altered" condition categories. Groups 1 through 5 are largely, although not completely, characterized by channel modified sites located in the lower watershed. CSCI scores were somewhat better in Group 3, but this is a small sample size and trends cannot be definitively made.

Figure C-11-V.14: CSCI Score versus Cluster Group, 2009 - 2016. This boxplot shows how the median biological condition (CSCI score) is expressed for each of the station groups derived from cluster analysis. There is a clear gradient of improving CSCI scores from cluster Group 1 through 7. Group 7 includes sites located mainly in the upper watershed where physical habitat conditions are relatively good.

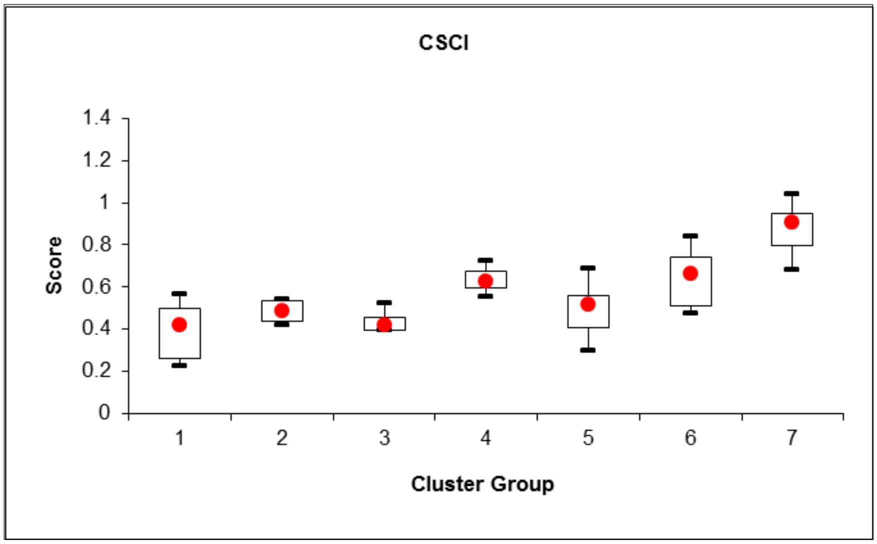


Figure C-11-V.15: Physical Habitat Condition versus Cluster Group as it relates to Instream Cover (Top), Sediment Deposition (Middle), and Channel Alteration (Bottom), 2009 - 2016. These graphs show the three key physical habitat measures by station cluster groups.

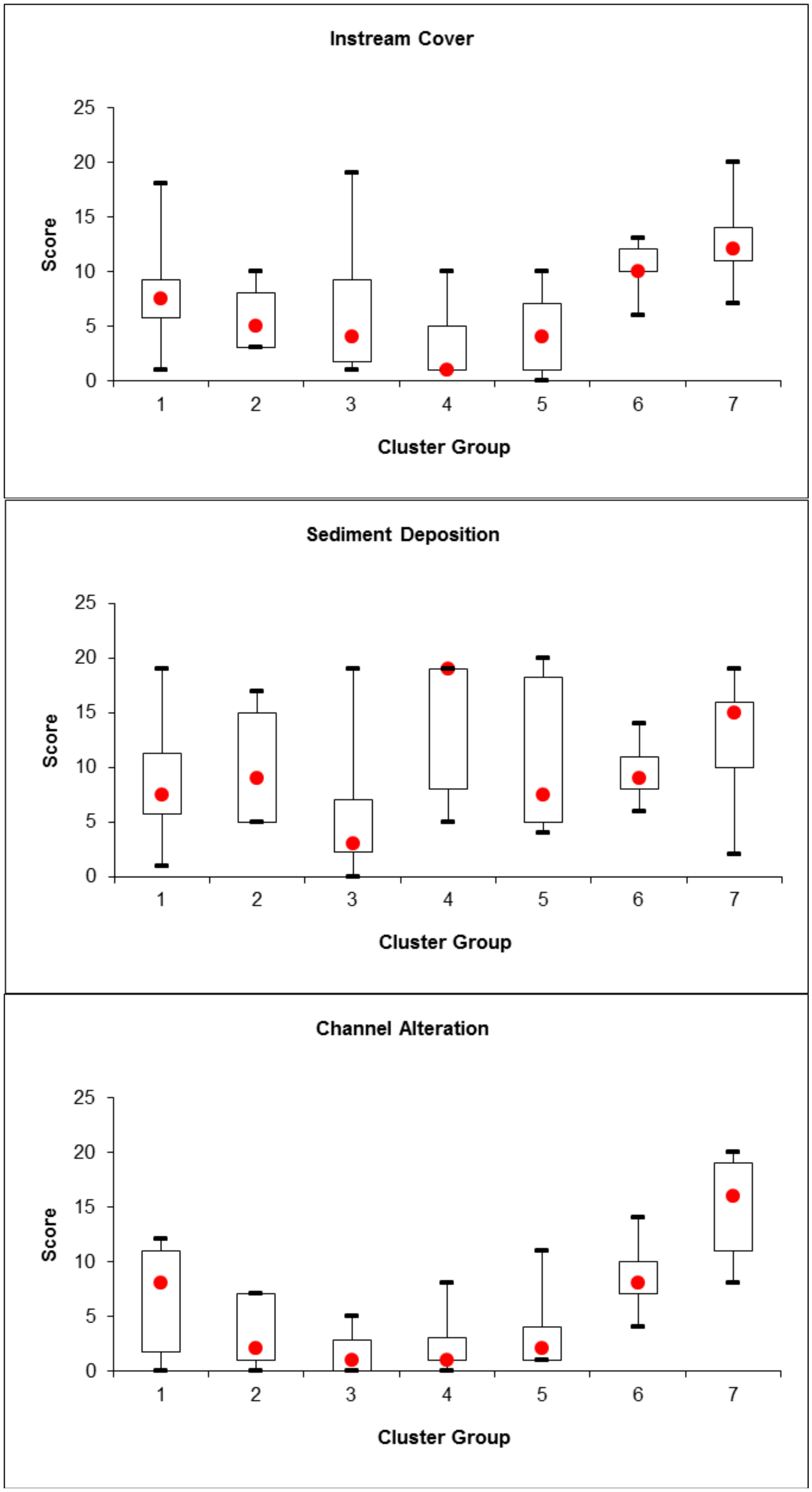
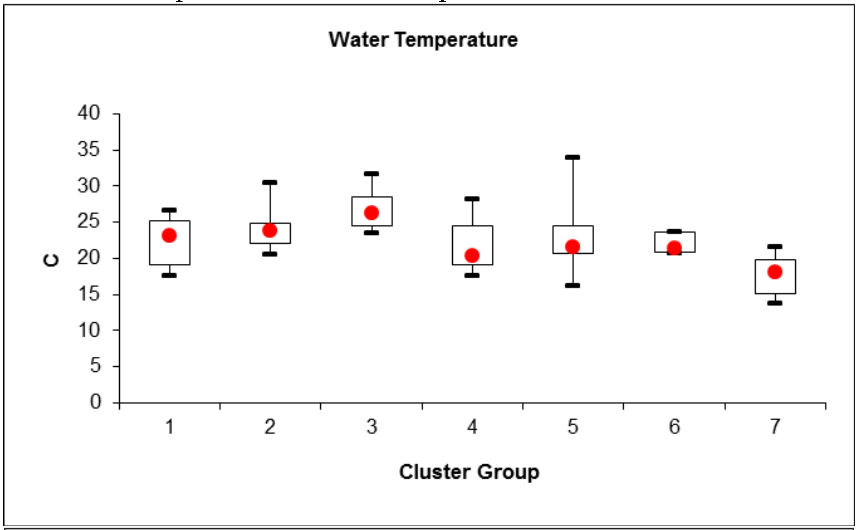
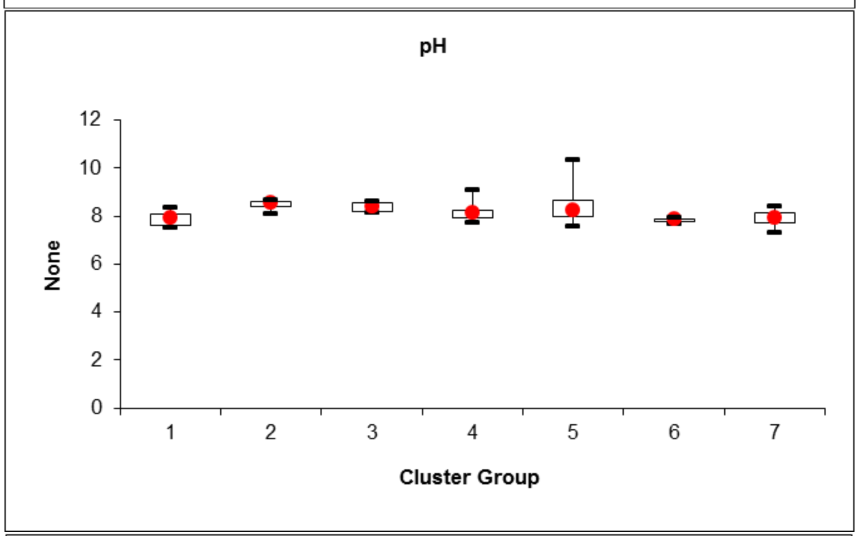
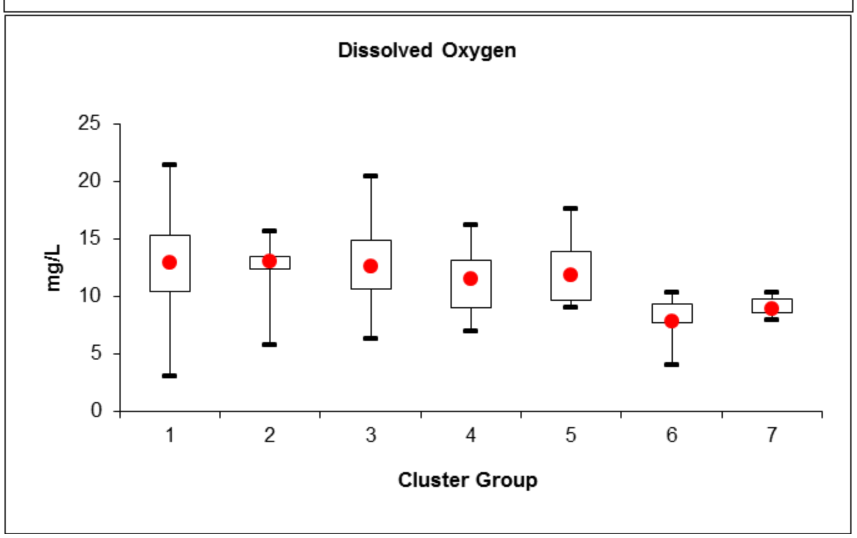
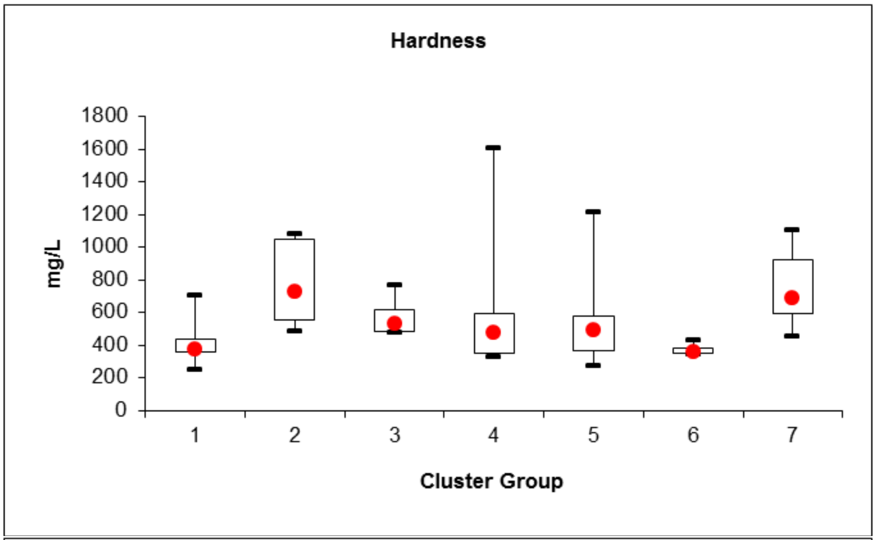


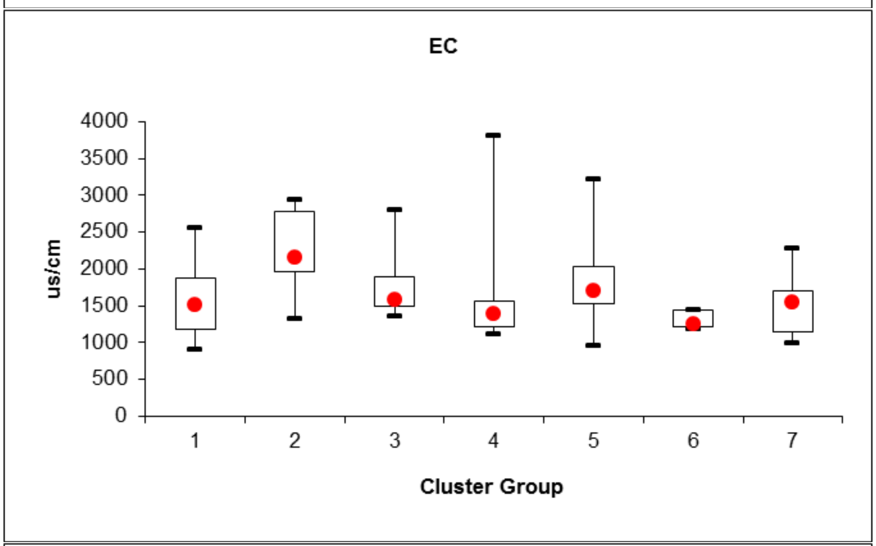
Figure C-11-V.16: Physical Parameters versus Cluster Group, 2009 – 2016 (Continued on Next Page). Water quality conditions were generally similar across cluster groups indicating these results probably do not have a strong influence on the biological condition, whereas the CSCI condition categories do not follow the same pattern. Note the elevated total suspended solids in Group 6.








Hardness
1800
1600
1400
1200
1000
800
600
400
200
0
mg/L
1
2
3
4
5
6
7
Cluster Group


EC
4000
3500
3000
2500
2000
1500
1000
500
0
us/cm
1
2
3
4
5
6
7
Cluster Group

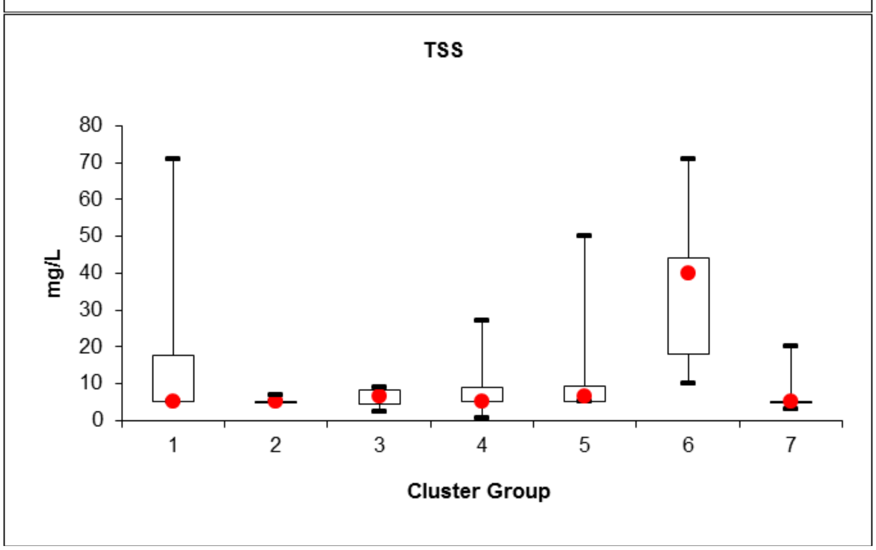
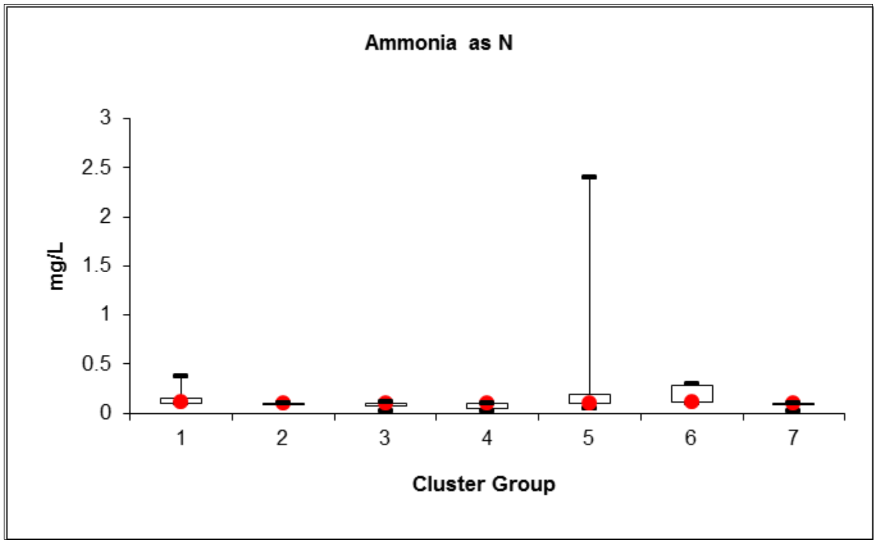
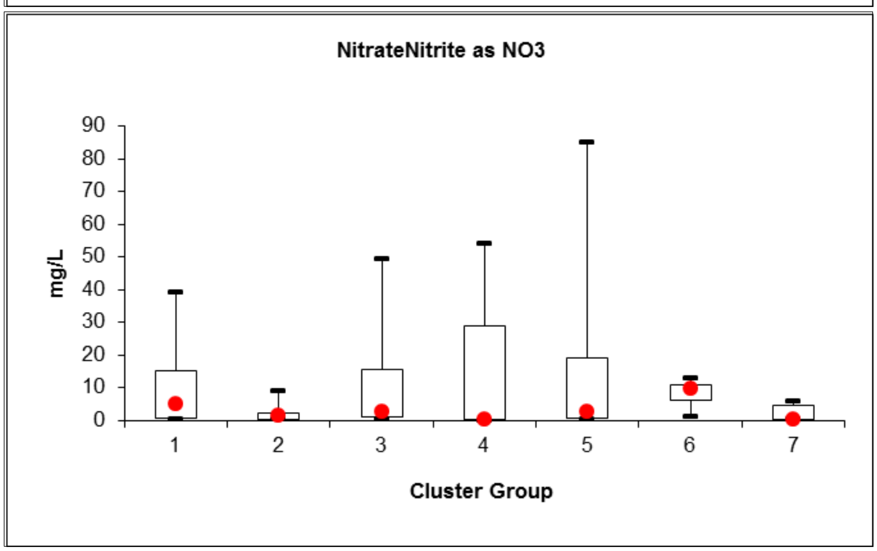
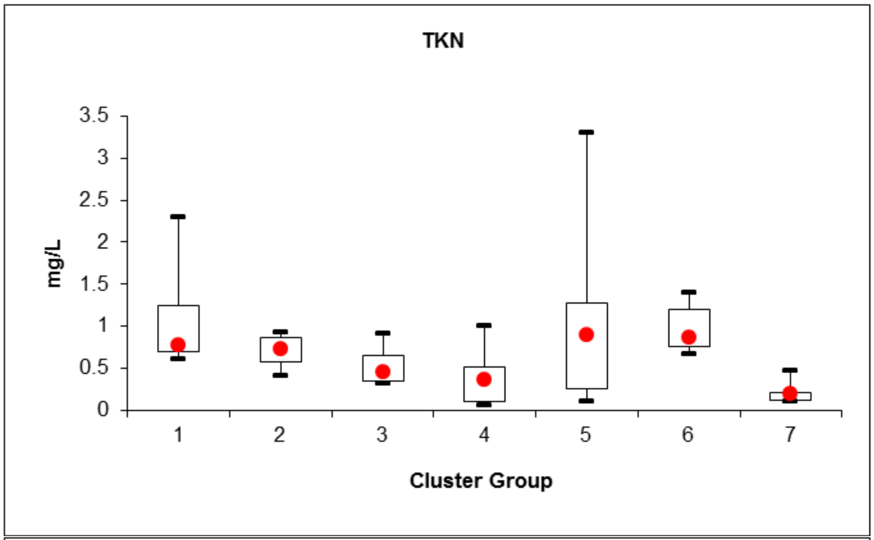
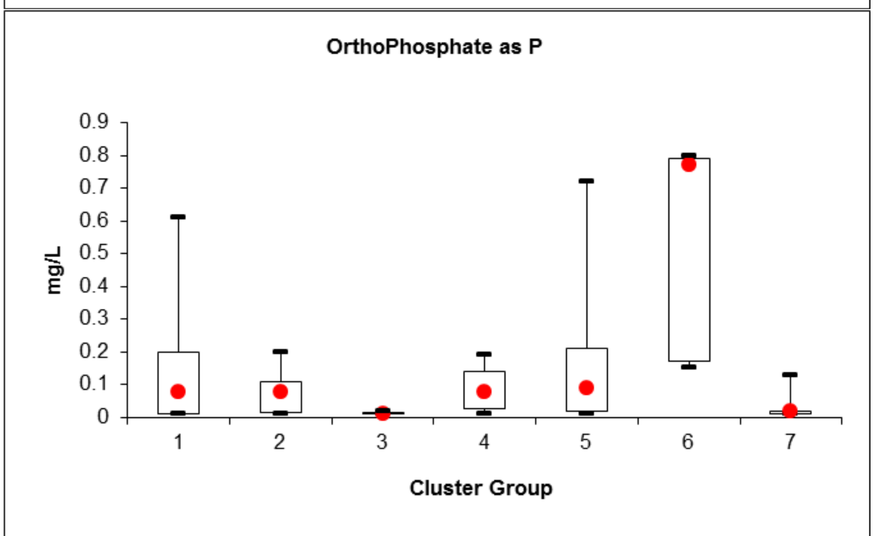

TSS
80
70
60
50
40
30
20
10
0
mg/L
1
2
3
4
5
6
7
Cluster Group

Figure C-11-V.17: Nutrient Parameters versus Cluster Group, 2009 – 2016 (Continued on Next Page). Nutrient conditions across the cluster groups also do not show an obvious pattern. There are occasional instances of elevated nitrate/nitrite in groups 1, 3, 4, and 5. However, these are probably site specific and are just one potential factor in regards to undesirable CSCI scores for these cluster groups. Note the elevated total phosphorus and orthophosphate concentrations at sites in Group 6.






TKN
mg/L
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
Cluster Group


OrthoPhosphate as P
mg/L
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
6
7
Cluster Group

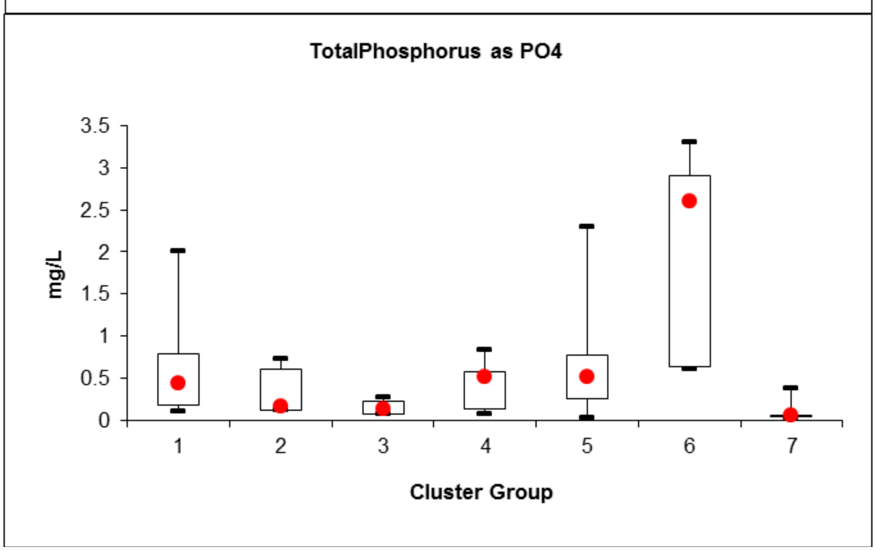
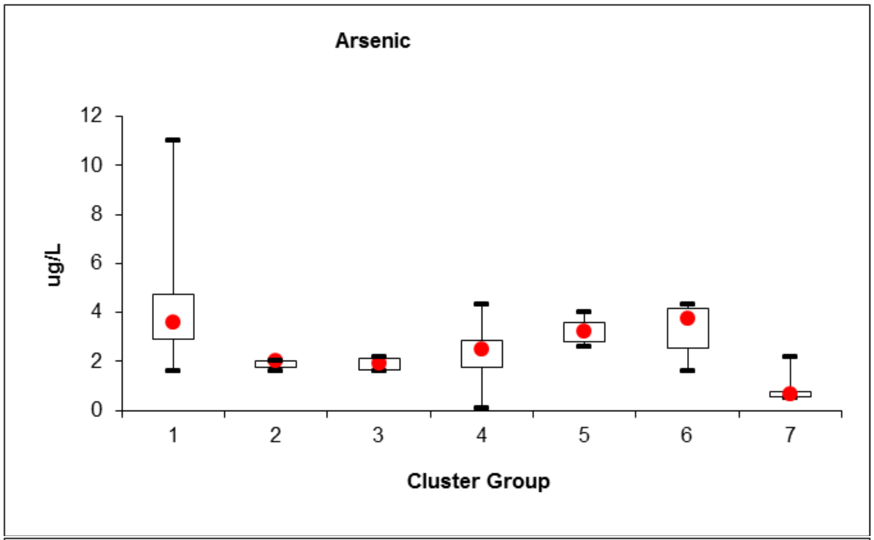
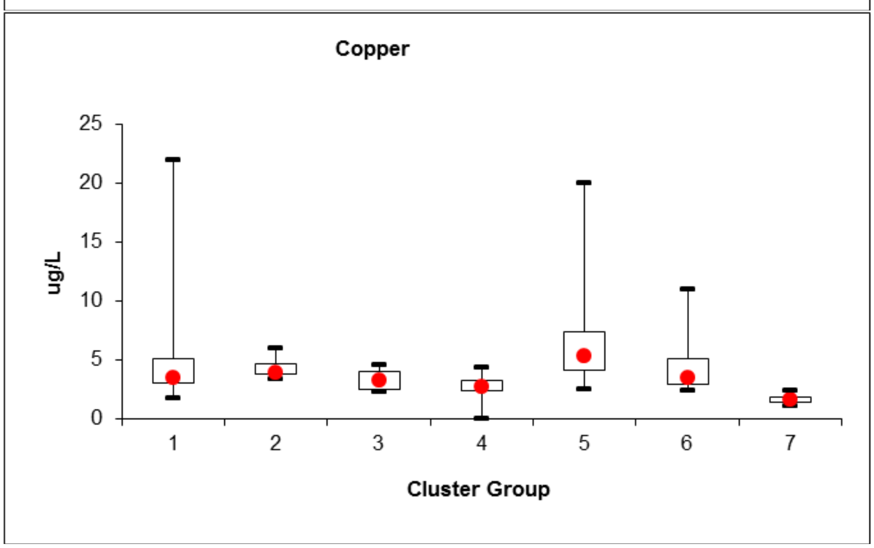
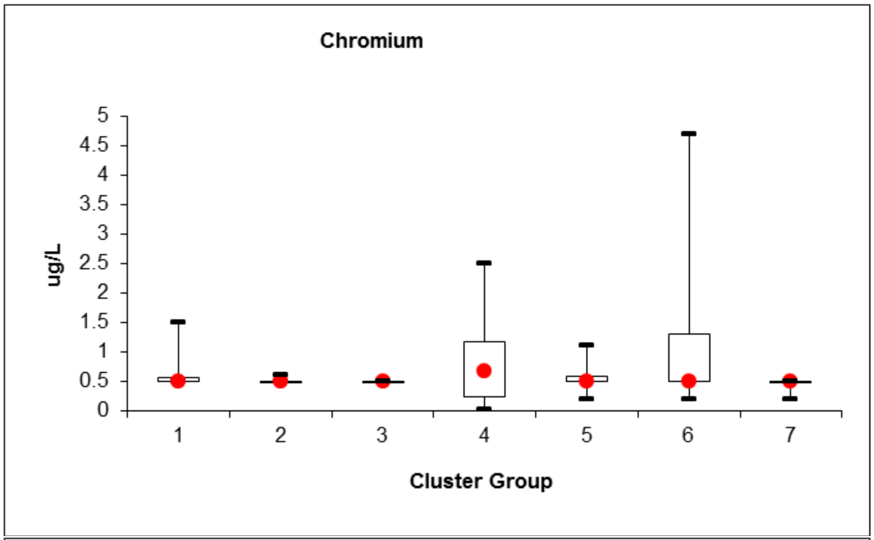
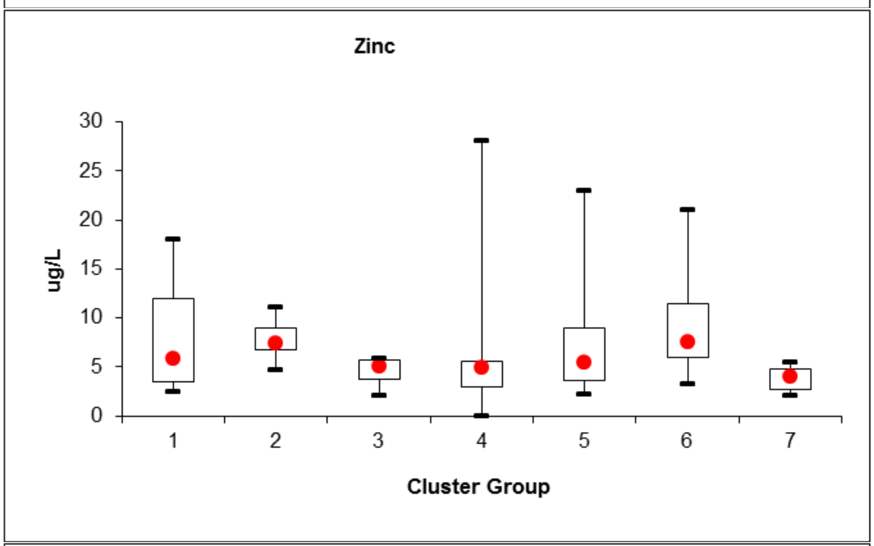

TotalPhosphorus as PO4
mg/L
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
Cluster Group

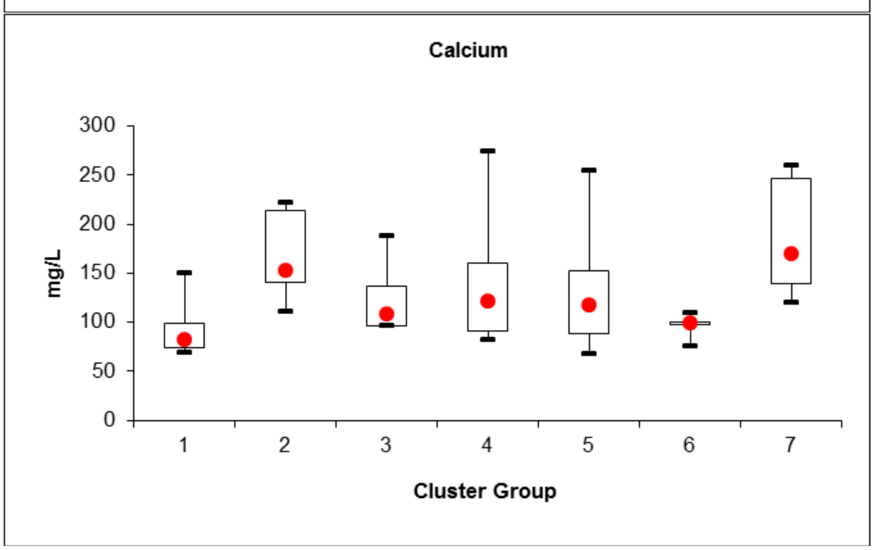
Figure C-11-V.18: Box and Whisker Plots of Dissolved Metals and Major Ions versus Cluster Groups, 2009 – 2016 (Continued on Next Two Pages). No clear dissolved metal trends are observed between the cluster groups outside of occasional elevated single outliers. Note that beginning in 2015, metals are no longer collected at SMC sites, but are continued at SGRRMP sites. Chloride and fluoride generally decrease with increasing cluster group order. Calcium and sulfate show no clear trend.

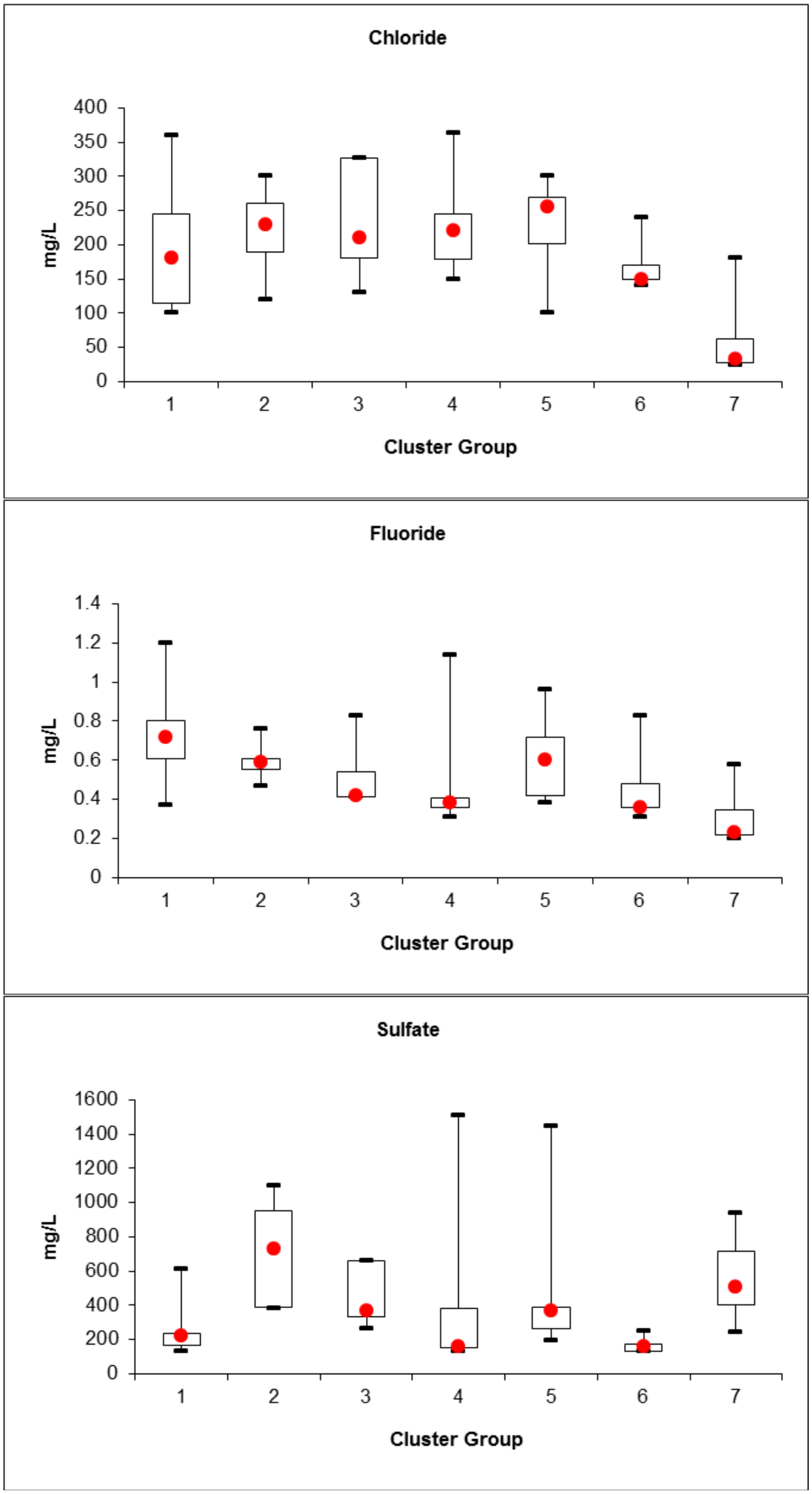





Chromium
ug/L
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
Cluster Group


Zinc
ug/L
30
25
20
15
10
5
0
1
2
3
4
5
6
7
Cluster Group


Calcium
mg/L
300
250
200
150
100
50
0
1
2
3
4
5
6
7
Cluster Group


Chloride
mg/L
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
Cluster Group
Fluoride
mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
Cluster Group
Sulfate
mg/L
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
7
Cluster Group

Physical habitat parameters differed markedly across the site groups. In general, physical habitat scores for channel alteration, in stream cover, and to a lesser extent sediment deposition, were in better condition at reference sites and worse in the lower watershed urban sites (**Figure C-11-V.15**). This is expected because diverse and more sensitive biological communities, such as those found in the upper watershed reference sites, require undisturbed and relatively complex instream habitat, coupled with good vegetative cover on the banks. Of note is the strong relationship between watershed position and channel alteration. The sites with the greatest median CSCI scores (Group 7) had the least amount of alteration. The lower watershed sites, in Groups 1 through 6 were moderately to substantially altered.

Clear patterns or trends in nutrients and metals results were difficult to discern, although elevated total phosphorus and orthophosphate were present in the upper reaches of the Santa Ana River. Nitrate and TKN were somewhat elevated in the upper levels of the data distribution for some of the lower watershed groups as compared to the upper watershed sites (**Figure C-11-V.17**). Dissolved zinc appeared elevated at the lower watersheds most influenced by channel modification. Dissolved arsenic, copper, and zinc trend lower at the reference sites than in the urban areas, while the median chromium levels are constant, suggesting that there could be a geological source (**Figure C-11-V.18**). Increased metals and nutrients in the lower watershed are presumably the result of urban and agricultural runoff from the surrounding watersheds. It should be noted that the SMC Program discontinued metals analysis in 2015, although this data is still collected as a part of the SGRRMP.

Values for physical chemistry parameters such as water temperature and dissolved oxygen were slightly elevated at the lower watershed site groups which is most likely associated with the reduction in canopy cover and algal growth in highly urbanized areas. Several parameters were relatively similar across cluster groups including pH, hardness, conductivity (EC) and total suspended solids (TSS) except in group 6 where TSS was much greater than all other groups.

The evaluation of eight years of SMC Program monitoring data in the Santa Ana Region shows that there is an apparent relationship between the biological community patterns and physical habitat parameters (e.g., channel alteration and instream cover). This relationship has been observed in a number of other bioassessment programs, including the County's bioassessment monitoring in the San Diego Region. On the other hand, strong relationships between biological patterns and water chemistry have not been typically observed in these programs. The relationships observed here may be causal, or it may simply be due to the fact that chemical concentrations and physical habitat alteration are highly correlated in urbanized environments. These issues will be evaluated further as more data become available and the scoring metrics for biotic health can more accurately model a complex and dynamic environment.

C-11-V.4 Special Studies

Urban stream bioassessment field monitoring efforts for 2015-16 included two special studies that examined sediment health. Out of the six stations sampled, three contained sampleable sediment at 801M12649, SMC00105, and SGLR10601. The first study focused on sediment toxicity. In addition to the standard sediment test for *Hyalella azteca* at 23 °C, the same organism was tested at 15 °C. Previous studies conducted by SWAMP's Stream Pollution Trends (SPoT) Monitoring Program have found that pyrethroid pesticides can be much more toxic at colder temperatures because of slower metabolic breakdown of pyrethroids at colder temperatures, as well as increased nerve sensitivity. Furthermore, these cooler temperatures more accurately reflect the ambient average surface water temperature in

California where sediment is present. Sediment was also tested for the midge larvae *Chironomus tentans*, which have a higher sensitivity to pyrethroids. No toxicity was observed at the three stations that were sampled for the two organisms, including *Hyalella azteca* at 15 °C.

The second sediment study involved a screening for microcystins in sediment at the same three stations. A byproduct from cyanobacteria, microcystins can cause adverse effects to aquatic and terrestrial organisms. Secondly, they can bioaccumulate, thus they can easily be transferred through the food web. Analysis was completed for total microcystins as well as six variant sub-analytes. All samples were non-detect for total microcystins as well as the variants.

Proposed special studies for the 2016-17 sampling season include a continuation of the sediment toxicity and microcystins in conjunction with an examination of the presence of sediment pyrethroids and fipronil. Special studies will be discussed amongst the SMC Bioassessment Workgroup, and potential study design should be completed in early 2017.