Los Angeles River Watershed Monitoring Program
2018 Annual Report

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L.A. Regional Water Quality Control

COUNCIL FOR WATERSHED HEALTH

Prepared by:

The Council for Watershed Health
177 E. Colorado Blvd., Suite 200
Pasadena, CA 91105

Aquatic Bioassay & Consulting Laboratories, Inc.
29 N Olive St
Ventura, CA 93001

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Agencies and Organizations
City of Burbank
City of Los Angeles
Los Angeles County Flood Control District
Los Angeles Regional Water Quality Control Board
Council for Watershed Health
Southern California Coastal Water Research Project
U.S. Environmental Protection Agency (USEPA)
U.S. Forest Service
Heal the Bay
Friends of the LA River (FOLAR)
L.A. Waterkeeper

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Algal IBI	Algal Index of Biological Integrity
ATL	Advisory Tissue Levels
BMI	Benthic Macroinvertebrate
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CRAM	California Rapid Assessment Method
CRM	Certified Reference Material
CSCI	California Stream Condition Index
CTR	California Toxics Rule
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DQO	Data Quality Objective
EWMP	Enhanced Watershed Management Plan
FCG	Fish Contaminant Goals
IBI	Index of Biological Integrity
LARWMP	Los Angeles River Watershed Monitoring Program
MDL	Method Detection Limit
MLOE	Multiple Lines Of Evidence
MQO	Measurement Quality Objective
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ND	Non-detect
OEHHA	Office of Environmental Health and Hazard Assessment (CA)
PAH	Polycyclic Aromatic Hydrocarbons
PCA	Principle Component Analysis
PCB	Polychlorinated Biphenyl
POP	Persistent Organic Pollutant. The listed constituents PCBs and DDTs are both persistent organic pollutants under the Stockholm Convention.
POTW	Publicly Owned Treatment Works
PPM	Parts Per Million
RPD	Relative Percent Difference
RF	Random Forest

SGRRMP	San Gabriel River Regional Monitoring Program
SQO	Sediment Quality Objective
SWAMP	Surface Water Ambient Monitoring Program
TDS	Total Dissolved Solids
TEQ	Toxicity Equivalent
TIE	Toxicity Identification Evaluation
USEPA	United States Environmental Protection Authority
VOC	Volatile Organic Compound
WQO	Water Quality Objective
WRP	Water Reclamation Plant

Executive Summary

The Los Angeles River Watershed Monitoring Program conducts annual assessments to better understand the health of a dynamic and predominantly urban watershed. The guiding questions and corresponding monitoring framework of the LARWMP provide both the public and resource managers with an improved understanding of conditions and trends in the watershed.

What is the condition of streams in the watershed?

The 2018 assessments of random sites within the urban, effluent-dominated, and natural regions of the watershed revealed marked and significant differences in condition between upper and lower watershed sites in terms of biological condition, physical habitat, and water chemistry. The majority of random sites in the watershed have biotic conditions that are below reference condition: 65% of sites were altered compared to reference conditions for benthic macroinvertabrates (CSCI), while 70% of sites have altered riparian zone habitat condition (CRAM) and altered attached algal communities (So CA Algal IBI) compared to reference conditions. Total nitrogen and nitrate were significantly higher in the effluent dominated regions of the watershed.

Physical habitat assessments helped quantify the differences in physical condition between urban/effluent and natural sites. Urban/effluent dominated sites had more channel alteration, less epifaunal substrate cover, and less percent canopy cover. Physical habitat metrics (epifaunal substrate, percent concrete, and percent channel alteration) were most closely associated with altered benthic macroinvertebrate communities, while a mix of water chemistry and physical habitat variables were associated with altered attached algae communities.

Recommendation: Explore the use of a new Landscape Modeling tool that is currently being developed by the State Water Board and SCCWRP that predicts constrained biological conditions based on data available in the USEPA's StreamCAT GIS layers. The goal of this tool is to allow managers to focus their resources on stream reaches where the biological condition is under-performing, over-performing, or undetermined.

Are conditions at areas of unique interest getting better or worse?

LARWMP conducts periodic monitoring at sites identified by the Technical Stakeholder Group (TSG) as unique areas of interest, which include confluence points, riparian areas, sentinel sites, and the L.A. River estuary. Regular and recurring assessment can help build upon our understanding of site conditions and how conditions are changing over time.

Monitoring results from confluence sites revealed that there was a general decrease in nutrient and water chemistry parameters in 2018. Although parameters associated with salts have been highly variable, concentrations of salts declined. Sulfate and chloride concentrations also decreased, with chloride concentrations meeting the regulatory threshold of 150mg/L for the first time since monitoring began. Concentrations of suspended solids decreased at Rio Hondo, concentrations of nutrients decreased at Tujunga Wash, and concentrations of phosphorous decreased at Compton Creek.

All targeted sites are altered, based on CSCI scores, and continued to be in altered and very likely altered condition in 2018. The largest changes in stream condition, as measured by CSCI, during the 2018 program year were observed at the Arroyo Seco site (LALT 501), where its score dipped by 18% compared to the previous year, and Tujunga Wash (LALT 503), scores increased by 47% compared to the previous year. CRAM scores at all confluence sites are well below the 10th percentile of California sites in reference condition (10th percentile threshold is 72). For each of the physical habitat metrics, Compton Creek confluence (LALT502) differed substantially from the other three confluence sites. Specifically, it had more canopy cover, no concrete or asphalt substrate (the channel is unlined at the sampling site), less channel alteration, more epifaunal substrate cover, and sediment deposition. Since monitoring began, the Glendale Narrows site has consistently scored below reference condition, and habitat condition continued to decline in 2018. Haines Creek Pools and Stream (LALT407), a site near ongoing restoration activities, had appeared to be slowly improving over time, but the CRAM score declined by 7 points in 2018.

Recommendation: With fire frequency expected to increase in coming years, there is a need for improved reporting on riparian plant community succession and the impact of fire on water quality and aquatic communities at sites in the LA River Watershed.

Are receiving waters near discharges meeting water quality objectives?

Monitoring efforts assess the potential impacts of POTWs, or NPDES permitted point-source discharges, on the Los Angeles River and its tributaries and whether these discharges meet the Water Quality Objectives detailed by the Los Angeles Basin Plan. The monitoring program assesses common contaminants in wastewater effluent to determine whether effluents are impacting water quality. The single-sample water quality objective for *E. coli* was met in 40% of downstream samples compared to 85% of upstream samples at D.C. Tillman Water Reclamation Plant. The water quality objective for *E. coli* was not met by any of the downstream samples compared to 10% at upstream samples at the Burbank Water Reclamation Plant. Effluent from the Los Angeles Glendale Water Reclamation Plant had a dilution effect, reducing bacteria concentration in downstream sites compared to upstream sites. Common disinfection byproducts (trihalomethanes) were detected below all discharge points, but concentrations were well below the EPA water quality objective at all sites. Metals downstream of the three POTW discharge points were below the California Toxics Rule (CTR) chronic and acute thresholds for every type of metal except where copper concentrations downstream of DCTWRP discharge exceeded chronic standards on one occasion, selenium concentrations upstream of DCTWRP exceeded chronic standards on four occasions, and copper concentrations upstream of LAGWRP exceeded chronic standards on one occasion.

Is it safe to recreate?

The majority of sites, particularly those in the upper watershed, regularly met *E. coli* single sample REC-1 standards during the summer sampling season. In 2018, 20% of all samples exceeded the REC-1 bathing water standards. There is considerable variation in percent exceedances across sites. Some recreational sites have consistently high bacterial exceedances every year of monitoring. The Tujunga Wash at Hansen Dam Recreation Area, for example, has persistently elevated *E. coli* concentrations (average of 80% of samples exceeded REC-1 standards). Hermit Falls and the Delta Day Flat Use site had no exceedances all summer.

There was not a strong relationship between site use, the average number of animals, people on shore, or bathers, and *E. coli* concentration across sites. Tujunga Wash at the Hansen Dam Rec Area, for example, had the highest number of exceedances and an average of only 0.05 bathers, 1.55 animals, and 1.65 people on shore during monitoring visits. The high number of bacteria exceedances is probably due to the high equestrian use at the Rec Area and the increased homeless population upstream of the sampling location. Sampling, however, often occurs in the morning, before large crowds arrive and station observations do not reflect activities occurring upstream. Across the monitoring season, there was also not a significant difference in exceedances between holidays/weekends and weekdays. Weak, but significant correlations were found between water temperature, electrical conductivity, turbidity, and *E. coli* concentrations across all sites. This suggests that sediments may be a source of bacteria at monitored sites because *E. coli* cells can persist longer in sediments than in open water and bacteria distributions are sensitive to environmental factors, like water temperature, that impact cell viability.

Recommendations:

- Develop public outreach and educational efforts that target recreational users regarding the safety of swimming and watershed stewardship.
- Share *E. coli* monitoring data with public in a format that is easily accessible and easy to interpret.
- Explore how water resource funding can work to address the intersection between water quality and homelessness.

Are locally caught fish safe to eat?

The goal of this portion of the monitoring program is to improve our understanding of the health risks associated with consuming fish in water bodies popular among anglers. Fish tissue contaminant monitoring for 2018 revealed that common carp, bluegill, redear sunfish, and largemouth bass from Echo Park are safe to eat. However, the recommended frequency of consumption and serving size vary by species and depend on size, trophic position, and feeding ecology. When compared to the OEHHA ATL thresholds for mercury, the mercury concentrations found in largemouth bass from Echo Park Lake indicate that it is safe for men and women over 45 year old to have three 8-oz servings per week, while children and women 18-25 years old should limit themselves to one 8-oz serving per week. Due to elevated PCB levels, one should limit their consumption of largemouth bass and bluegill to two 8 ounce servings per week.

Recommendation: Work with OEHHA to assist with the development of fish advisories and appropriate signage to help broaden and strengthen outreach to anglers on safe fish consumption.

Introduction

1. Background: The Los Angeles River Watershed

The Los Angeles River watershed (Figure 1) encompasses western and central portions of Los Angeles County. The San Gabriel, Santa Susana, and Santa Monica Mountains bound the River to the north and west, the San Gabriel River to the east, and the Pacific Ocean to the south. The Los Angeles River's headwaters originate in the Santa Monica, Santa Susana, and San Gabriel Mountains. The river terminates at the San Pedro Bay/Los Angeles and Long Beach Harbor complex, which is semi-enclosed by a 7.5 mile breakwater. The river's tidal prism/estuary begins in Long Beach at Willow Street and runs approximately three miles before joining with Queensway Bay.

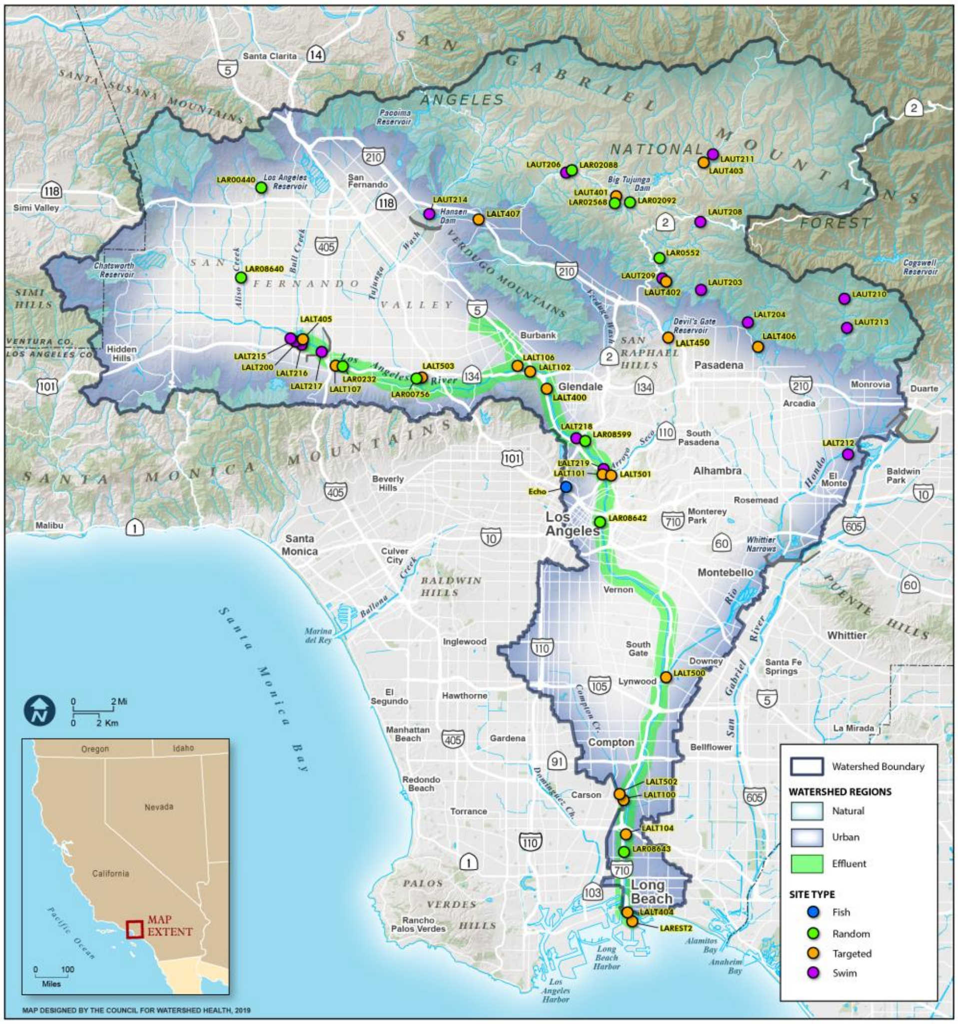

Figure 1. 2009 to 2018 sampling locations for LARWMP.

The 824 mi^2 of the Los Angeles River Watershed encompasses riparian areas, forests, natural streams, urban tributaries, residential neighborhoods, and industrial land uses. Approximately 324 mi^2 of the watershed is open space or forest. South of the mountains, the river flows through highly developed residential, commercial, and industrial areas. From the Arroyo Seco, north of downtown Los Angeles, to its confluence with the Rio Hondo, rail yards, freeways, and major commercial development border the river. South of the Rio Hondo, the river flows through industrial, residential, and commercial areas, including major refineries and storage facilities for petroleum products, major freeways, rail lines, and rail yards serving the Ports of Los Angeles and Long Beach. While most of the river in the developed portion of the watershed is lined with concrete, the unlined bottoms of the Sepulveda Flood Control Basin and the Glendale Narrows provide areas of riparian habitat important due to their ecological and recreational value. Compton Creek, just upstream of its confluence with the Los Angeles River, also supports riparian wetland habitat.

2. The Los Angeles River Watershed Monitoring Program (LARWMP)

In 2007, local, state, and federal stakeholders formed LARWMP, a collaborative monitoring effort. Monitoring efforts are shared by partnering agencies, permittees, and conservation organizations. Partners lend technical expertise, guidance, and support monitoring efforts and lab analysis either directly or through funding. The 2018 monitoring efforts for bioassessments, habitat assessment, bacteria testing, and fish tissue bioaccumulation, detailed in this report, were supported by five sampling teams, three laboratories, and funding from the Cities of Los Angeles, Burbank, and the Los Angeles County Flood Control District (Table 1, Table 2, and Table 3).

Prior to the implementation of the LARWMP, the majority of monitoring efforts were focused on compliance monitoring and little was known about the condition of streams in the watershed. LARWMP incorporated elements of pre-existing water quality and biological monitoring that was occurring in the watershed and the compliance monitoring of publicly owned Water Reclamation Plant (WRPs) and extended it to the entire watershed area.

LARWMP’s sampling design provides the ability to track trends at fixed (target) sites and to evaluate them in the context of conditions in the watershed by comparing them to data collected from random (probabilistically-selected) sites (Table 4). The watershed-scale effort improves the cost effectiveness, standardization, and coordination of various monitoring efforts in the Los Angeles region. The LARWMP strives to be responsive to the River’s evolving beneficial uses and impairments (Table 5, Table 6) and to provide managers and the public with a more complete picture of conditions and trends in the Los Angeles River watershed.

The objectives of the program are to develop a watershed-scale understanding of the condition (health) of surface waters using a monitoring framework that supports comprehensive and periodic assessments of sites along streams, the main channel, in riparian and estuarine habitats, and downstream of treatment works. This report summarizes the monitoring activities and results for 2018. It is one of a series of annual monitoring reports produced for the Los Angeles River Watershed Monitoring Program (LARWMP) since 2008.

LARWMP is designed to answer the following five questions:

1. What is the condition of streams in the watershed?
2. Are conditions at areas of unique interest getting better or worse?
3. Are receiving waters near discharges meeting water quality objectives?
4. Is it safe to recreate?
5. Are locally caught fish safe to eat?

Each year, the technical stakeholder group guides the implementation of the program to ensure efforts are responsive to the priorities of both the public and managers and ensures the program is consistent in both design and methodology with regional monitoring and assessment efforts.

A more complete description of LARWMP regional setting, motivating questions, its technical design, and its implementation approach can be found in the Los Angeles River Watershed Monitoring Program Monitoring Plan (CWH 2009[1]), Annual Reports, the 2018 State of the Watershed, and Quality Assurance Project Plans, which are posted on the project webpage: https://www.watershedhealth.org/reports.

Table 1. Sampling and laboratory analysis responsibilities for random and target sites for 2018.

Spring/Summer 2018 Sampling		**Chemistry**			**Benthic Macroinvertebrates**			**Algae**			**CRAM**	
	Site ID	sampling	lab analysis	funding	sampling	lab analysis	funding	sampling	lab analysis	funding	assessment	funding
Targeted Sample												
Confluence of Rio Hondo and mainstem of LA River	LALT500	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-	-	-
Confluence of Arroyo Seco and mainstem of LA River	LALT501	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-	-	-
Confluence of Compton Creek and mainstem of LA River	LALT502	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-	-	-
Confluence of Tujunga Creek and mainstem of LA River	LALT503[1.]	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-	ABC	Cities
Los Angeles River at Marsh Park	LAR08599	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Random Samples												
Aliso Canyon Wash (Urban)	LAR08640	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Los Angeles River (Effluent)	LAR08642	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Los Angeles River (Effluent)	LAR08643	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Trend Revisit Sites												
Los Angeles River (Effluent)	LAR0232	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Arroyo Seco (Natural)	LAR0552	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Revisit Sites												
Aliso Canyon Wash (Urban)	LAR00440	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Confluence of Tujunga Creek and mainstem of LA River (Urban)	LAR00756[1.]	ABC	EMD	Cities	Weston	Weston	LACDPW	-	-	-		
Big Tujunga Creek (Natural)	SMC02568	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Big Tujunga Creek (Natural)	LAR02088	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Big Tujunga Creek (Natural)	LAR02092	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities

1. Station LAR00756 was within 300 meters of station LALT503, therefore it was sampled once and is both a targeted and random site.

Table 2. Sampling and laboratory analysis responsibilities for bacteria monitoring in 2018.

Spring/Summer Sampling	Site ID	**Microbiology** sampling	lab analysis	funding
Swimming Sites				
Bull Creek Sepulveda Basin	LALT200	ABC	EMD	Cities
Millard Campground[1.]	LALT203	ABC	EMD	Cities
Eaton Canyon Natural Area Park	LALT204	ABC	EMD	Cities
LA-Glendale R7	LALT207	EMD	EMD	Cities
Tujunga Wash at Hansen Dam	LALT214	ABC	EMD	Cities
Los Angeles River	LALT218	CWH/ABC	EMD	Cities
Los Angeles River	LALT219	CWH/ABC	EMD	Cities
Big Tujunga Delta Flat Day Use	LAUT206	ABC	EMD	Cities
Oakwilde Campground or Switzer Falls/Campground	LAUT208	ABC	EMD	Cities
Gould Mesa Campground	LAUT209	ABC	EMD	Cities
Sturtevant Falls	LAUT210	ABC	EMD	Cities
Hermit Falls	LAUT213	CWH	EMD	Cities
Sentinel Sites				
Status &Trend Del Amo	LALT100	LACDPW	EMD	Cities
Status &Trend Figueroa St	LALT101	LACDPW	EMD	Cities
LA River Riverside Dr Cross	LALT102	LACDPW	EMD	Cities
Tillman R7	LALT103	LACDPW	EMD	Cities
LACDPW at Wardlow St	LALT104	LACDPW	EMD	Cities
Tillman Site I	LALT105	LACDPW	EMD	Cities
Status &Trend Burbank	LALT106	LACDPW	EMD	Cities
Status &Trend Tujunga Moorpak	LALT107	LACDPW	EMD	Cities

Table 3. Sampling and laboratory analysis responsibilities for fish tissue bioaccumulation monitoring.

Fish Tissue Bioaccumulation Sites	Site ID	Year	Bioaccumulation sampling	lab analysis	funding
Belvedere Lake	LALT310	2014	ABC/DFG	EMD	Cities
Debs Lake	LALT312	2015	ABC/DFG	EMD	Cities
Reseda Lake	LALT313	2015	ABC/DFG	EMD	Cities
Peck Road Park (Lake)	LALT302	2016	ABC/DFG	EMD	Cities
Balboa Lake	LALT301	2017	ABC/DFG	EMD	Cities
Echo Park (Lake)	LALT300	2018	ABC/DFG	EMD	Cities

Table 4. Monitoring design, indicators, and sampling frequency.

Question	Approach	Sites	Indicators	Frequency
Q1: What is the condition of streams?	Probabalistic design with streams assigned to natural, effluent dominated, urban runoff dominated sub-regions	10 randomly selected each year	Bioassessment using BMIs and attached algae, physical habitat, CRAM, water chemistry	Annually, in spring/summer
Q2: What is the trend of condition at unique areas?	Fixed target sites located to detect changes over time	9 high value habitat sites	Riparian habitat condition: CRAM	2 to 4 sites rotating annually in summer
		4 confluence sites to major tributaries/mainstem	Bioassessment, physical habitat, water chemistry	Annually, in spring/summer
		9 sentinel bacteria sites	*E. coli*	Weekly May to September
Q3: Are receiving waters below discharges meeting water quality objectives?	Use existing NPDES water quality data collected by LA River dischargers from receiving waters upstream and downstream of their discharge points.	Sites located upstream and downstream of discharges: - Los Angeles/Glendale - City of Burbank - Tillman Water Reclamation Plant	Constituents with established water quality standards, e.g. CTR for dissolved metals; *E. coli* bacteria; trihalomethane(s)	Varies depending on permit: monthly, quarterly, annual
Q4: Is it safe to recreate?	Sites selected based on use by the public	12 sites located in ponds, reservoirs, streams and LA River	*E. coli*	LA River Unregulated Swim Sites: 5 times/month May to September LA River Sites in the Recreation Zone: 2 times/week May to September
Q5: Is it safe to eat locally caught fish?	Focus on popular fishing sites; commonly caught species; measuring high-risk chemicals	2 sites located in streams, reservoirs, lakes, rivers and estuary	Measure mercury, selenium, DDT and PCB in commonly caught fish at each location	Annually in summer

[1] High-value sites are locations of relatively isolated, unique habitat

Table 5. Impairments (303d listed) along the main stem of the Los Angeles River by reach (select constituents).

		303(d) listed Impairments															
Reach	Reach Segment	Ammonia	Copper	Lead	Nutrients (algae)	Cadmium	Coliform Bacteria	Copper	Cyanide	Diazinon	Zinc (dissolved)	pH	Selenium	DDT	PCB	Sediment Toxicity	Trash
LA River Estuary	Queensway Bay													▨	▨	▨	▨
LA River Reach 1	Estuary to Carson St.	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨					▨
LA River Reach 2	Carson to Figueroa St.	▨		▨	▨		▨	▨									▨
LA River Reach 3	Figueroa St. to Riverside Dr.	▨	▨	▨	▨												▨
LA River Reach 4	Sepulveda Dr. to Sepulveda Basin	▨	▨	▨	▨		▨										▨
LA River Reach 5	Sepulveda Basin	▨	▨	▨	▨												▨
LA River Reach 6	Above Sepulveda Flood Control Basin						▨						▨				

Table 6. Select beneficial uses of the main stem of the Los Angeles River. Note that * denote reaches where access is prohibited by LA County Department of Public Works. Only limited contact activities, such as fishing and kayaking, are allowed in the Recreation Zone.

		Existing and Intermittent Beneficial Uses														
Reach	Reach Breaks	GWR	WARM	WILD	WET	REC1*	REC1	REC2	IND	COMM	EST	MAR	RARE	MIGR	SPWN	WET
LA River Estuary	Ends at Willow St.			▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
LA River Reach 1	Estuary to Carson St	▨	▨	▨		▨		▨				▨	▨			
LA River Reach 2	Carson to Figueroa St	▨	▨			▨		▨								
LA River Reach 3	Riverside Dr to Figueroa St	▨	▨	▨	▨		▨	▨								
LA River Reach 4	Sepulveda Dr to Sepulveda Dam	▨	▨	▨	▨		▨	▨								
LA River Reach 5	Sepulveda Basin	▨	▨	▨	▨		▨	▨								
LA River Reach 6	Above Sepulveda Flood Control Basin	▨	▨	▨	▨		▨	▨								

Question 1. What is the condition of streams in the Los Angeles River Watershed?

1. Background

To determine the condition of streams in the Los Angeles River watershed, data were collected at 81 random sites during eight annual surveys from 2009 through 2018 (Figure 2). Sites are selected randomly to facilitate drawing statistically valid inferences about an area as a whole, rather than about just the site itself. Spatially, these sites are representative of the three major sub-regions: natural streams in the upper reaches of both the mainstem and tributaries (natural sites), effluent-dominated reaches in the mainstem and the lower portions of the estuary (effluent dominated sites), and urban runoff-dominated reaches of tributaries flowing through developed portions of the watershed (urban sites).

Ambient surveys, which include both physical habitat assessments and bioassessments, can help identify and prioritize sites for protection or rehabilitation based on how sites compare to other regional sites. This type of data provides a measure of ecological health to aid in better understanding whether streams support aquatic life and assigned beneficial uses. Biological communities at stream sites respond to and integrate multiple stressors across both space and time, improving our understanding of the impact of stressors on stream communities (Mazor 2015).

In 2014, the Technical Stakeholder Group (TSG) agreed to modify the LARWMP sampling design based on design changes made by the Southern California Stormwater Monitoring Coalitions (SMC) Regional Monitoring Program. This design change was made to help improve our ability to detect changing conditions not only in the Los Angeles watershed but in the Southern California region as a whole. The design incorporates site revisits at random sites previously sampled by the SMC program. In addition, the program began re-visits at sites previously sampled through the LARWMP program, contributing more information that can help us detect changing conditions in the Los Angeles watershed. Additionally, one random site known to be a non-perennial stream was added to the program to help address a regional gap in assessment of non-perennial streams, which make up 25% of stream miles in the watershed (SMC, 2015).

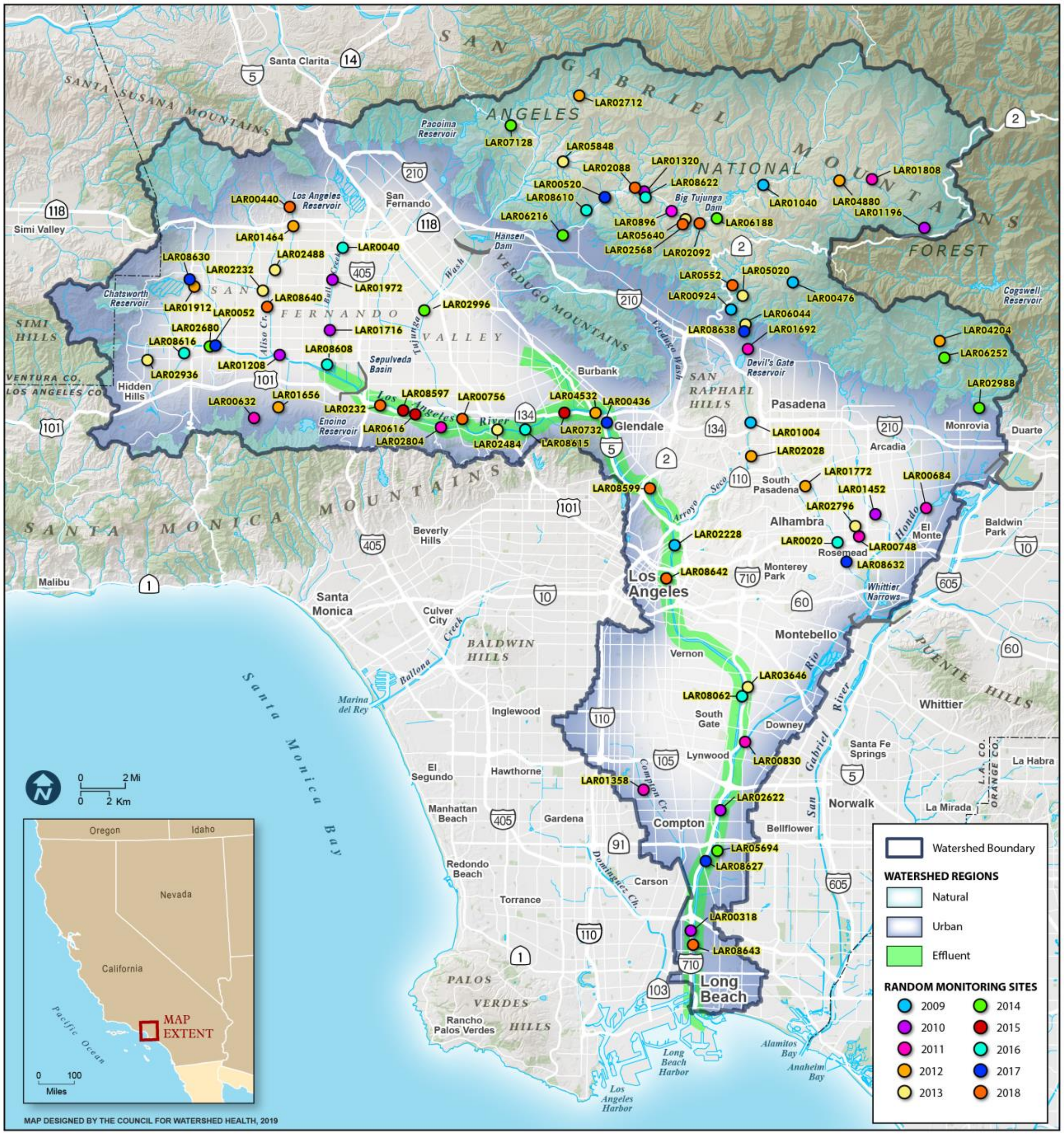

Figure 2. Location of random sites sampled from 2009 to 2018.

2. Methods

LARWMP employed benthic macroinvertebrates (BMIs), California Stream Condition Index (CSCI), attached algae (So Ca Algal IBI), and California Rapid Assessment Methods (CRAM) to assess biotic condition. A complete list of biotic condition indicators and water chemistry analytes collected for this program, including methods, units, and detection limits can be found in Appendix C, Table C1.

a. Benthic Macroinvertebrates

The field protocols and assessment procedures for BMIs and attached algae followed the protocols described by Ode (2007) and Fetscher *et al.* (2009). Briefly, BMIs were collected using a D kick-net from eleven equidistant transects along a 150-m reach and were identified to Level 2 (generally genus) as specified by the Southwest Association of Freshwater Invertebrate Taxonomists, Standard Taxonomic Effort List (SAFIT; Richards and Rogers 2006). Algal samples were collected one meter upstream of where BMI samples were collected using the protocols of Fetscher *et al.* (2009).

b. California Stream Condition Index

The California Stream Condition Index (CSCI) was used to assess the BMI community condition. The California Stream Condition Index (CSCI) is a statewide biological scoring tool that translates complex data about benthic macroinvertebrates (BMIs) found living in a stream into an overall measure of stream health (Mazor *et al.* 2015). The CSCI incorporates two indices, the multi-metric index, helpful in understanding ecological structure and function, and the observed-to-expected (O/E) index, which measures taxonomic completeness (Rehn et al. 2015). The CSCI was developed with a large data set spanning a wide range of environmental settings. Scores from nearly 2,000 study reaches sampled across California range from about 0.1 to 1.4 (Mazor *et al.,* 2015). For the purposes of making statewide assessments, three thresholds were established based on 30th, 10th, and 1st percentile of CSCI scoring range at reference sites according to Rhen (2015) (Figure 3). These three thresholds divide the CSCI scoring range into 4 categories of biological condition as follows: ≥0.92 = likely intact condition; 0.91 to 0.80 = possibly altered condition; 0.79 to 0.63 = likely altered condition; ≤0.62 = very likely altered condition. While these ranges do not represent regulatory thresholds, they provide a useful framework for interpreting CSCI results.

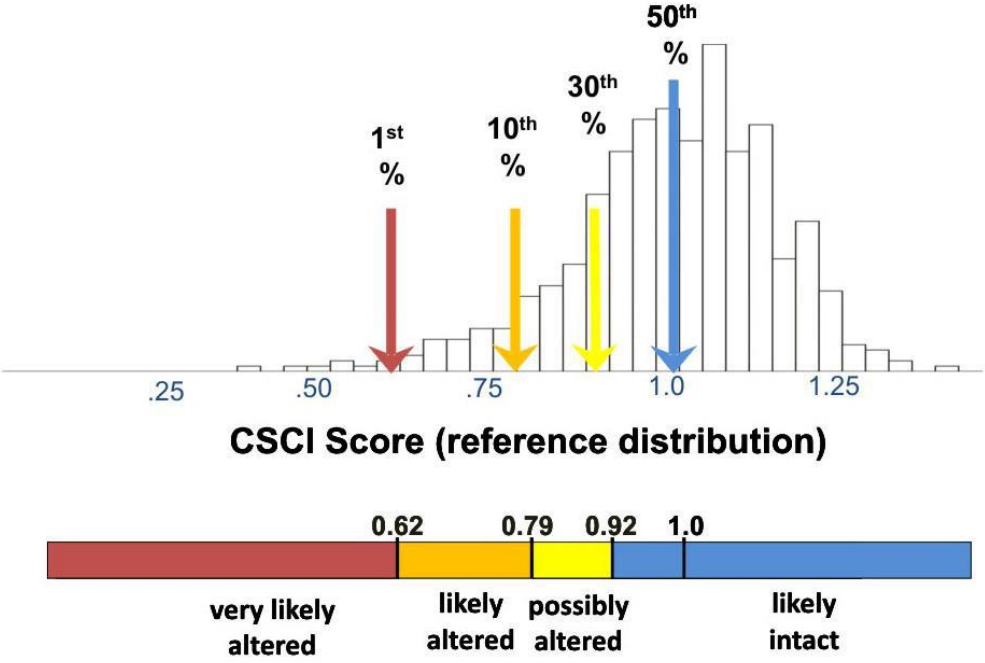

Figure 3. Distribution of CSCI scores at CA reference sites with thresholds and condition categories (Rhen et al., 2015).

c. Southern California Algal IBI

Attached algae compliment a weight-of-evidence approach in understanding stream community response to stress. Algae are useful indicators because they have short generation times, are responsive to a variety of environmental stressors, and are pervasive across stream substratum; they also work well in urbanized environments since BMIs are generally more closely related to habitat features and algae to water quality conditions (Fetscher et al. 2006). Both diatoms and soft body algae were used as indicators and identified to the lowest taxonomic resolution possible, which was typically the species level. The standardization of algae naming conventions was “harmonized” among the primary taxonomists at the California State University at San Marcos who developed the protocols. The Southern California multi-metric attached algae IBI protocol was developed by Fetscher *et al.* (2013). Streams in reference condition are expected to have algal IBI scores >57.

d. California Rapid Assessment

Riparian wetland condition was assessed using the California Rapid Assessment Method (CRAM; Collins et al. 2008), a method developed by the USEPA and modified by SWAMP for use in California (Fetscher and McLauglin 2008). The method was developed to allow evaluation of statewide investments in restoring, protecting, and managing wetlands. Briefly, the CRAM method assesses four attributes of wetland condition: buffer and landscape, hydrologic connectivity, physical structure, and biotic structure. Each of these attributes is comprised of several metrics and sub-metrics that are evaluated in the field for a prescribed assessment area. The CRAM metrics are ecologically meaningful and reflect the relationship between stress and the high priority functions and ecological services of wetlands. The greater the CRAM score, the better the biotic, physical, hydrologic, and buffer zone condition of the habitat. Streams in reference condition are expected to have a CRAM score ≥72 (Mazor 2015). In addition, since CRAM scores provide insight into a stream's physical condition, they are often used as a surrogate for abiotic stress.

e. Physical Habitat

Physical habitat assessments were completed in conjunction with algal and benthic macroinvertabrate assessments to aid in the interpretation of biological data. Human alteration and the instream and topographical features that effect habitat quality and structure are important factors that shape aquatic communities (Barbour et al., 1999). Briefly, the same 11 equidistant transects that were used for the collection of BMI and algal samples were used in the assessment of wetted width, bank stability, discharge, substrate, canopy cover, flow habitats, bank dimensions, human influence, depth, algal cover, and cobble embeddedness. Ten inter-transects, at the mid-point of the 11 transects used for sample collection, were also used to collect information related to wetted width, flow habitats, and pebble counts. All physical habitat assessments were completed as specified by Ode (2007).

f. Aquatic Chemistry

Nutrients, major ions, and general chemistry analytes (pH, dissolved oxygen, suspended solids, alkalinity, and hardness) were monitored at each site. Data was collected in-situ through the use of digital field probes that were deployed by field crews or via grab sample and lab analysis. Measured analytes and methods are described in Appendix C – Analyte List, Detection Limits and Methods.

g. Data Analysis

The R statistical package and excel were used for the majority of graphing and data analysis. Significant differences between regions were examined using the Kruskal Wallis nonparametric test and a Tukey's HSD test for post-hoc comparisons between regions. Multivariate analyses were done to better understand relationship between sites, measured variables, and to understand the variables that are important in determining CSCI and Algal IBI scores.

- A NMDS plot helps graphically represent the relationship between sites and variables in multidimensional space for non-parametric data. The NMDS was constructed using physical habitat and water chemistry data from 2009-2018. Data was pre-processed using a square root transformation. The dissimilarity between sites was calculated using Euclidian distance and plotted according to measures of similarity/dissimilarity. NMDS analyses do not allow missing data, and to avoid discarding a large number of samples, a k nearest neighbor algorithm (k=3) was used to input data for the NMDS.
- Variable importance plots for predicting CSCI scores and algal IBI (and diatom and soft algae scores) were constructed using a random forest model. Physical habitat data from 2010-2018 was square root transformed and imputed, as described above, and input into the model. The random forest model shuffles data from a single variable while all other variables remain constant. The model is re-created using the permutated values, re-run, and the mean square error (MSE) was compared to the original model to determine the variable importance. This is done for each variable. The random forest model generated variable importance plots show a ranking of variables according to how much the MSE increased in modeled results when that variable was permutated.

3. Results

Summary results for all biotic condition measurements and water quality analytes by watershed sub-region are presented in Table 7.

a. Biotic Condition

A pattern of better biotic conditions, higher scores, in the natural regions of the watershed compared to the effluent dominated and urban reaches is consistently seen in algal IBI, CRAM, and CSCI scores (Figure 4, Figure 5, Figure 6).

The cumulative frequency distribution for the biotic condition index scores provides insight into the percentage of streams that are in reference and non-reference condition according to three different indicators of ecological health (Figure 7). In the Los Angeles River watershed, most sites are not in reference condition and have altered biological conditions. Over the 2009-2018 monitoring period, approximately 65% of all random sites were altered or were below reference condition for benthic macroinvertebrate communities (CSCI scores). In addition, riparian zone habitat condition (CRAM) and algal communities (Algal IBI) were altered or were below reference thresholds, at roughly 70% of sites.

The CSCI scores across sites ranged from 0.21 to 1.35, with greater average and median CSCI scores found at the natural sites compared to the urban and effluent-dominated sites (Table 7, Figure 8). The CSCI scores from 2009-2018 range from 0.33 to 1.35 for natural sites, 0.35 to 1.01 for effluent dominated, and 0.21 to 1.07 for urban sites, showing the wide variability in benthic macroinvertebrate community condition within natural and urban regions.

The CSCI incorporates two indices, the multi-metric index, helpful in understanding ecological structure and function, and the observed-to-expected (O/E) index, which measures taxonomic completeness. For the O/E index, site degradation is reflected by a loss of expected taxa resulting in a lower O/E score. Effluent-dominated and urban sites had lower O/E scores reflecting the poor condition of benthic macroinvertebrates and taxa loss at sites in areas that are heavily urbanized (Figure 8).

Algal IBI scores mirrored other biotic indicators, showing higher median scores for the natural sites than effluent-dominated and urban sites (Figure 8). In contrast, measures of algal biomass were highest at urban and effluent dominated sites. Environmental conditions that encourage algal growth, such as nutrients, warm temperatures, and sunlight, were also highest in urban and effluent dominated regions (Table 7).

The CRAM results underscore the contrast between the highly urbanized lower watershed and the relatively natural conditions found in the upper watershed (Figure 8). Development in the lower watershed has virtually eliminated natural streambed habitat and adjacent buffer zones. In most cases, the natural riparian vegetation has either been eliminated or replaced by invasive or exotic species.

Each CRAM score is composed of four individual attribute scores that define riparian habitat condition. They include buffer zone, hydrology, and physical and biotic structure (Figure 8). Natural sites were characterized by wide, undisturbed buffer zones, good hydrologic connectivity, and a multilayer, interspersed vegetative canopy composed of native species. In contrast, the urban and effluent-dominant sites often had no buffer zones, highly modified cement-lined channels, and lacked vegetative cover. Intermediate to these extremes were the effluent dominated sites along less disturbed soft bottom reaches, sites in the Glendale Narrows and Sepulveda Basin for example.

Table 7. Summary statistics for biotic conditions and water quality analytes at all random sites combined, collected from 2009 to 2018.

	Watershed				Urban				Effluent				Natural			
Analtye	n=	mean ± stdev	min	max	n=	mean stdev	min	max	n=	mean stdev	min	max	n=	mean stdev	min	max
Biological Condition																
Benthic Macroinvertebrates (CSCI)	105	0.72 ± 0.26	0.21	1.35	36	0.50 ± 0.18	0.21	1.07	22	0.62 ± 0.15	0.35	1.01	47	0.92 ± 0.17	0.33	1.35
MMI	105	0.64 ± 0.25	0.18	1.43	36	0.45 ± 0.15	0.18	0.88	22	0.50 ± 0.15	0.19	0.89	47	0.85 ± 0.18	0.31	1.43
O/E	105	0.79 ± 0.29	0.12	1.32	36	0.55 ± 0.25	0.12	1.27	22	0.75 ± 0.16	0.45	1.12	47	0.99 ± 0.20	0.35	1.32
Attached Algae (So CA IBI)	84	46 ± 21	9	95	27	34 ± 16	11	80	17	27 ± 14	9	54	40	61 ± 15	32	95
D18	84	49 ± 25	4	100	27	38 ± 23	6	92	17	28 ± 20	4	62	40	65 ± 18	26	100
S2	85	44 ± 19	13	100	28	36 ± 14	13	70	17	31 ± 10	17	48	40	55 ± 19	17	100
Riparian Habitat Score (CRAM)	103	56 ± 22	27	99	36	38 ± 9	27	67	22	38 ± 5	27	53	45	79 ± 8	63	99
Biotic Structure	103	47 ± 24	22	97	36	29 ± 11	22	69	22	29 ± 7	22	50	45	71 ± 15	39	97
Buffer Landscape	103	73 ± 19	25	100	36	57 ± 16	25	88	22	63 ± 9	25	68	45	91 ± 6	75	100
Hydrology	103	56 ± 25	25	100	36	37 ± 10	25	58	22	36 ± 9	25	58	45	82 ± 10	58	100
Physical Structure	103	46 ± 24	25	100	36	28 ± 10	25	75	22	26 ± 3	25	38	45	70 ± 15	38	100
InSitu Measurements																
Temperature (C°)	104	21.09 ± 5.72	10.97	36.69	36	24.32 ± 6.43	13.84	36.69	22	23.40 ± 4.38	16.30	32.80	46	17.45 ± 3.05	10.97	25.03
Dissolved Oxygen (mg/L)	105	9.35 ± 2.45	5.10	17.45	36	10.25 ± 2.93	5.30	16.81	22	10.49 ± 2.71	5.10	17.45	47	8.14 ± 0.96	6.00	10.48
pH	105	8.31 ± 0.72	6.99	10.80	36	8.77 ± 0.90	7.34	10.80	22	8.40 ± 0.48	7.42	9.15	47	7.92 ± 0.37	6.99	8.51
Salinity (ppt)	104	0.47 ± 0.36	0.13	1.93	36	0.73 ± 0.48	0.14	1.93	21	0.52 ± 0.05	0.36	0.60	47	0.24 ± 0.06	0.13	0.37
SpecificConductivity (us/cm)	105	922 ± 667	8	3681	36	1404 ± 892	8	3681	22	1056 ± 88	797	1154	47	489 ± 122	245	762
General Chemistry																
Alkalinity as CaCO3 (mg/L)	105	230 ± 427	40	4520	36	300 ± 728	40	4520	22	141 ± 26	100	206	47	218 ± 39	119	276
Hardness as CaCO3 (mg/L)	99	311 ± 318	94	2540	34	488 ± 498	94	2540	22	230 ± 45	168	310	43	214 ± 47	96	370
Chloride (mg/L)	100	95 ± 102	5	554	35	171 ± 117	11	554	22	141 ± 18	109	163	43	10 ± 3	5	15
Sulfate (mg/L)	100	174 ± 320	4	2360	35	357 ± 487	17	2360	22	163 ± 26	123	222	43	30 ± 26	4	135
TSS (mg/L)	88	44 ± 163	0	1330	29	106 ± 273	2	1330	20	33 ± 48	6	218	39	3 ± 4	0	17
Nutrients																
Ammonia as N (mg/L)	105	0.2 ± 1.0	0.0	10.0	36	0.4 ± 1.7	0.0	10.0	22	0.1 ± 0.1	0.0	0.4	47	0.0 ± 0.0	0.0	0.2
Nitrate as N (mg/L)	105	1.2 ± 1.8	0.0	6.5	36	1.2 ± 1.6	0.0	6.5	22	3.8 ± 1.4	1.0	5.9	47	0.1 ± 0.1	0.0	0.5
Nitrite as N (mg/L)	105	0.0 ± 0.1	0.0	0.4	36	0.0 ± 0.0	0.0	0.1	22	0.1 ± 0.1	0.0	0.4	47	0.0 ± 0.0	0.0	0.0
NitrogenTotal (mg/L)	105	3.4 ± 5.0	0.0	38.8	36	5.6 ± 7.2	0.2	38.8	22	5.9 ± 1.4	2.7	8.0	47	0.5 ± 1.0	0.0	6.5
OrthoPhosphate as P (mg/L)	105	0.1 ± 0.1	0.0	1.1	36	0.1 ± 0.2	0.0	0.8	22	0.1 ± 0.1	0.0	0.3	47	0.1 ± 0.2	0.0	1.1
Phosphorus as P (mg/L)	105	0.2 ± 0.3	0.0	2.2	36	0.4 ± 0.4	0.0	2.2	22	0.3 ± 0.1	0.1	0.8	47	0.1 ± 0.2	0.0	1.3
Dissolved Organic Carbon (mg/L)	103	6.9 ± 6.6	1.2	37.6	36	11.7 ± 9.0	1.8	37.6	22	7.0 ± 0.6	6.1	8.4	45	3.1 ± 1.4	1.2	6.9
Total Organic Carbon (mg/L)	103	8.8 ± 12.1	0.2	102.2	36	13.3 ± 10.5	2.5	42.0	22	8.0 ± 1.3	6.8	11.2	45	5.7 ± 14.9	0.2	102.2
Algal Biomass																
AFDM (mg/cm^2)	86	5.33 ± 13.34	0.07	113.38	29	5.27 ± 8.90	0.16	48.25	17	9.40 ± 26.92	0.07	113.38	40	3.65 ± 4.88	0.17	26.63
Chl-a (ug/cm^2)	86	6.39 ± 6.90	0.41	37.00	29	7.35 ± 7.21	0.41	34.00	17	11.13 ± 8.65	2.98	37.00	40	3.67 ± 4.21	0.41	25.00
Dissolved Metals																
Arsenic (ug/L)	67	1.8 ± 1.4	0.0	6.5	27	2.4 ± 1.4	0.1	6.5	11	1.8 ± 0.9	0.3	3.5	29	1.3 ± 1.3	0.0	5.4
Cadmium (ug/L)	71	0.1 ± 0.1	0.0	0.4	29	0.1 ± 0.1	0.0	0.3	11	0.2 ± 0.1	0.0	0.4	31	0.0 ± 0.0	0.0	0.0
Chromium (ug/L)	69	1.5 ± 1.5	0.1	7.5	27	1.8 ± 1.7	0.2	7.5	11	1.2 ± 0.7	0.4	2.5	31	1.4 ± 1.5	0.1	7.3
Copper (ug/L)	71	6.3 ± 7.2	0.0	30.6	29	11.6 ± 8.4	0.6	30.6	11	6.2 ± 2.4	1.5	9.0	31	1.3 ± 0.7	0.0	3.1
Iron (ug/L)	71	183.0 ± 1084.7	2.5	9180.0	29	65.0 ± 63.5	2.5	253.0	11	36.3 ± 41.4	12.2	156.0	31	345.4 ± 1640.9	2.6	9180.0
Lead (ug/L)	71	0.2 ± 0.2	0.0	1.3	29	0.3 ± 0.3	0.0	1.3	11	0.3 ± 0.1	0.1	0.5	31	0.1 ± 0.0	0.0	0.2
Mercury (ug/L)	71	0.0 ± 0.0	0.0	0.0	29	0.0 ± 0.0	0.0	0.0	11	0.0 ± 0.0	0.0	0.0	31	0.0 ± 0.0	0.0	0.0
Nickel (ug/L)	71	4.8 ± 10.8	0.4	78.0	29	8.4 ± 16.3	0.7	78.0	11	4.6 ± 2.0	1.7	7.8	31	1.3 ± 0.8	0.4	3.9
Selenium (ug/L)	71	0.9 ± 1.8	0.1	11.5	29	1.7 ± 2.5	0.1	11.5	11	1.1 ± 0.4	0.2	1.6	31	0.2 ± 0.1	0.1	0.4
Zinc (ug/L)	71	9.5 ± 10.6	0.5	47.3	29	9.0 ± 6.6	1.5	24.2	11	28.9 ± 10.4	8.4	47.3	31	3.0 ± 2.2	0.5	13.2

Figure 4. CSCI scores based on probabilistic sites sampled from 2009 to 2018. Likely intact condition = CSCI ≥0.92; possibly altered condition = CSCI 0.91 to 0.80; likely altered condition = CSCI 0.79 to 0.63; very likely altered condition = CSCI ≤0.62.

Figure 5. So Ca Algal IBI Scores for LARWMP probabilistic sites sampled from 2009 to 2018. Sites with scores >57 are in reference condition.

Figure 6. CRAM scores based on probabilistic sites sampled from 2009 to 2018. Likely intact condition = CRAM ≥79; possibly altered condition = CRAM 79 to 72; likely altered condition = CRAM 72 to 63; very likely altered condition = CRAM ≤63.

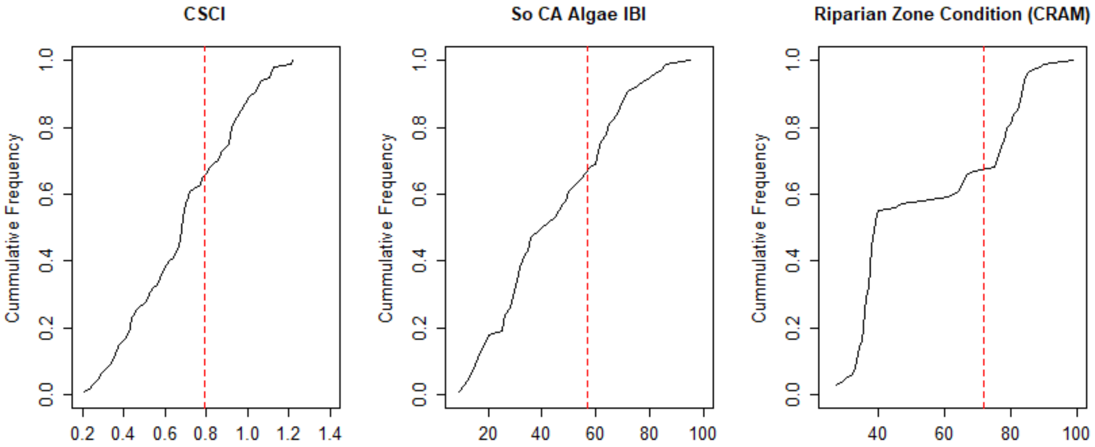

Figure 7. Cumulative frequency distribution of CSCI, Algal IBI, and CRAM scores at random sites from 2009-2018.

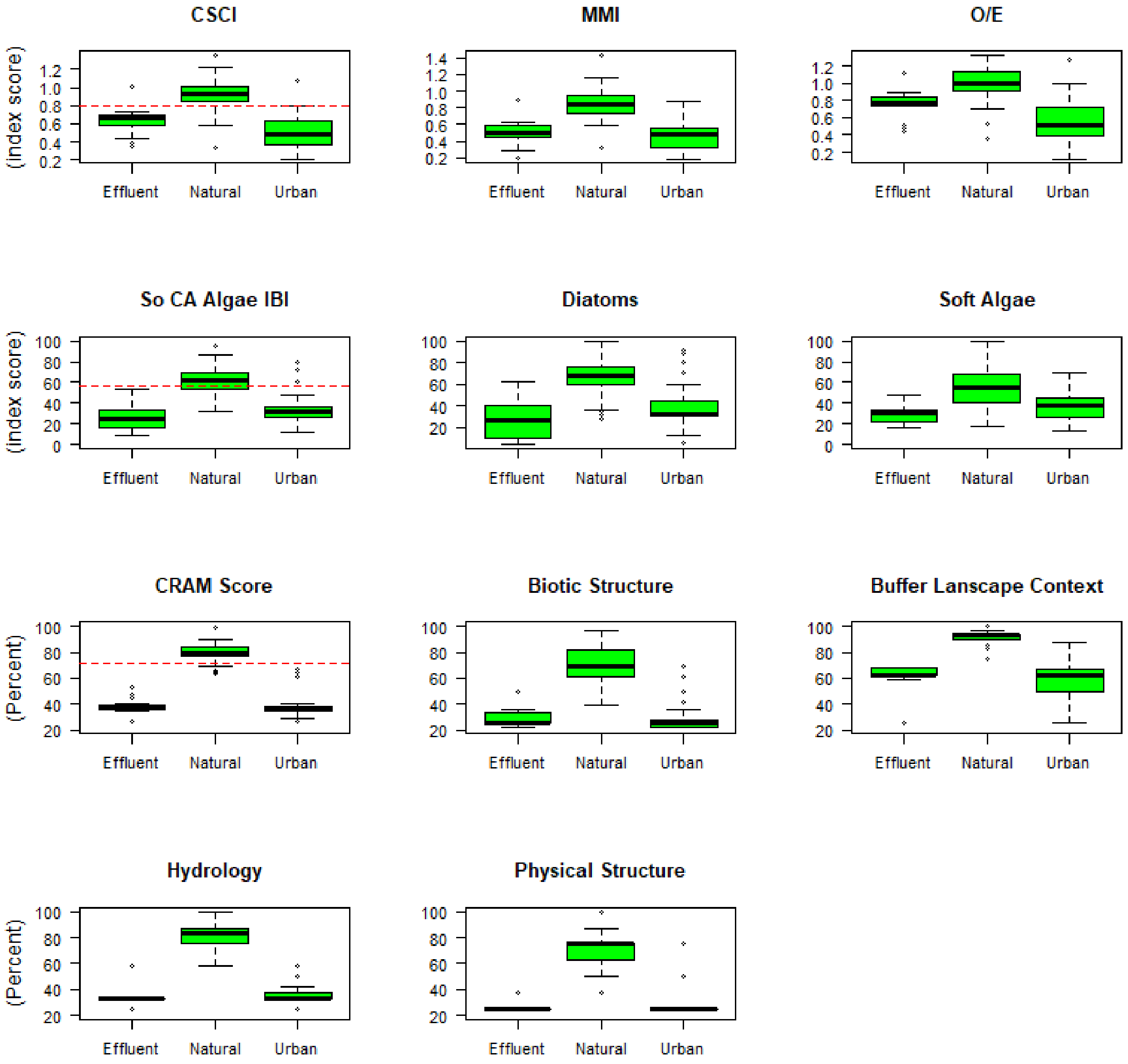

Figure 8. CSCI, Algal IBI, and CRAM scores and attribute scores for effluent, natural, and urban random sites from 2009-2018. CRAM attribute scores include measures of biotic structure, buffer landscape context, hydrology, and physical structure.

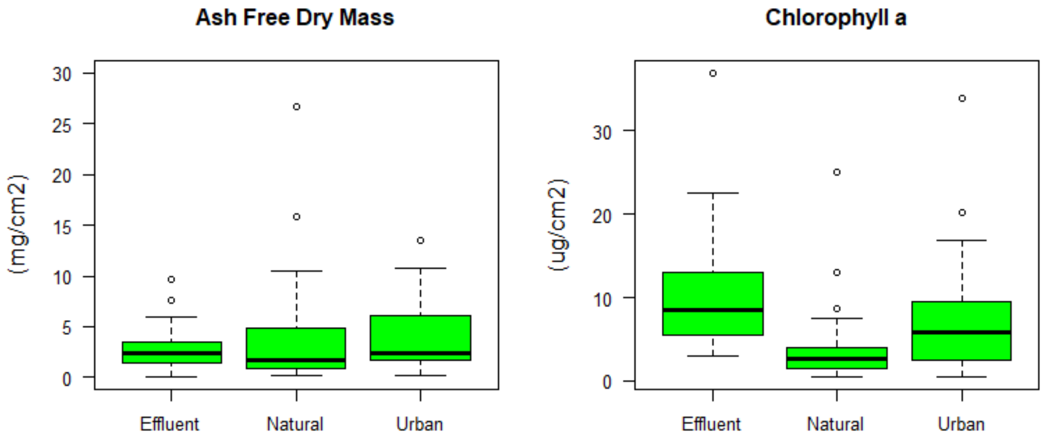

Figure 9. Ash free dry mass and chlorophyll A concentrations, both methods that quantify algal biomass, in effluent, natural, and urban regions in the watershed.

Figure 10 shows the proportion of BMI feeding groups represented in each of the three watershed sub-regions for all random sites from 2009 to 2018. Collectors, a feeding assemblage that feeds on fine particulate organic matter in the stream bottom, were the dominant group in each sub-region. Collectors make up a larger proportion of the total in the effluent-dominated and urban regions of the watershed. Effluent-dominated regions had five feeding groups and urban sites had four feeding groups. These regions are mostly concrete-lined and/or highly channelized reaches with little or no canopy cover and substrate complexity. The upper watershed communities had a more balanced assemblage represented by eight feeding groups (omnivores in the natural sites made up a 0.17 proportion of feeding groups but are not represented in the pie chart). Filterers were more prevalent in this sub-region, generally indicating better water quality conditions (Vannote et al. 1980). The parasite feeding group was missing from all sub-regions and despite studies suggesting their importance to community structure and community functioning (Mouritsen and Poulin, 2005), few studies have been done on this BMI feeding assemblage to date.

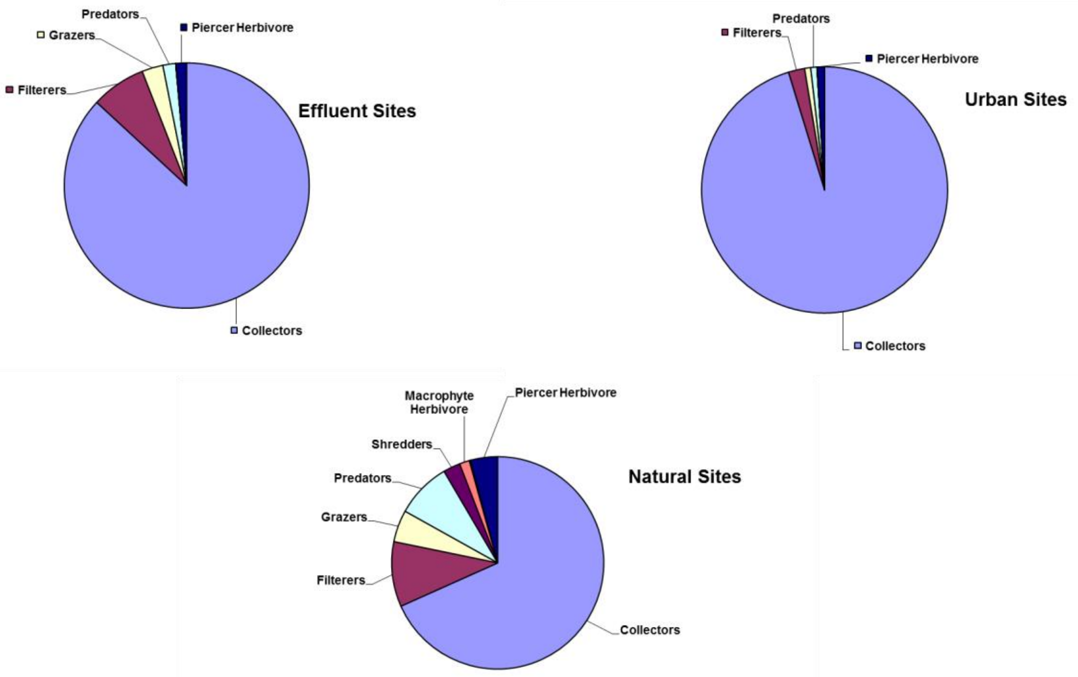

Figure 10. Relative proportion of benthic macroinvertebrate functional feeding groups in each watershed sub-region for 2008-2018 random sites.

b. *Aquatic Chemistry and Physical Habitat*

The spatial pattern of nutrient concentrations in the watershed is shown in Figure 11. Effluent-dominated and urban sites had greater median concentrations of nutrients compared to natural sites, though nutrient concentrations did not vary significantly by region with the exception of nitrate and total nitrogen ($p<0.01$). Average nitrate and total nitrogen concentrations were highest in the effluent-dominated stream segments, though nitrate-nitrogen concentrations were below the Basin Plan objective of 10 mg/L. Other water quality parameters that showed large and statistically significant differences between natural and effluent/urban sub-regions included conductivity, temperature, sulfate, phosphorous, and chloride ($p<0.05$)—all were lowest at natural sites (Table 7) where reduced runoff, salt and nutrient inputs, and surrounding shady habitat likely explain observed patterns.

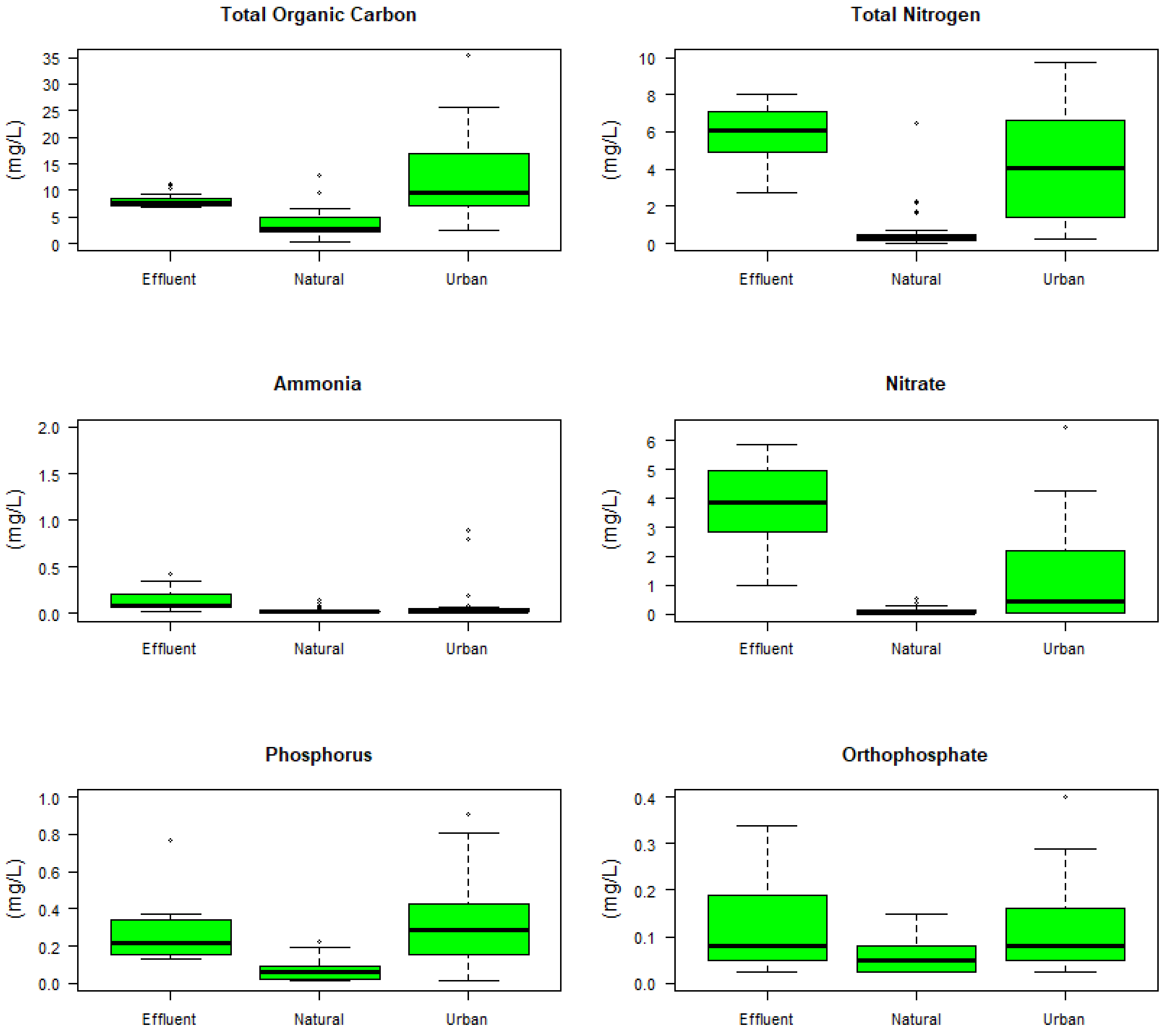

Figure 11. Box-and-whisker plots showing the median and range of representative nutrients measures in each of the three Los Angeles River watershed regions from 2009-2018.

c. Physical Habitat Assessments

Physical habitat was assessed using SWAMP (2007) protocols, which focus on streambed quality and the condition of the surrounding riparian zone out to 50 meters. Physical habitat conditions were generally best in the upper watershed compared to the lower watershed (Table 12), specifically in terms of percent canopy, channel alteration, and epifaunal substrate cover. The epifaunal substrate is a measure of the amount of natural streambed complexity due to the presence of cobble, fallen trees, undercut stream banks, etc. This complexity is important for healthy benthic macroinvertebrate and fish communities.

Channel alteration was limited at natural sites, resulting in high scores. In contrast, effluent-dominated and urban sites are mostly channelized and concrete-lined which resulted in their poor scores. It is important to note that percent bank erosion and sediment deposition, where low sediment deposition is represented by high scores, are misrepresentative in the urban and effluent-dominated reaches due to the high degree of channelization and channel alteration limiting erosional processes.

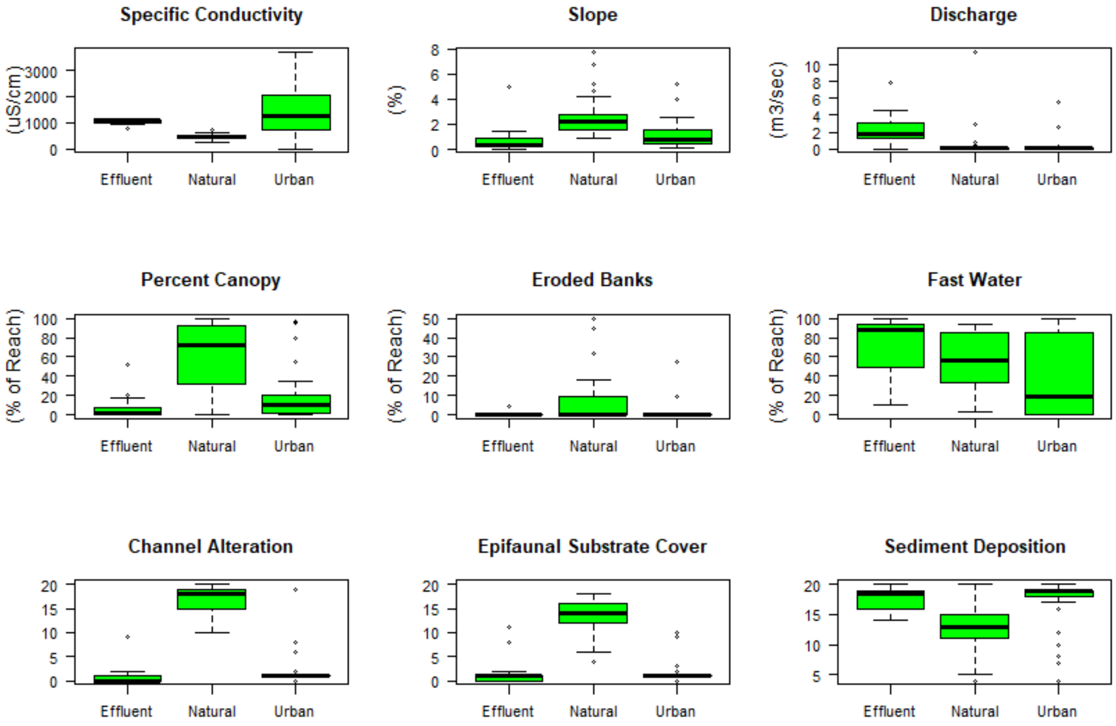

Figure 12. Box-and-whisker plots showing the median and range of representative physical habitat parameters measured in each of the three Los Angeles River watershed regions from 2009-2018. Channel alteration, epifaunal substrate cover, and sediment deposition are scored assessments, higher scores denote better condition

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d. Relationship between Physical and Biological Conditions

Our final step in assessing the health of streams in the watershed was to analyze how physical habitat and environmental variables were associated with observed biotic conditions. Non-metric Multidimensional Scaling (NMDS) was used to ordinate all the physical habitat and chemistry data to look for patterns in the spatial relationship between sites and biotic conditions. Figure 13 shows that the natural watershed sites are clearly separated from effluent dominated and urban sites, which cluster together. While NMDS is not a statistical test, plots can help show the relationship between variables and sites. For example, no single physical habitat or water chemistry variable had a large effect on NMDS clustering. Sites in natural regions are closely associated and clustered with physical habitat variables. Sites in the effluent and urban segments clustered around water chemistry and some physical habitat variables that are altered/ elevated—such as temperature, nutrients, ionic strength-- in urbanized portions of the watersheds. The urban sites were less tightly clustered and revealed the range of conditions at sites along urban tributaries.

Variable importance plots for predicting CSCI scores (Figure 14) and algal IBI and sub-metric scores (Figure 15, Figure 16, Figure 17) were constructed using a random forest (RF) model. The random forest model generated variable importance plots show a ranking of variables according to how much the MSE increased in modeled results when that variable was permutated. Percent cobble and gravel, discharge, and channel alteration were the most important variables according to the random forest model predictions of CSCI scores (Figure 14).

A combination of ionic strength, percent vulnerability, and nutrient variables were strong predictors of algal IBI scores according to the RF model (Figure 15). The variables that were important predictors of diatom versus soft algal assemblage scores varied slightly. Diatom scores were most closely associated with variables related to ionic strength and salinity (Figure 16). Soft algae scores were more closely associated with ionic strength, percent vulnerability, temperature, and physical habitat (Figure 17).

Stressors, as defined by this report, are chemical or physical factors or environmental conditions that alter algal and BMI communities. Stressors can include: temperature, discharge rates, lack of suitable habitat complexity, and chemical contamination. The variables identified as important through the RF model varied depending on the biotic index but included physical habitat, variables impacting ionic strength, and nutrients, consistent with the high priority stressors identified by regional analysis (Mazor, 2015).

Figure 13. Multi-dimensional scaling using physical habitat data. Watershed sub-regions are depicted by shape, while CSCI scores are represented by color (N = 80, normalization transformation, stress = 0.1062).

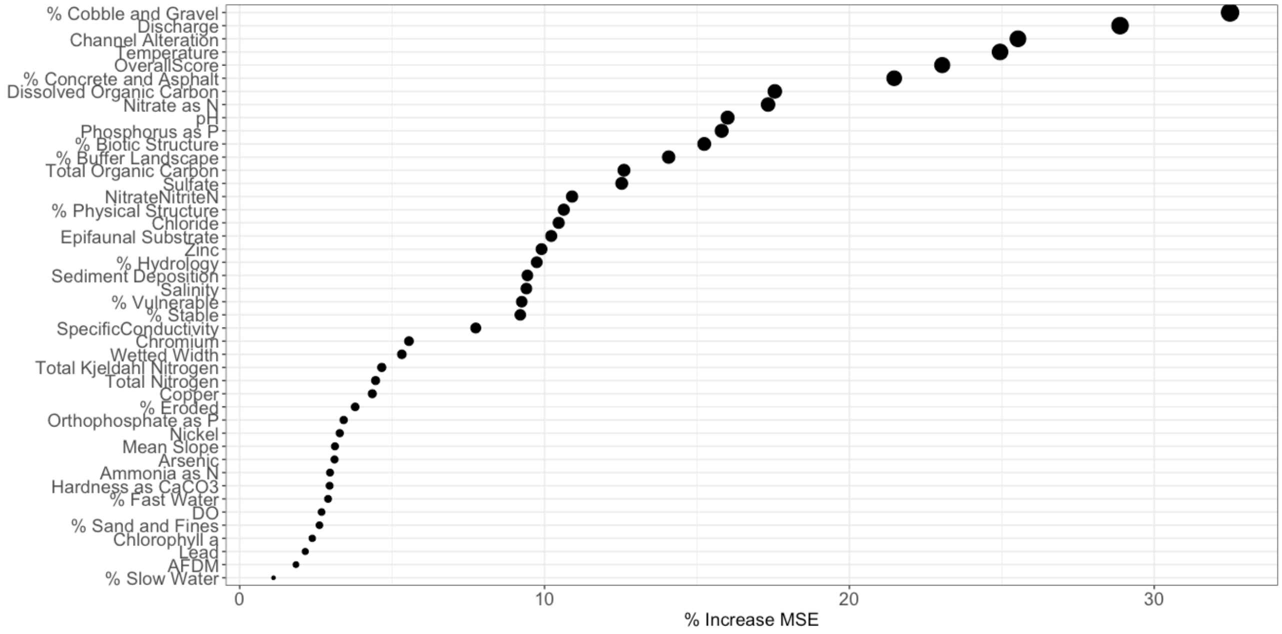

Figure 14. Variable importance plot showing an evaluation of the strength of association of the environmental variables to the biological condition using a random forest model that was created using physical habitat data (2009-2018) to predict CSCI scores (N = 80, square root transformation).

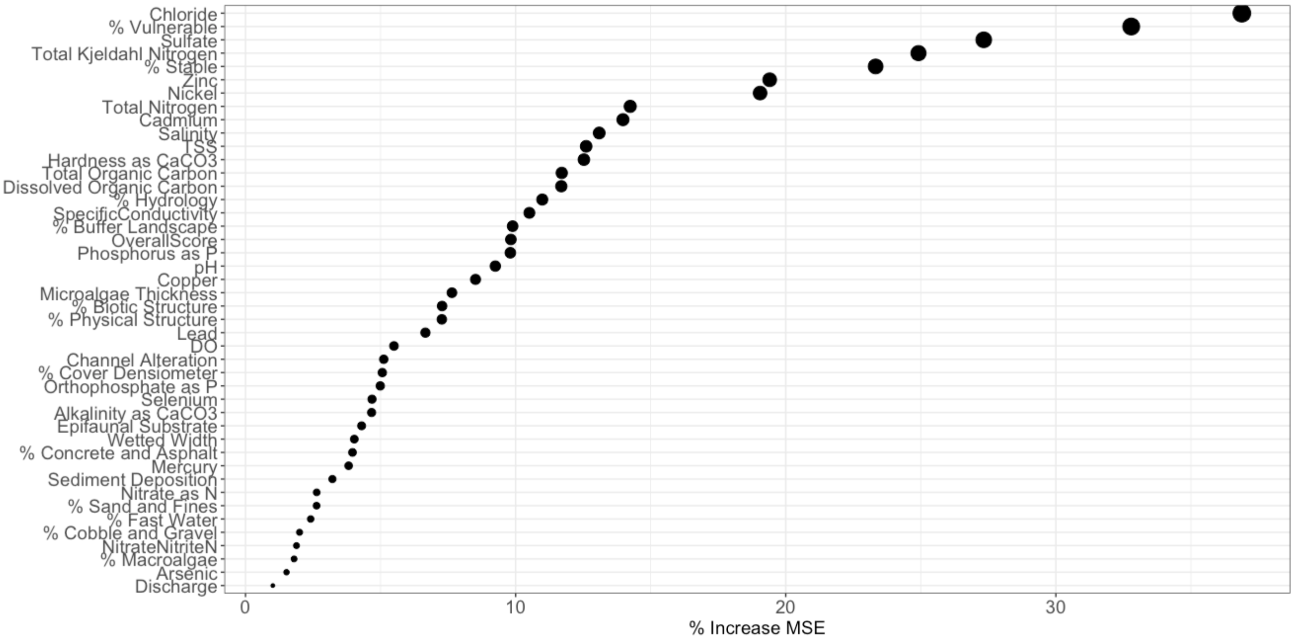

Figure 15. Variable importance plot showing an evaluation of the strength of association of the environmental variables to the biological condition using a random forest model that was created using physical habitat data (2009-2018) to predict algal IBI scores (N =63, normalization transformation).

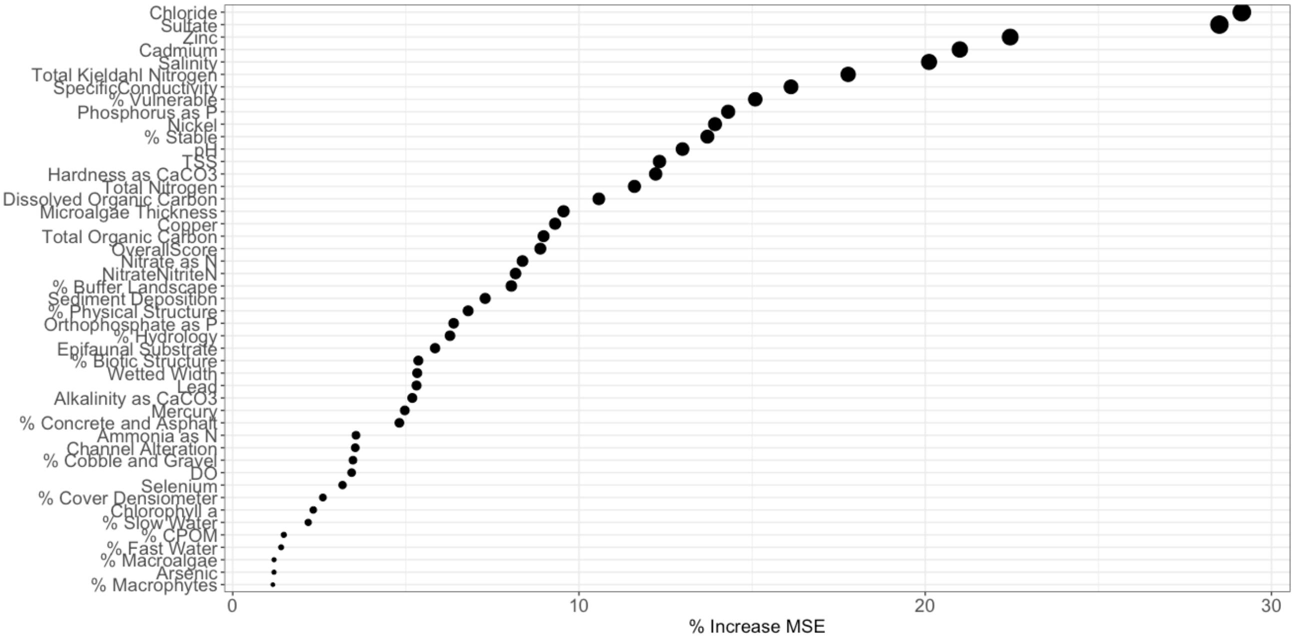

Figure 16. Variable importance plot showing an evaluation of the strength of association of the environmental variables to diatom scores using a random forest model that was created using physical habitat data (2009-2018, N =63, normalization transformation).

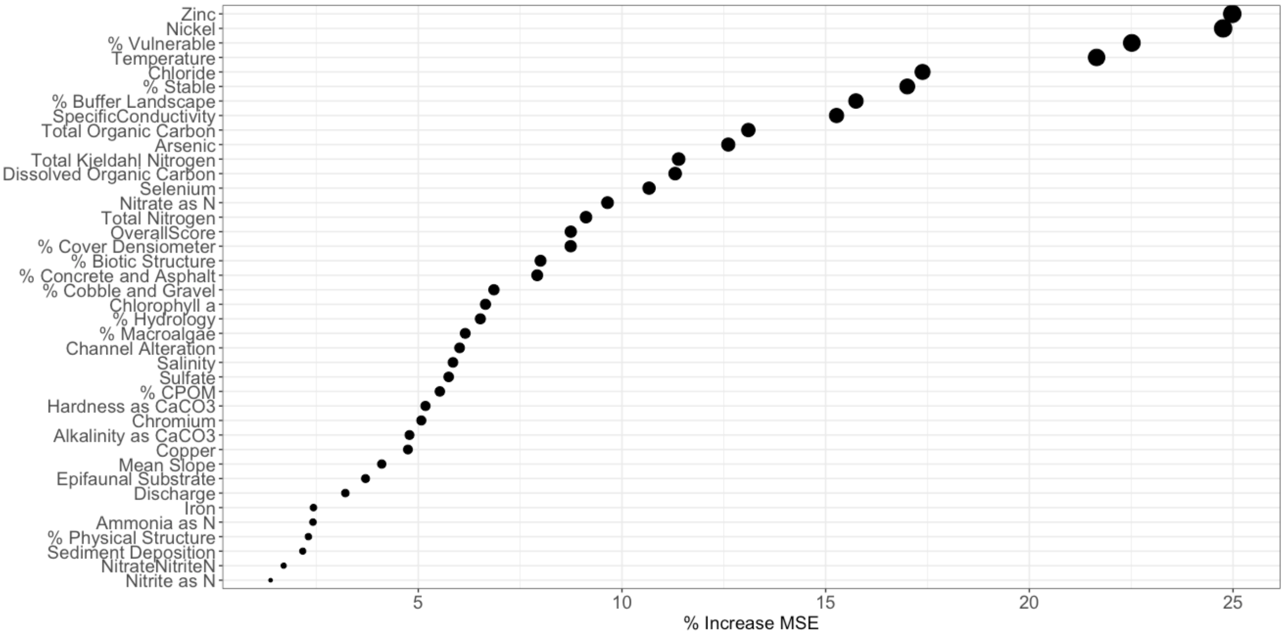

Figure 17. Variable importance plot showing an evaluation of the strength of association of the environmental variable to soft algae scores using a random forest model created using physical habitat data (2009-2018, N = 64, normalization transformation).

Chapter Summary

This portion of the program is designed to assess the dry-weather ambient condition of streams in the watershed based on a probabilistic sampling design. 81 random sites have been monitored from 2009 to 2018 and measured for biotic and riparian zone condition, water chemistry, and physical habitat condition.

Key findings include:

- Biotic condition was measured using benthic macroinvertebrates (BMIs), algal IBI, and riparian zone condition. Each of the indices showed that biological conditions in the natural sites of the upper watershed were significantly better than effluent and urban sites.
    - Benthic macroinvertebrate communities were altered compared to reference condition at approximately 65% of sites. Riparian zone habitat condition and algal communities were both below the reference threshold in roughly 70% of sites.

  - BMI and algal communities were healthiest in the upper watershed compared to the lower watershed, where lined and altered channels predominate.
  - The condition of physical habitat can play an important role in structuring aquatic communities. Riparian zone physical habitat conditions ranged from nearly pristine in the upper watershed to highly degraded in the channelized lower watershed and effluent-dominated channel, as measured by the California Rapid Assessment Method (CRAM). Physical habitat assessments showed urban/effluent sites to have higher channel alteration, less substrate cover, and lower canopy cover.
- Nutrients were consistently lower at natural sites, when compared to urban and effluent sites. Nitrate and total nitrogen were significantly higher in the effluent-dominated channel, but were both below the Basin Plan objective of 10 mg/L for nitrate-nitrogen.

- Ordination analysis showed a clear distinction between upper and lower watershed sites. Sites in the upper watershed were associated with physical habitat variables such as epifaunal cover, percent cover, and stream substrate cover (% cobble and % sand and fines), while lower watershed sites clustered around water chemistry and physical habitat variables.
- Variable importance plots for CSCI scores showed that physical habitat conditions (percent cobble and grave and channel alteration), discharge, and temperature were important variables associated with CSCI scores. Water chemistry, physical habitat, and nutrients were important variables associated with algal IBI scores. Water chemistry and nutrients were important variables associated with diatoms, while water chemistry, physical habitat, and temperature were associated with soft algae.

Question 2. Are conditions at areas of unique interest getting better or worse?

1. Background

Question 2 monitoring efforts focus on specific locations in the watershed that represent unique areas of special concern to the workgroup. These sites are monitored annually to help better understand how conditions in the watershed are changing over time and when protection or restoration is needed. For this purpose, four separate programs were created:

- Four target sites were established upstream of confluence points in the lower watershed to monitor water chemistry and assess biological, riparian, and physical habitat condition (Figure 18). These sites differ from the random sites that assess overall condition of streams in the watershed; their locations are fixed and are sampled each year. Over time these data are being used to assess trends and if changes in these trends can be attributed to natural, anthropogenic, or watershed management changes.

- Alternating sites that reflect the TSG's interest in better understanding the impact of watershed activities, such as invasive eradication, green infrastructure implementation, dredging activities, and restoration, to stream health.

- One site in the Los Angeles River is located at the head of the estuary near the Los Angeles River main stem. This monitoring was designed so that data assessment tools specific to sediment quality objectives (SQOs), developed by SWAMP, can be used to assess the condition of the estuary (Bay et al. 2014).

- The Workgroup chose nine high-value and unique habitat locations to assess trends in riparian zone condition. The emphasis of these assessments is on riparian habitat conditions rather than water quality. Riparian sites provide valuable baseline data for potential habitat restoration or protection efforts.

- One sentinel sites in the estuary near the ocean to assess the concentrations of fecal indicator bacteria emanating from different areas in the lower watershed. Since these sites were established in areas designated as 'non-swimmable', they are not part of the swimming safety program discussed later in this report.

The methods that were used to better understand the condition of sites that are unique areas of interest are consistent with those described in the previous chapter. Refer to Chapter 1 Methods and the LARWMP QAPP for a more detailed description of methodology.

2. Trends at Freshwater Target Sites

A total of 44 samples have been collected from the four confluence locations during the eleven annual surveys from 2008 to 2018 (Figure 18 and Table 8). Samples were collected and analyzed for aquatic chemistry, and biological and riparian habitat condition. The goal of repeated annual sampling at these locations is to monitor changing conditions related to water quality and riparian, physical habitat, and biological condition at the four sub-regions of the watershed over time.

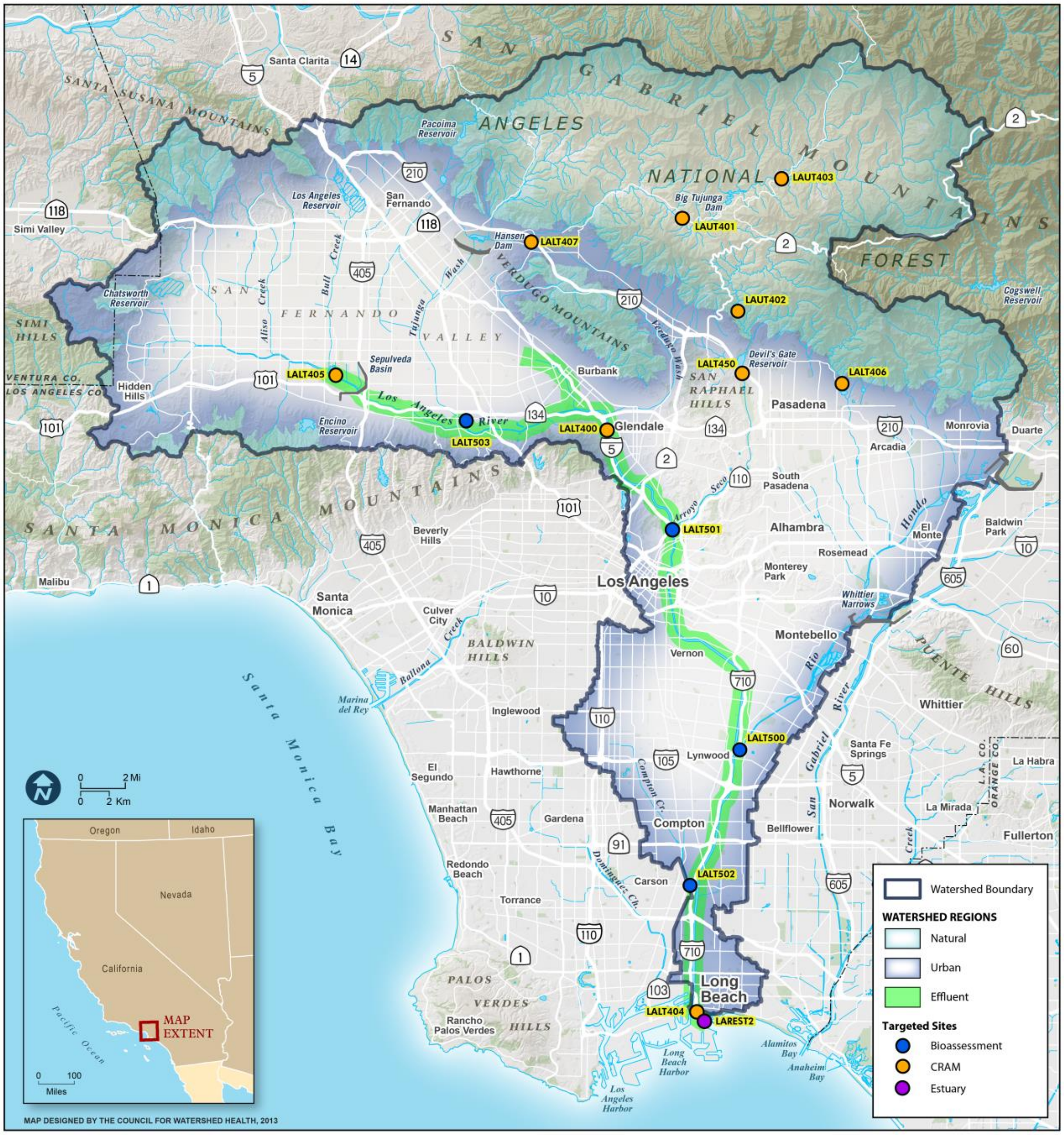

Figure 18. Location of confluence, estuary, and high-value habitat sites.

Table 8. Location of targeted confluence sites sampled from 2009 through 2018

Targeted Confluence Locations	Channel Type	Site ID	Latitude	Longitude
Confluence of Rio Hondo and mainstem of LA River	Lined	LALT500	33.93642	-118.17147
Confluence of Arroyo Seco and mainstem of LA River	Lined	LALT501	34.08059	-118.22475
Confluence of Compton Creek and mainstem of LA River	Unlined	LALT502	34.84529	-118.20784
Confluence of Tujunga Wash and mainstem of LA River	Lined	LALT503	34.14833	-118.38916

a. Aquatic Chemistry

Aquatic chemistry results have been highly variable for most constituents during the ten-year monitoring period. Though many of the parameters associated with salts have been highly variable and weakly increasing at a subset of sites, concentrations of salts were steady or declined in 2018. Sulfate and chloride began steadily increasing at the Tujunga Wash confluence (LALT503) site starting in 2014 and reached a peak in 2016 (Figure 19). In 2018, the concentrations of chloride and sulfate declined by 47% and 30%, respectively. Despite the increasing trend, sulfate concentrations at the Tujunga Wash confluence only exceeded the reach-specific water quality objective of 300 mg/L in 2016. The concentrations for chloride at LALT503, however, have exceeded the reach specific water quality objective of 150 mg/L every year since monitoring began but concentrations were below the regulatory threshold in 2018 (Table 3-10, LARWQCB 2014). Though the factors that led to the increasing trend in salts are unknown, the area upstream of the Tujunga Wash hosts a large percentage of industrial stormwater discharge permittees.

As shown in Figure 19, a large spike in suspended solids was observed at the Rio Hondo (LALT500) confluence in 2014 and 2017. In 2018, the concentrations of suspended solids at this site dropped by 99% and concentrations were the lowest values observed at a confluence site during the 2018 program year.

As shown in Figure 19, hardness at the Arroyo Seco confluence (LALT501) increased slightly but steadily over time from 2009 to 2015, likely due to the 2011-2016 droughts. However, from 2015 to 2016, hardness dropped substantially and values have hovered below 200 mg/L in recent years. Similarly, at the Tujunga Wash confluence site (LALT 503), concentrations peaked in 2015 and dipped in subsequent years. In 2018, hardness at the Tujunga Wash site was comparable to other sites.

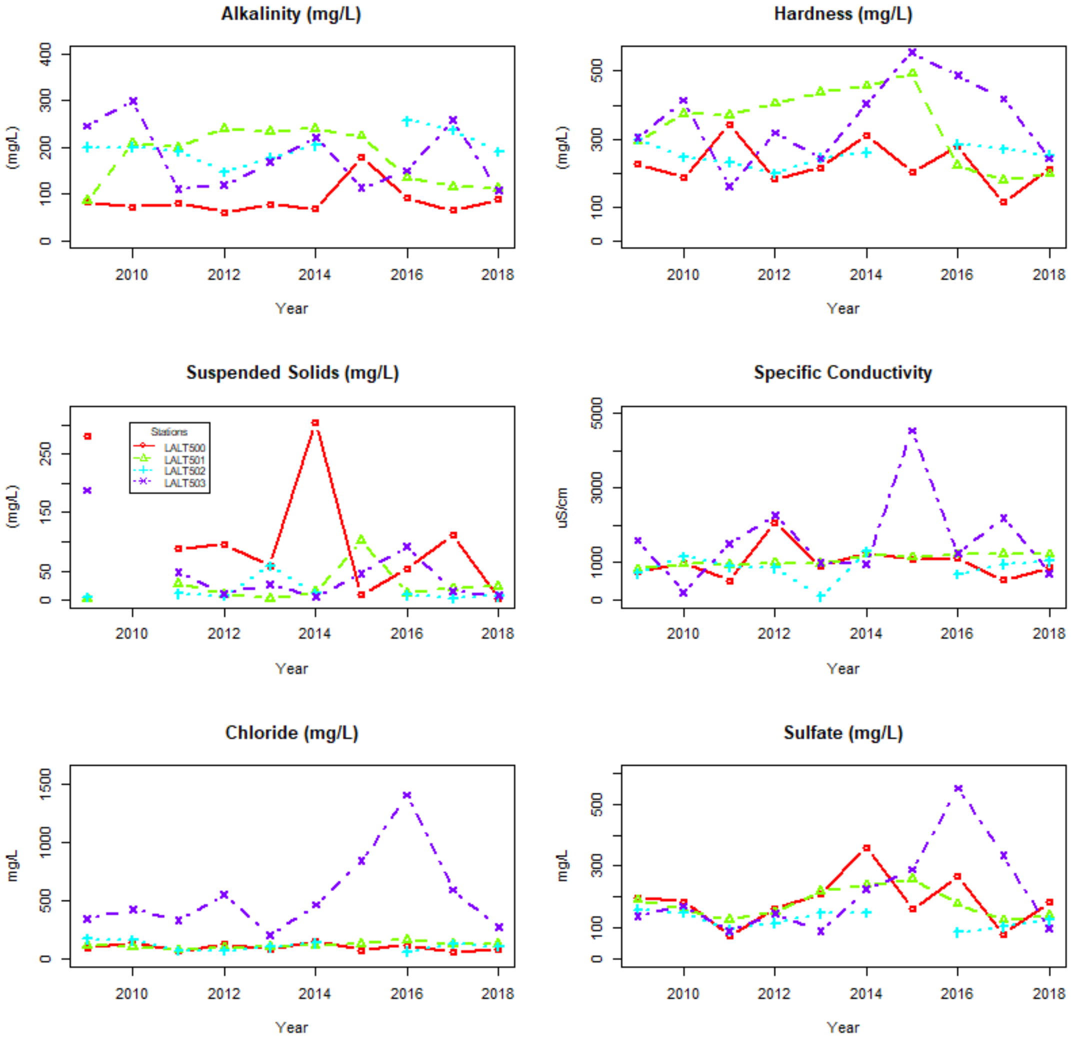

Figure 19. General chemistry at confluence sites sampled annually from 2009 to 2018.

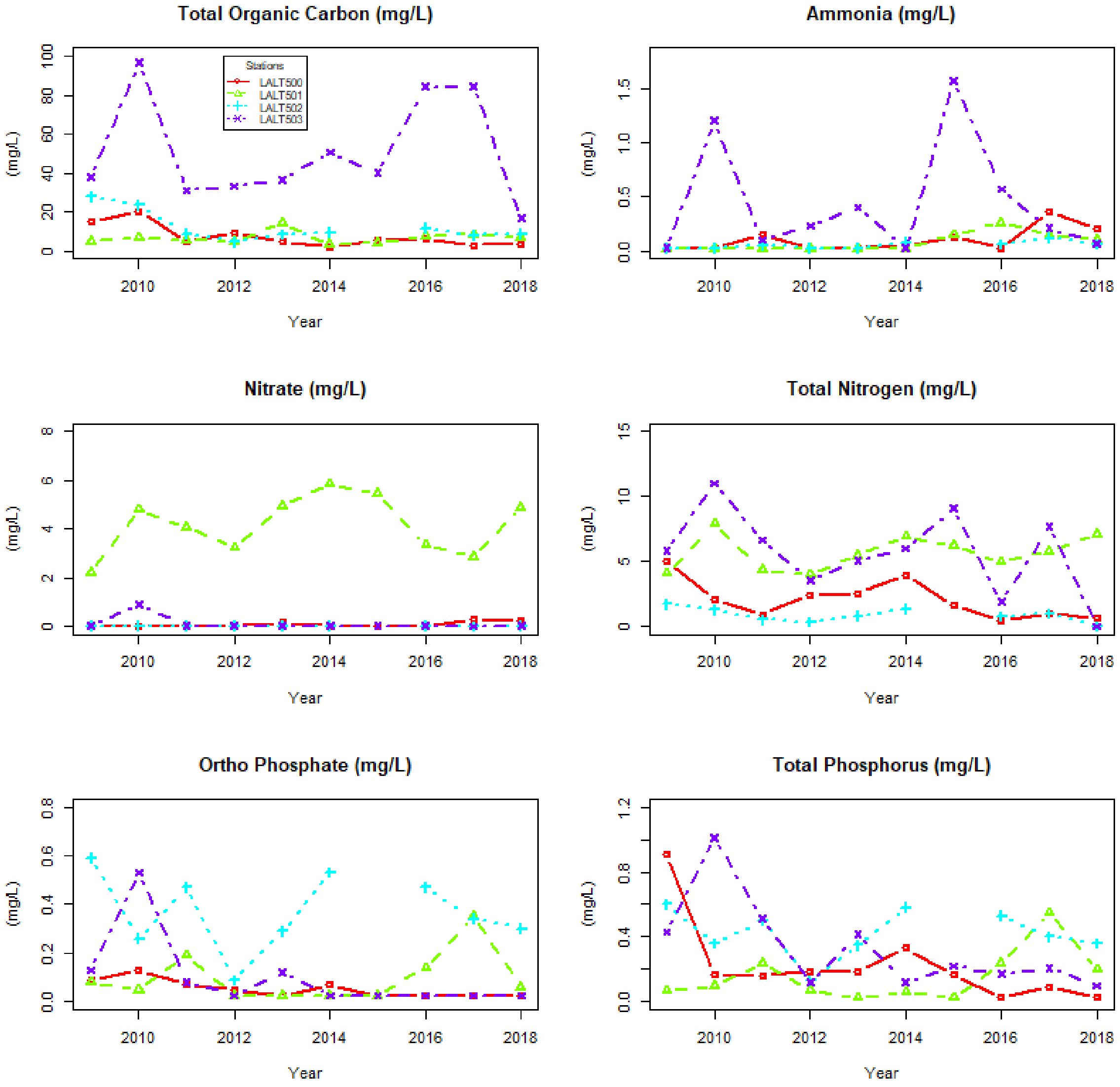

Figure 20. Nutrient concentrations at confluence sites sampled annually from 2009 to 2018.

The Tujunga Wash site has also experienced ammonia, total organic carbon, and total phosphorus concentrations that, on occasion, have been elevated in comparison to other confluence sites (Figure 20). Like the trend in general chemistry constituents, the concentrations of these nutrients decreased in 2018 and were comparable to values observed at other sites. Nitrate concentrations continued to be elevated at the Arroyo Seco confluence (LALT501) compared to other confluence sites but were still below the water quality threshold of 10 mg/L, specified in the Los Angeles Basin Plan (LARWQCB 2014). Orthophosphate has been variable across all confluence sites since monitoring began. For example, concentrations peaked in 2009 at Rio Hondo (LALT 500), in 2010 at the Tujunga Wash (LALT 503), in 2014 at Compton Creek (LALT 502), and in 2017 at the Arroyo Seco (LALT 501). During the 2018 program year, total phosphorus concentrations at Compton Creek (LALT 502) were at least 80% higher than other confluence sites. However, concentrations have been steadily decreasing at Compton Creek since 2014.

b. Biological and Riparian Habitat (CRAM) Condition

Figure 21 presents the biotic condition index scores for BMI (CSCI) and riparian habitat scores (CRAM; overall and attribute) for the targeted sites sampled from 2009 to 2018. Though CSCI scores at all confluence sites vary from year to year, some by as much as 230% (a 0.429 jump in CSCI score was observed at LALT 503 from 2015 to 2016), all targeted sites are altered (scores below 0.79 fall into the likely or very likely altered categories) and continued to be altered/very likely altered condition in 2018. The largest changes in stream condition during the 2018 program year were observed at LALT 501, scored dipped by 18% compared to the previous year, and LALT 503, scores increased by 47% compared to the previous year. All confluence sites have fallen into in the lower CSCI range of 'very likely altered' over the past 10 years. In 2018, only LALT 501 was slightly above the very likely altered threshold.

Low CSCI scores across at confluence sites are not surprising given that these sites are in highly modified channels in the urbanized portion of the watershed. In addition to good water quality conditions, healthy biological communities require complex instream and riparian cover, natural flow regimes, and a wide and undisturbed riparian and buffer zone. These types of conditions are rare at confluence sites along the L.A. River, as indicated by CRAM scores (Figure 21). CRAM scores at confluence sites are less variable than CSCI scores and are well below the 10th percentile of California sites in reference condition (10th percentile threshold is 72) at all sites. Though CRAM scores are higher at LALT 502, a soft bottom portion of the River, higher CRAM scores at this site have not translated to higher CSCI scores.

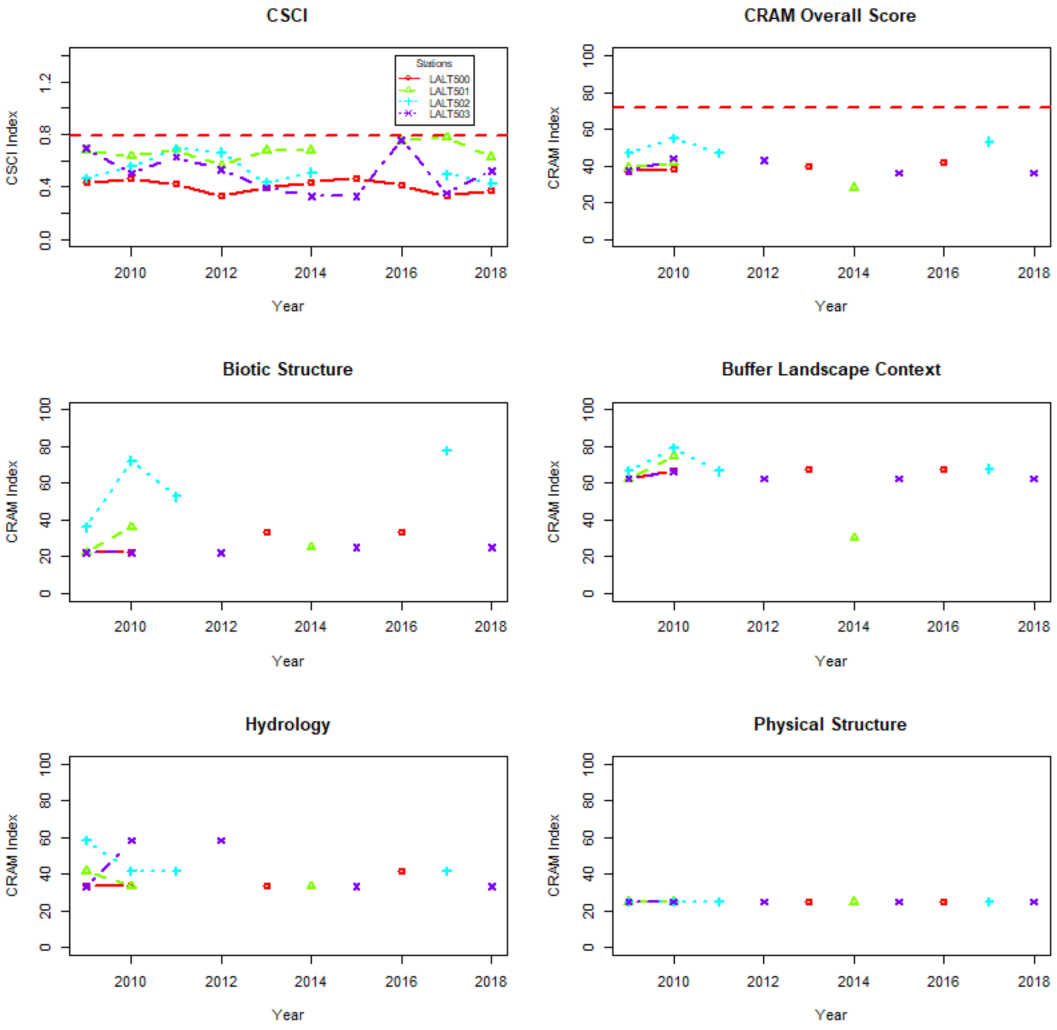

Figure 21. CSCI and CRAM scores (overall and attribute) at confluence sites sampled annually from 2009 to 20198. The red dashed horizontal lines on the CSCI and CRAM Overall Score graphs indicate the threshold, below which the site is in non-reference condition (0.79 for CSCI and 72 for overall CRAM score).

c. Physical Habitat

Figure 22 shows selected metrics of physical habitat condition. The three top plots show transect-based measurements recorded in conjunction with bioassessment sampling, while the three bottom plots show three visual physical habitat assessment scores. Compton Creek confluence (LALT502) experienced a substantial decline in percentage sands/fines in 2011 and again in 2016, indicating a possible scouring event. The percentage of sands/fines increased again in 2018. The other three sites showed similar, highly variable, patterns in physical habitat metrics during the 2018 program year as in previous years.

For each of the physical habitat metrics presented, Compton Creek confluence (LALT502) has differed substantially from the other three confluence sites across years. Specifically, it had more canopy cover (or similar canopy cover to LALT501 for three of the eight years), smaller particle sizes, no concrete or asphalt substrate (the channel is unlined at the sampling site), less channel alteration, and more epifaunal substrate cover and sediment deposition. The scores for biotic structure and the overall riparian habitat condition are higher at Compton Creek compared to other confluence sites (Figure 21). Higher physical habitat and CRAM scores at Compton Creek has not, however, translated to improved biological condition (CSCI score) at this site.

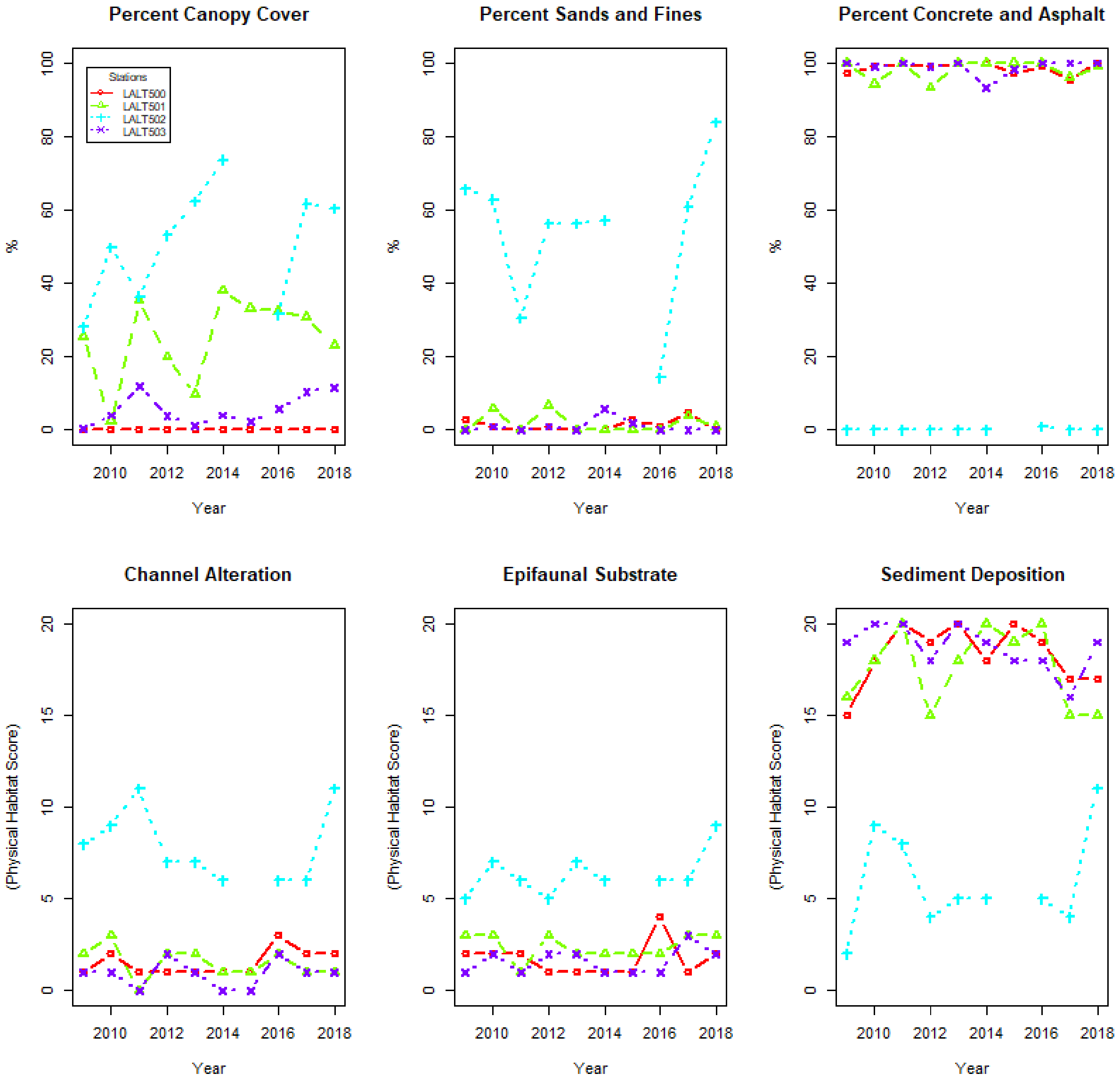

Figure 22. Physical habitat at confluence sites sampled annually from 2009 to 2018.

3. Los Angeles River Estuary

LARWMP monitors sediment at the LA River estuary to ensure sediment quality is suitable for aquatic life and is protective of human health (for seafood consumption). Sediment samples were collected from 2009 through 2016 at the mouth of the Los Angeles River Estuary near Queensway Bridge (LAREST2). The design of LARWMP's estuary monitoring program is based on a multiple lines of evidence (MLOE) approach developed by SCCWRP for the State of California's Sediment Quality Objectives (SQO) program (Bay *et al.*, 2014). This approach incorporates sediment chemistry, toxicity, and biological community assessments to evaluate the condition of sites located in marine embayments in southern California. The results of each of these analyses represent a line of evidence (LOE) that is converted to a condition category score. The three condition category scores are then combined to provide a single-station assessment category.

Sediment chemistry testing included the suite of metals and organic constituents specified in the SQO program (Bay *et al.*, 2014). Toxicity testing included the 10-day amphipod (*Eohaustorius estuarius;* U.S. EPA600/R-94-025) survival test and the 48-hour mussel (*Mytilus galloprovincialis*; Anderson et al. 1996) development test. Infauna samples were collected and analyzed in adherence to protocols of the Southern California Bight Regional Monitoring Program (SCCWRP 2008).

The integrated SQO's category scores for the Los Angeles River Estuary site are provided in Table 9 (Bay *et al.* 2014). Component scores vary from year to year as storms, scouring, and sediment deposition alter sediment quality. In 2010, 2013 and 2014, integrated scores could not be calculated due to missing data for either chemistry or toxicity. For the years when integrated scores could be calculated, EST2 ranked from 'unimpacted' to 'clearly impacted'.

The integrated SQO chemistry scores ranged from 'highly disturbed' in 2009 and 2016, to 'moderately disturbed' in 2010, 2011, 2012 and 2015, indicating some reduction in sediment contaminant concentrations from 2009 to 2015, followed by a recent increase in contaminant levels from 2015 to 2016. The integrated toxicity scores ranged from 'non-toxic' in 2011 and 2015 to 'moderately disturbed' in all other years, except 2013 and 2016 when they were 'minimally disturbed'.

The integrated infauna scores ranged from ‘minimally disturbed’ in 2010 and 2011, to ‘high disturbance’ in 2012 and 2016. Annual scouring due to winter runoff from the Los Angeles River leads to replacement of sediments and can cause large changes in biotic habitat conditions. Notably, total rainfall during the 2010 and 2011 wet seasons in Los Angeles was higher than average on years when lower disturbance to infauna communities were measured. Total seasonal rainfall for all other years was below average (National Weather Service n.d.). Thus, in 2016, although the integrated toxicity score remained relatively low, an increase in the integrated chemistry and infauna scores resulted in the overall designation of “Likely Impacted.”

In 2018, the LARWMP program discontinued monitoring activities at the Los Angeles River Estuary. These data are collected and reported by the Long Beach Nearshore Watershed WMP/EWMP group and are publicly available. Monitoring for the SQO is performed once every two years and was completed in August 2018. Results will be available in the 2018/2019 report Long Beach Nearshore Watershed report to be released in December 2019.

Table 9. Integration of chemistry, toxicity, and infauna category scores for estuarine sediment quality objectives through 2015. Category scores range from: (1) reference; (2) minimal disturbance; (3) moderate disturbance; (4) high disturbance.

Metric	2009	2010	2011	2012	2013	2014	2015	2016
Chemisty								
CA LRM	4	3	4	4	Not Analyzed	Not Analyzed	4	4
CSI	3	2	2	2	Not Analyzed	Not Analyzed	2	3
Integrated Chemistry Score	4	3	3	3	Not Analyzed	Not Analyzed	3	4
Toxicity								
Eohaustorius estuarius	3	Not Analyzed	1	4	2	4	1	1
Mytilus galloprovincialis	3	3	1	1	1	2	1	3
Integrated Toxicity Score	3	3	1	3	2	3	1	2
Infauna								
BRI	2	1	2	4	1	3	2	4
IBI	3	2	1	4	3	3	2	4
RBI	4	1	2	4	3	3	3	1
RIVPACS	2	2	1	4	4	2	3	4
Integrated Infauna Score	3	2	2	4	3	3	3	4
Site Assesment	Clearly Impacted	NA	Unimpacted	Likely Impacted	NA	NA	Possibly Impacted	Likely Impacted

4. High-Value Habitat Sites

The condition of the riparian zone was assessed at nine sites deemed by members of the Workgroup to be minimally impacted, high-value, or sites at high risk of impact/loss in the watershed (Table 10). The goal of measuring the condition of these sites over time is to ensure that conditions are not degrading. The riparian zone was assessed using the California Rapid Assessment Method. CRAM assessments at these sites commenced in 2009. After two to four years of annual visits, the Workgroup determined that subsequent visits would occur every two to three years since conditions at these locations were not changing rapidly.

Figure 23 shows the individual CRAM scores from 2009 to 2018 for the high-value sites. Most of the CRAM scores at the lower watershed sites (prefix LALT) fell below the 10th percentile of the reference distribution of sites throughout California, indicating they are 'likely altered'. The Glendale Narrows site (LALT 400), for example, has consistently scored below reference condition. In 2018, the downward trend in site condition that began in 2016 continued, with a decline of 6 points in 2018. The exception to this general trend of poorer condition at lower watershed sites and more optimal condition at upper watershed sites have been sites downstream of areas that were recently burned and near ongoing restoration activities. For example, the Arroyo Seco USGS Gage site (LALT450), downstream of sites that burned as recently as 2009, achieved a CRAM score just above the reference threshold in 2014 and continued to hover just above reference condition in 2017. However, Haines Creek Pools and Stream (LALT407), a site near ongoing restoration activities, had appeared to be slowly improving over time. CRAM scores improved from a non-reference CRAM score of 61 in 2009, to reference scores of 76 in 2012, and 79 in 2015. However, in 2018 the CRAM scores declined by 7 points (a score of 72).

The best riparian zone conditions have been found consistently at sites located in the upper watershed (prefix LAUT) (refer to Q1 LARWMP findings). However, the 2009 Station Fire created the opportunity for the LARWMP program to better understand fire, its impacts, and recovery at upper watershed riparian sites. Upper watershed sites LAUT401, LAUT402, and LAUT403—located in the Tujunga Sensitive Habitat, Upper Arroyo Seco, and Alder Creek, respectively—burned during the 2009 Station Fire and fell below the 10th percentile threshold in 2009 (except for LAUT 403). Habitat conditions improved over the next set of site visits to well above the 10th percentile of the reference distribution. However, CRAM scores at the Tujunga Sensitive Habitat and Upper Arroyo Seco dropped to near the 10th percentile of the reference distribution in 2015, perhaps due to the ongoing drought. The following year the CRAM scores at Tujunga Sensitive Habitat improved. Meanwhile, at the Upper Arroyo Seco site, habitat conditions continued to hover near the reference condition threshold. In 2018, CRAM scores at the Arroyo Seco dipped to just below reference condition.

The impact of fire on riparian systems remains relatively understudied and varies depending on fire extent and severity. In some instances, riparian areas serve as refuge for fire sensitive species. However, when conditions are dry and fuel loads high, riparian areas can become corridors for fire (Pettit and Naiman, 2007). LARWMP will continue to monitor habitat condition of riparian areas burned during the 2009 Station Fire to aid in better understanding the response of this ecosystem to fire.

Table 10. Location of high value habitat sites

Site Name	Channel Type	Site ID	Latitude	Longitude
Arroyo Seco USGS Gage	Unlined	LALT450	34.18157	-118.17297
Glendale Narrows	Unlined	LALT400	34.139368	-118.2752
Golden Shores Wetlands	Unlined	LALT404	33.76442	-118.2039
Sepulveda Basin	Unlined	LALT405	34.17666	-118.49335
Eaton Wash	Unlined	LALT406	34.17463	-118.0953
Haines Creek Pools and Stream	Unlined	LALT407	34.2679	-118.3434
Tujunga Sensitive Habitat	Unlined	LAUT401	34.28220	-118.22160
Upper Arroyo Seco	Unlined	LAUT402	34.22121	-118.17715
Alder Creek	Unlined	LAUT403	34.30973	-118.14190

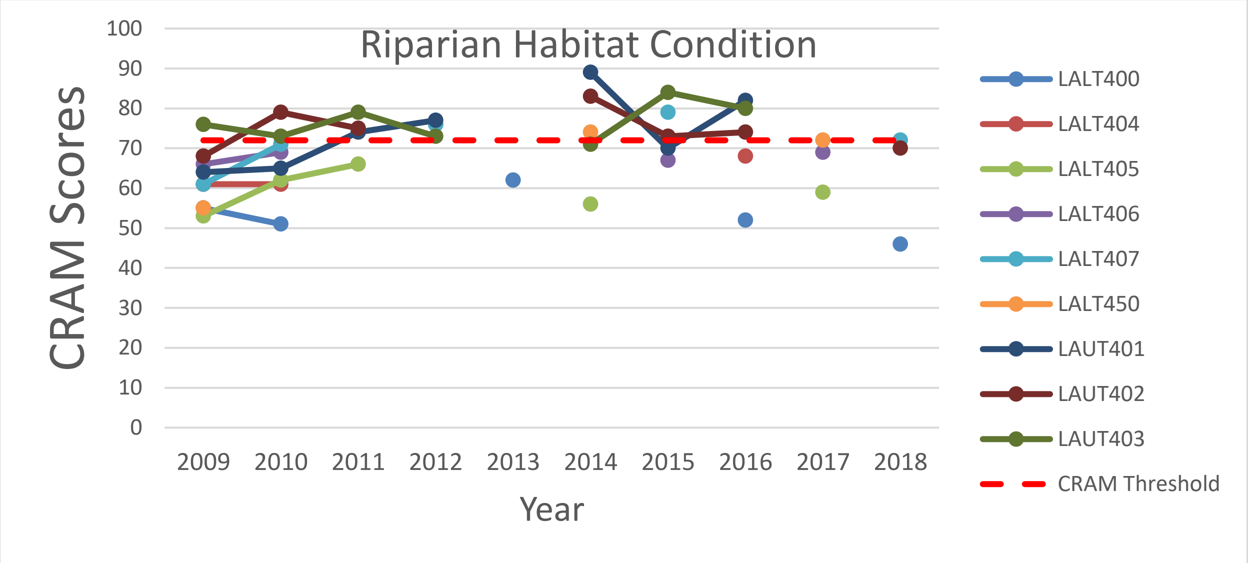

Figure 23. Riparian zone condition (CRAM scores) at high-value sites from 2009-2018. The red horizontal line represents the 10th percentile of the reference distribution of sites in California. Scores below this line represent 'likely altered' habitat.

Los Angeles River Estuary Bacteria

In 2018, the LARWMP program discontinued monitoring activities at the Los Angeles River Estuary. These data are collected and reported by the Long Beach Nearshore Watershed WMP/EWMP group and data are publicly available. Monitoring for bacteria at Long Beach City Beaches is performed from April 1-October 31 2018. During that time, 17.6% of samples collected west of Belmont Pier exceeded WQO. Closest to the Los Angeles River Estuary, data collected as part of the City of Long Beach Nearshore Watershed Integrated Monitoring Program showed that fecal coliform and total coliform exceedances were noted during 3 wet weather events in 2018 and an Enterococcus exceedance occurred during summer dry weather sampling. More detailed findings can be found in the 2018/2019 report Long Beach Nearshore Watershed report.

Chapter Summary

Trends at Freshwater Target Sites

- A total of 44 samples have been collected from the four confluence locations during the eight annual surveys from 2009 to 2018.
- Though many of the parameters associated with salts have been highly variable, and weakly increasing at a subset of sites, concentrations of salts were steady or declined in 2018.
- Sulfate and chloride had steadily increased at the Tujunga Wash (LALT 503) confluence site from 2014 to 2016. In 2018, the concentrations of chloride and sulfate declined by 47% and 30%, respectively. In 2018, chloride concentrations at LALT503 were below the regulatory threshold of 150 mg/L for the first time since monitoring began.
- In 2018, the concentrations of suspended solids at Rio Hondo (LALT 500) dropped by 99% and values were among the lowest observed at a confluence site.
- Hardness at the Arroyo Seco (LALT 501) and Tujunga Wash (LALT 503) sites have continued to decline.
- The Tujunga Wash site (LALT 503) has also experienced ammonia, total organic carbon, and total phosphorus concentrations that, on occasion, have been elevated in comparison to other confluence sites. Like the trend in general chemistry constituents, the concentrations of these nutrients decreased in 2018 and were comparable to values observed at other sites.

- Nitrate concentrations were highest at the Arroyo Seco confluence (LALT501) than other confluence sites from 2009 to 2018. Nitrate concentrations are still below the water quality threshold protective of aquatic life (10 mg/L) specified in the Los Angeles Basin Plan.
- During the 2018 program year, total phosphorus concentrations at Compton Creek (LALT 502) were at least 80% higher than other confluence sites. However, concentrations have been steadily decreasing at Compton Creek since 2014.
- All targeted sites are altered, based on CSCI scores, and continued to be in altered and very likely altered condition in 2018. The largest changes in stream condition, as measured by CSCI, during the 2018 program year were observed at the Arroyo Seco site (LALT 501), scored dipped by 18% compared to the previous year, and Tujunga Wash (LALT 503), scores increased by 47% compared to the previous year.
- CRAM scores at all confluence sites are well below the 10th percentile of California sites in reference condition (10th percentile threshold is 72).
- For each of the physical habitat metrics, Compton Creek confluence (LALT502) differed substantially from the other three confluence sites. Specifically, it had more canopy cover, no concrete or asphalt substrate (the channel is unlined at the sampling site), less channel alteration, more epifaunal substrate cover, and sediment deposition.

High-Value Habitat Sites

- In 2018, riparian habitat condition was assessed at the Haines Creek Pools and Stream (LALT 407), the Upper Arroyo Seco (LAUT 402), and the Glendale Narrows (LALT 400). Habitat condition is assessed using the California Rapid Assessment Method (CRAM)
- Since monitoring began, the Glendale Narrows site has consistently scored below reference condition. In 2018, the downward trend in habitat condition, that began in 2016, continued. CRAM score declined by 6 points at Glendale Narrows site in 2018.
- Haines Creek Pools and Stream (LALT407), a site near ongoing restoration activities, had appeared to be slowly improving over time. CRAM scores improved from a non-reference CRAM score of 61 in 2009 to reference scores of 76 in 2012, and 79 in 2015. In 2018 the CRAM scores declined by 7 points

- CRAM scores at the Upper Arroyo Seco (LAUT 402), which have hovered just above the reference condition threshold, dipped to just below reference condition in 2018.

Question 3. Are permitted discharges meeting WQOs in receiving waters?

1. Background.

Question 3 addresses the potential impacts of permitted point-source discharges on the Los Angeles River, its tributaries, and receiving waters' ability to meet the Water Quality Objectives (WQOs) set forth in the Los Angeles Basin Plan (LARWQCB, 2019). The data compiled by LARWMP include metals, bacteria (*E. coli*), nutrients, and trihalomethanes. These parameters are measured to provide a basic assessment of water quality and include the contaminants commonly introduced into a stream system via effluent from Publicly Owned Treatment Works (POTWs).

This chapter summarizes NPDES monitoring data for the period from January through December 2018 for three major POTWs that discharge into the Los Angeles River: The City of Los Angeles' Tillman Water Reclamation Plant (DCTWRP), the City of Los Angeles' Glendale Water Reclamation Plant (LAGWRP), and the City of Burbank's Water Reclamation Plant (BWRP). Site codes for the receiving water stations upstream and downstream of each POTW's discharge and their locations are shown in Table 11 and Figure 24, respectively. These receiving water stations are monitored by the permittees as a requirement of their NPDES permits and were chosen to best represent locations upstream and downstream of the discharge locations. Values were compared to LARWQCB Basin Plan Water Quality objectives (Table 12).

Table 11. Station designations for NPDES monitoring sites

POTW	Upstream Site	Downstream Site
City of Los Angeles- Tillman	LATT612	LATT630
City of Los Angeles-Glendale	LAGT650	LAGT654
City of Burbank- Burbank	R-1	R-2

Table 12. Water Quality Objectives for nutrients in the Los Angeles Regional Water Quality Control Board Basin Plan and plan amendments, updated in May 2019. Ammonia (NH3) objectives are based on the average pH of each discharge site in 2018.

	NITRATE NITROGEN NO3-N (mg/L)	NITRITE NITROGEN NO2-N (mg/L)	AMMONIA NITROGEN NH3-N (mg/L)
DCTWRP	10	1	10.1
LAGWRP	10	1	6.95
BWRP	10	1	14.4

Figure 24. **Locations of NPDES receiving water sites monitored by the City of Los Angeles and the City of Burbank.**

2. City of Los Angeles - DCTWRP

The cumulative frequency distributions for *E. coli* above and below the City of Los Angeles' DCTWRP discharge location are shown in Figure 25. The single-sample WQO of 235 MPN/100mL for REC-1 beneficial use was attained for approximately 85% of upstream samples and 40% of the downstream samples during the 2018 sampling year.

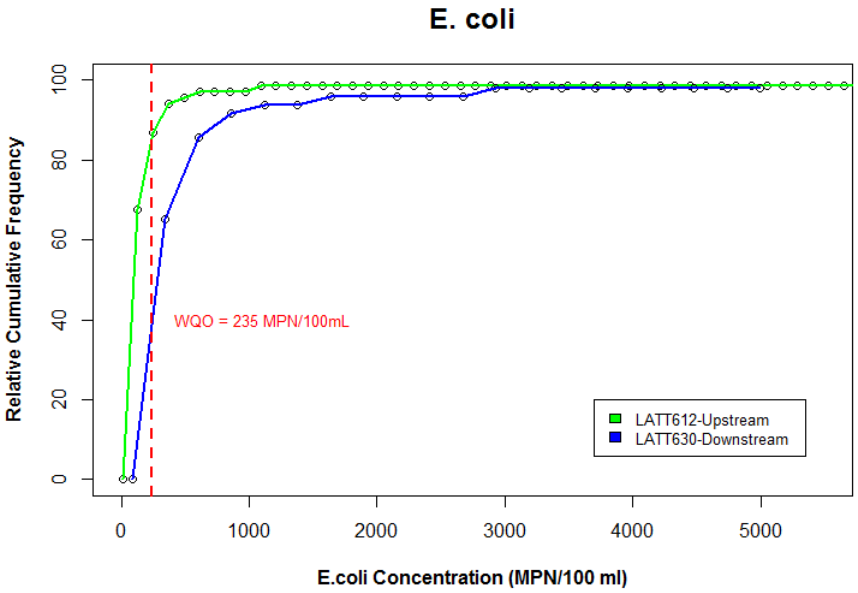

Figure 25. Cumulative frequency distributions of *E. coli* concentrations above and below the DCTWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

Table 13. Range of nutrient concentrations downstream of DCTWRP discharge in 2018.

	NITRATE NITROGEN NO3-N (mg/L) (n=52)	NITRITE NITROGEN NO2-N (mg/L) (n=52)	AMMONIA NITROGEN NH3-N (mg/L) (n=52)	ORGANIC NITROGEN (mg/L) (n=15)	TOTAL NITROGEN (mg/L) (n=15)
MIN	3.61	0.04	0.05	1.2	5.7
MAX	6.43	0.76	1.12	2.3	8.2
MEDIAN	4.78	0.17	0.36	1.5	6.9
MEAN	4.78	0.23	0.37	1.56	6.81

Table 13 shows the range in nutrient concentrations observed at a site downstream of DCTWRP discharge. Nitrate, nitrite, and ammonia were tested weekly. Organic and total nitrogen were tested one to two times a month. Nutrient concentrations at DCTWRP did not exceed 30-day average regulatory thresholds. The largest median values were observed for NO_3-N and total nitrogen.

Total trihalomethanes, which are common disinfection by-products, were detected below the discharge location, but at concentrations that were well below the EPA water quality objective of 80 ug/L (Table 14).

Table 14. Trihalomethane concentrations below the DCTWRP discharge (LATT630).

Trihalomethanes (µg/L)	Site	2/6/2018	8/7/2018
Bromodichloromethane (ug/L)	LATT630	1.47	0.46
Bromoform (ug/L)	LATT630	ND	ND
Chloroform (ug/L)	LATT630	3.7	1.81
Dibromochloromethane (ug/L)	LATT630	0.37	ND

Total trihalomethanes were calculated as the sum of bromodichloromethane, bromoform, chloroform, and dibromochloromethane. "ND" indicates the analyte was not detected or the detected value was below the MDL. The EPA water quality objective for total trihalomethanes is 80 ug/L (U.S. EPA 2002).

The metals concentrations shown in Figure 26 are compared to the California Toxics Rule (CTR) chronic and acute standards, which are typically expressed as dissolved metals concentrations, and applied to hardness-adjusted dissolved metals. It is important to note that total recoverable metals, rather than dissolved metals, were measured by the City of Los Angeles as a requirement of their NPDES permit. Total recoverable concentrations from DCTWRP and LAGWRP were converted to dissolved concentrations, which represent the biologically active fraction of the total metal concentration, using a Metals Translator Guidance document written by the EPA (USEPA 1996).

Figure 26 shows the concentration of select metals upstream and downstream of the DCTWRP discharge location. Concentrations of zinc and cadmium were below both chronic and acute CTR thresholds. Copper exceeded the chronic threshold on one of the four occasions downstream of POTW discharge points. Selenium concentrations upstream of the discharge exceeded the CTR chronic threshold on all four occasions. Unpaired, one-tailed t-tests were used to identify differences between upstream and downstream locations. Zinc ($p<0.001$) and cadmium ($p=0.02$) were significantly greater downstream of the discharge, though still below chronic and acute thresholds. Selenium concentrations were significantly greater ($p<0.001$) upstream of the discharge.

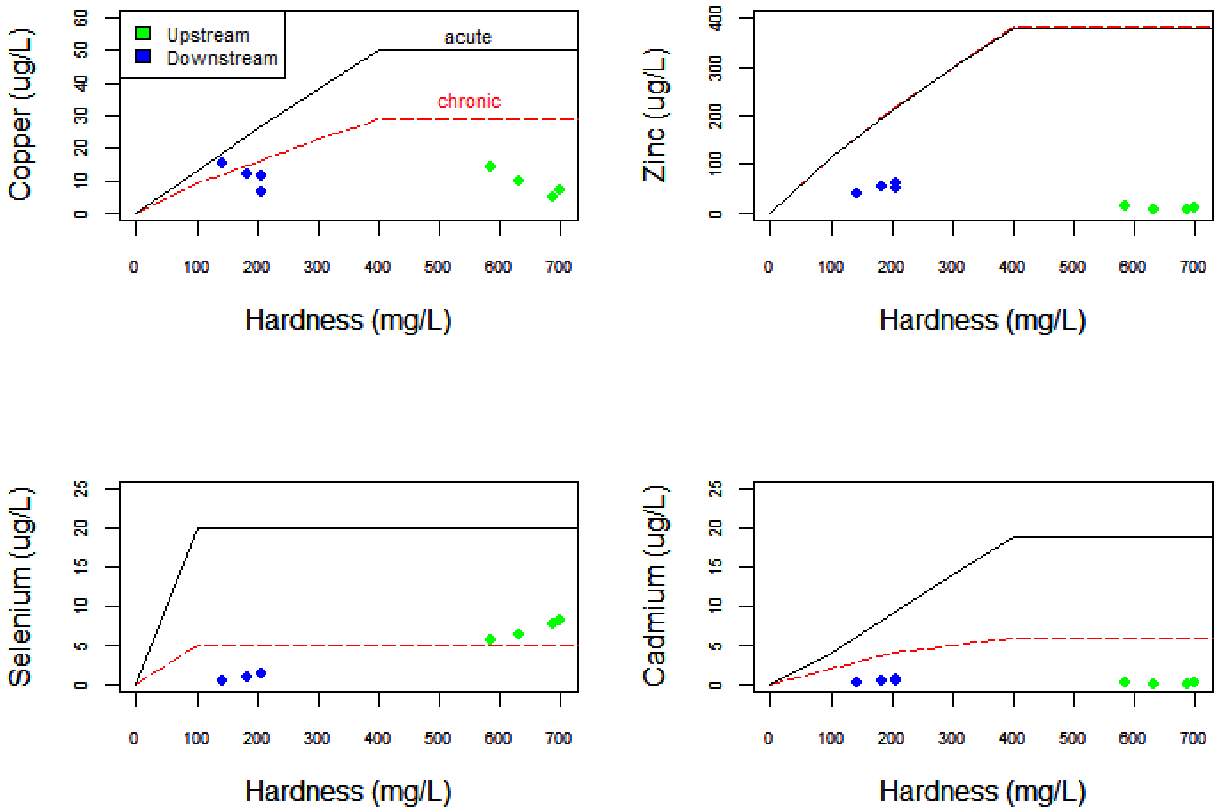

Figure 26. Converted dissolved metals concentrations above and below the DCTWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Black lines indicate acute CTR thresholds and red line indicates chronic CTR thresholds. Includes estimated values for low concentrations that exceeded the method detection limit but that did not meet the laboratory's reporting limit.

3. City of Los Angeles – LAGWRP

Figure 27 shows the cumulative frequency distributions for *E. coli* at sites above and below the discharge point for the LAGWRP. Approximately 20% of the *E. coli* samples met the WQO at the upstream site, while approximately 40% of the samples met the WQO at the downstream site. The concentrations were generally lower downstream compared to upstream samples, indicating a dilution effect as a result of the LAGWRP effluent.

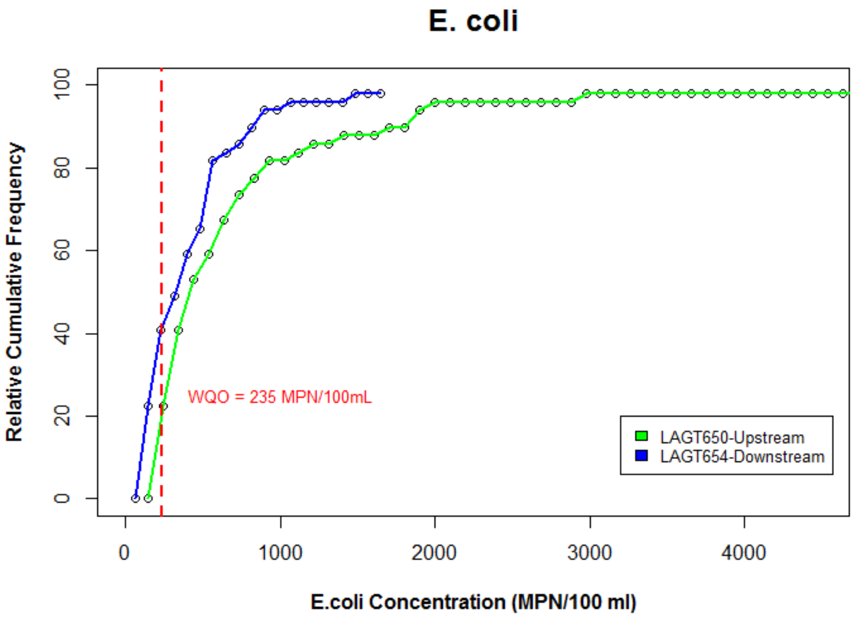

Figure 27. Cumulative frequency distribution of *E. coli* above and below the LAGWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

Table 15 shows the range in nutrient concentration measured below the LAGWRP discharge. Nitrate, nitrite, and ammonia were tested weekly. Organic and total nitrogen were tested one to two times a month. The largest median concentrations were observed for NO_3-N and total nitrogen. All nutrient concentrations were below regulatory thresholds.

Table 15. Range of nutrient concentrations downstream of LAGWRP discharge in 2018.

	NITRATE NITROGEN NO3-N (mg/L) (n=52)	NITRITE NITROGEN NO2-N (mg/L) (n=52)	AMMONIA NITROGEN NH3-N (mg/L) (n=52)	ORGANIC NITROGEN (mg/L) (n=15)	TOTAL NITROGEN (mg/L) (n=15)
MIN	2.02	0.07	0.10	1.20	5.40
MAX	6.35	0.71	1.03	2.10	8.60
MEDIAN	4.43	0.22	0.53	1.55	6.25
MEAN	4.46	0.25	0.52	1.62	6.72

Total recoverable metals were measured both upstream and downstream of the LAGWRP discharge (Figure 28). Concentrations for zinc, selenium, and cadmium were below the CTR thresholds for both upstream and downstream sites on all four occasions. Copper concentrations were below CTR thresholds with the exception of an upstream concentration that exceeded the chronic thresholds on one occasion. In general, concentrations of metals at the upstream site are similar to those at the downstream site.

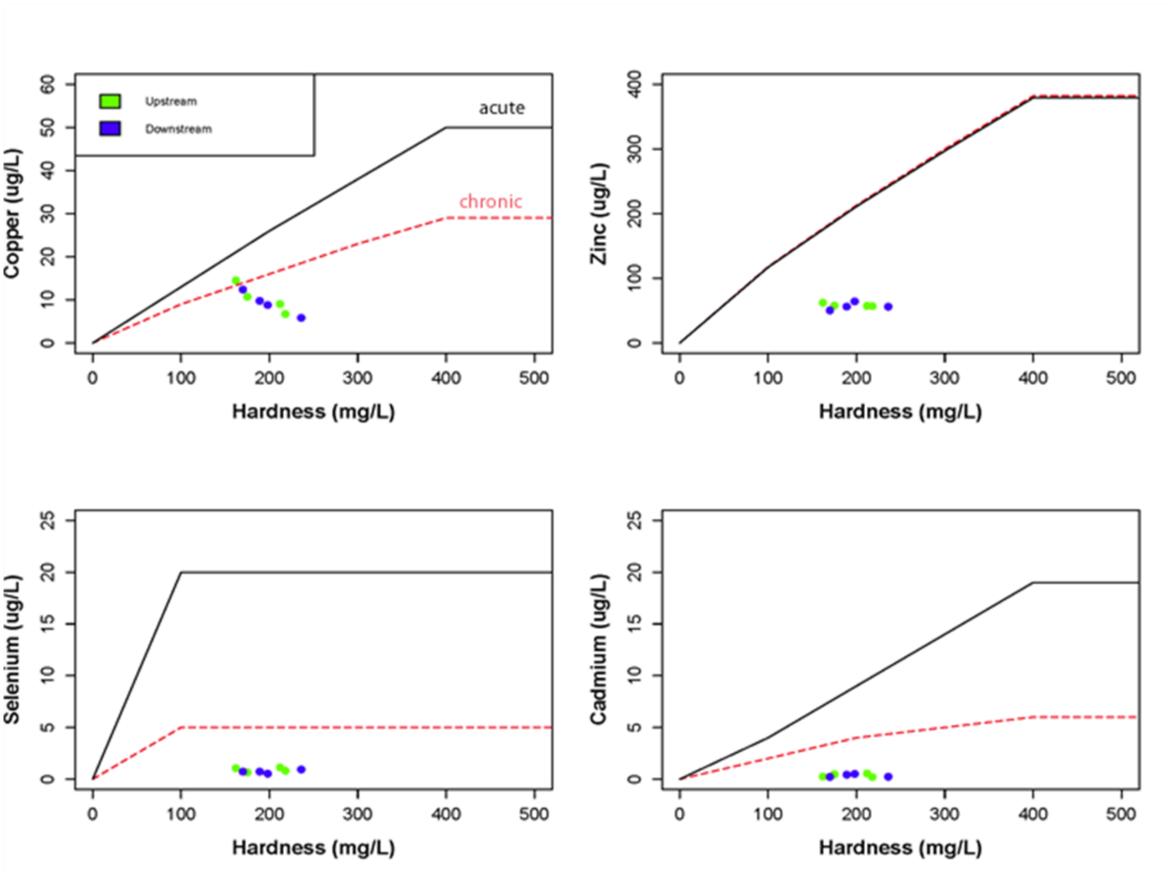

Figure 28. Converted dissolved metals concentrations above and below the LAGWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Black lines indicate acute CTR thresholds and redlines indicate chronic CTR thresholds. Includes estimated values for low concentrations that exceeded the method detection limit, but that did not meet the laboratory's reporting limit.

Total trihalomethanes were detected below the discharge location, but the concentrations downstream of the discharge were still well below the EPA water quality objective of 80 ug/L (Table 16). Trihalomethanes were not detected or were below the MDL on the August sampling date.

Table 16. Concentrations of trihalomethanes below the LAGWRP discharge (LAGT654).

Trihalomethanes (µg/L)	Site	2/6/2018	8/7/2018
Bromodichloromethane (ug/L)	LAGT654	1.02	ND
Bromoform (ug/L)	LAGT654	ND	0
Chloroform (ug/L)	LAGT654	3.35	ND
Dibromochloromethane (ug/L)	LAGT654	ND	0
Trihalomethanes (Total) (ug/L)	LAGT654	4.37	0.00

Total trihalomethanes were calculated as the sum of bromodichloromethane, bromoform, chloroform, and dibromochloromethane. “ND” indicates the analyte was not detected or the detected value was below the MDL. The EPA water quality objective for total trihalomethanes is 80 ug/L (U.S. EPA 2002).

4. City of Burbank - BWRP

The cumulative frequency distributions for *E. coli* upstream and downstream of the City of Burbank’s BWRP discharge location are shown in Figure 29. Approximately 10% of upstream samples met the WQO, while none of the downstream samples met the WQO.

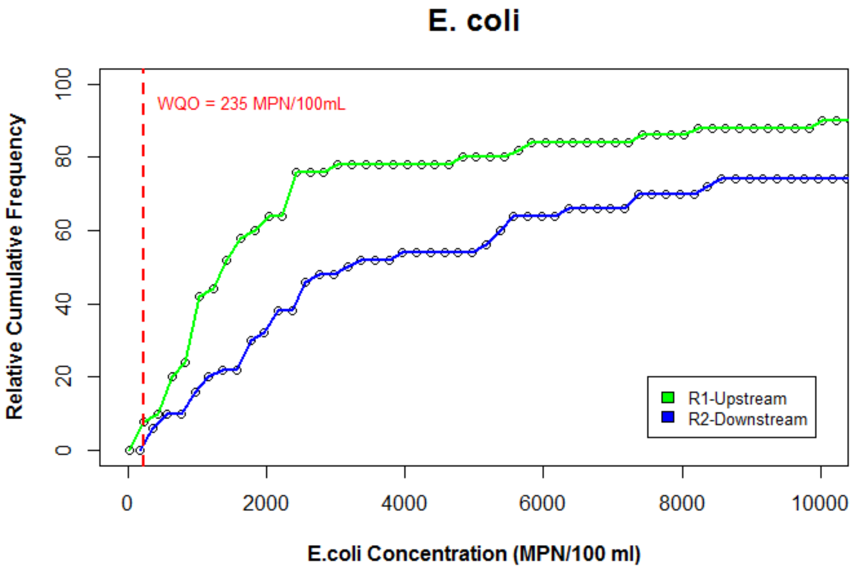

Figure 29. Cumulative frequency distributions for *E. coli* above and below the BWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

Table 17 shows the range in nutrient concentration measured below the BWRP discharge. Nutrients were measured approximately every week. The largest median concentrations were observed for NO_3-N and total nitrogen, but they were under regulatory thresholds. However, nitrite nitrogen had a maximum value that exceeded the WQO of 1 mg/L.

Table 17. Range of concentrations of nitrogenous compounds downstream of the BWRP discharge point (R2) in 2018.

	NITRATE NITROGEN NO3-N (mg/L) (n=51)	NITRITE NITROGEN NO2-N (mg/L) (n=51)	AMMONIA NITROGEN NH3-N (mg/L) (n=51)	ORGANIC NITROGEN (mg/L) (n=51)	TOTAL NITROGEN (mg/L) (n=51)
MIN	2.20	0.0048	0.83	0.20	4.20
MAX	8.10	1.30	1.30	6.90	13.70
MEDIAN	4.40	0.18	1.10	1.00	7.10
MEAN	4.65	0.22	1.08	1.44	7.36

Figure 30 shows the hardness-adjusted dissolved metal concentrations compared to their CTR chronic and acute standards. Unpaired, one-tailed t-tests (checked for equal variance) were used to identify differences between upstream and downstream locations. Zinc was significantly greater at the downstream site ($p < 0.001$). However, metal concentrations were below the CTR chronic and acute standards for all metals, on all occasions.

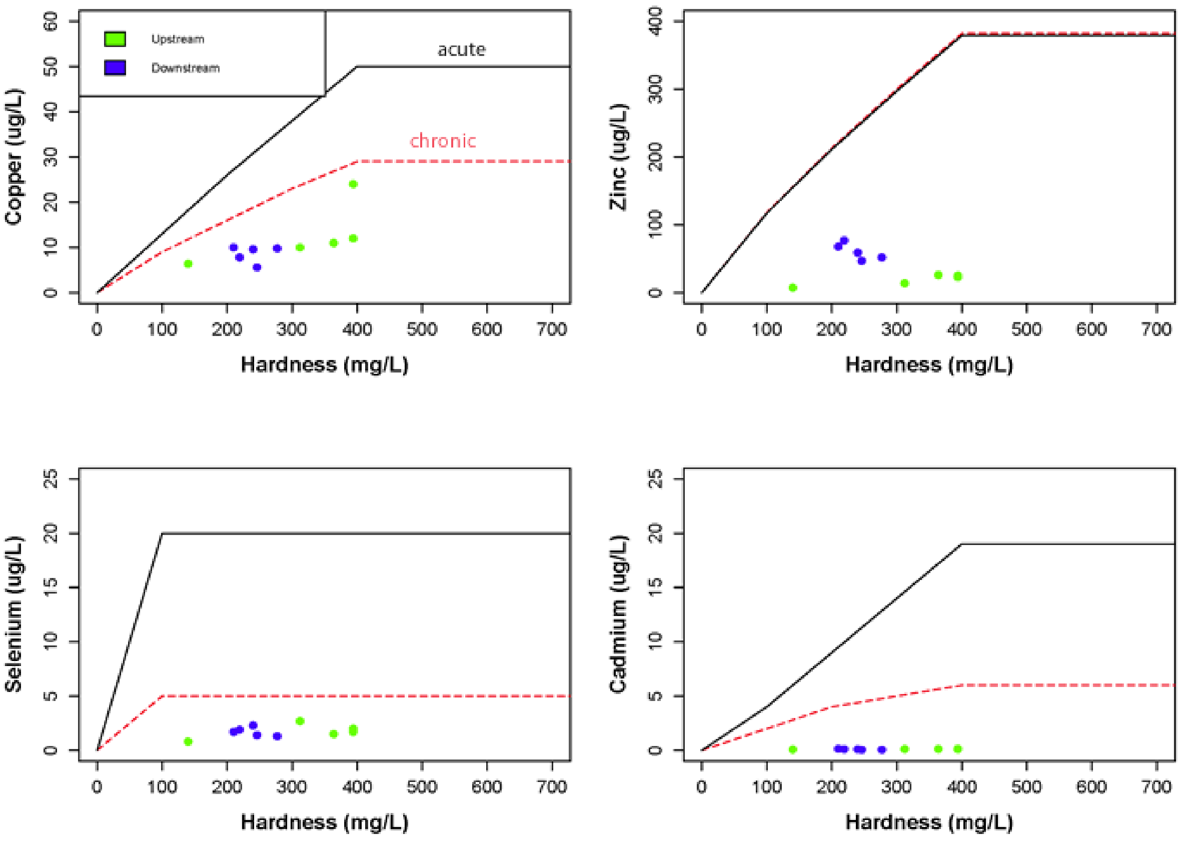

Figure 30. Dissolved metals concentrations above and below the BWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Black lines indicate acute thresholds and red lines indicate chronic thresholds. Estimated values for low concentrations that exceeded the method

detection limit but did not meet the laboratory's reporting limit are included. The acute threshold for selenium is 20 ug/L.

Trihalomethanes were not detected above the discharge location (R1). They were detected below the discharge location (R2) on February 5, 2018 and were not detected or below the MDL on August 6, 2018. However, the detected concentration was well below the EPA water quality objective 80 ug/L (Table 18).

Table 18. Trihalomethane concentrations above (R1) and below (R2) the BWRP discharge.

	Site	2/5/2018	8/6/2018
Trihalomethanes (Total) (µg/L)	R1	ND	ND
Trihalomethanes (Total) (µg/L)	R2	4.6	ND

Total trihalomethanes was precalculated and reported by the City of Burbank. "ND" indicates the analyte was not detected or the detected value was below the MDL. The EPA water quality objective for total trihalomethanes is 80 ug/L (U.S. EPA 2002).

Chapter Summary

The Cities of Los Angeles and Burbank monitor receiving waters upstream and downstream of their discharges as a requirement of their NPDES permits. Fecal indicator bacteria, aquatic chemistry, for samples collected in 2018 were evaluated against WQO thresholds. The following patterns were observed:

- The single-sample WQO of 235 MPN/100mL for REC-1 beneficial use was attained for approximately:
  - DCTWRP - 85% of upstream samples compared to 40% of downstream samples.
  - LAGWRP – 20% of upstream samples compared to 40% of downstream samples. The concentrations were generally lower downstream compared to upstream samples, indicating a dilution effect.
  - BWRP – 10% of upstream samples compared to none of the downstream samples
- Concentrations of nitrogenous compounds below POTWs discharges did not exceed the monthly average WQOs described in the Los Angeles Basin Plan for NO_3-N, NO_2-N, and NH_3-N. Concentrations of nitrogenous compounds below the BWRP discharge site only exceeded the NO_2-N WQO on one occasion.
- Metals downstream of the three POTW discharge points were below the California Toxics Rule (CTR) chronic and acute thresholds for every type of metal except on one occasion where copper concentrations downstream of DCTWRP discharge exceeded chronic standards.
- Samples upstream of the DCTWRP discharge exceeded the selenium chronic standard on four occasions.
- Samples upstream of the LAGWRP discharge exceeded the copper chronic standard on one occasion.
- Trihalomethanes were present below the discharges, but in all cases, concentrations were well below the EPA WQO 80 ug/L.

Question 4: Is it safe to recreate?

1. Background

Thousands of visitors swim at unpermitted sites within the Los Angeles River Watershed each summer. The fourth element of the monitoring program assesses the beneficial use of informal sites in the Los Angeles River Watershed for Water Contact Recreation (REC-1). Prior to the initiation of LARWMP, the concentrations of potentially harmful fecal pathogens and the bacteria that indicate their presence was not known. Monitoring at unpermitted recreational swim sites reflects concerns for the risk of gastrointestinal illness posed by pathogen contamination to recreational swimmers in streams of the Los Angeles River watershed. Depending on the site, sources of indicator bacteria and pathogen contamination could include humans, dogs, wildlife, urban runoff, and refuse from campgrounds and homeless encampments.

Monitoring fecal indicator bacteria (FIB) is valuable because tests are inexpensive and the body of literature shows *E. coli* to be an adequate predictor for gastrointestinal illness. Standards used by both EPA and LARWQCB are also based on *E. coli* cultivation methodology (EPA, 2010; Wade et al., 2003). However, studies have found that no single indicator is protective of public health and that in many studies, FIB do not correlate well with pathogens (Hardwood et al., 2005). Studies have also highlighted the need to better understand whether faster and more specific microbial methods can better predict health outcomes (Wade et al., 2003), particularly since human fecal sources have an increased pathogenic risk. While microbial source tracking is a promising method for better understanding fecal source and related public health risks, challenges related to performance, specificity, and sensitivity remain and should be addressed before the methods are moved toward the regulatory realm (Harwood et al., 2013).

2. Methods

LARWMP's bacteria-monitoring program established *E. coli* sampling that is conducted five times a month, during the summer (Memorial Day to Labor Day) at informal, high-use recreational swimming areas (Figure 31 and Table 19). Sites sampled for swimming safety are selected based on the collective knowledge of the workgroup related to the most frequently used swimming locations in the watershed. To better understand the relationships between periods of heavy recreational swim use and *E. coli* concentrations, sampling is conducted on weekends and holidays to capture the occasions when the greatest numbers of people are swimming. The San Gabriel River Watershed program, a similar program to LARWMP, found that indicator bacteria levels are higher on weekends and holidays when recreational swim use is greatest (SGRRMP 2009).

Field-monitoring teams deployed each morning and collected grab samples at swim sites. Observational data were also recorded at each site including information on flow habitats, number of visitors and swimmers, animals present, wind direction, and site refuse. Hand held meters and probes were used to collect data on dissolved oxygen, pH, water conductivity, and water temperature. The bacteria concentrations were compared against State of California REC-1 swimming standards (LARWQCB 2014) (Table 20).

Figure 31. Recreational swim site locations in 2018.

Table 19. Sampling locations and site codes for indicator bacteria.

Program Element	Sampling Sites	Site Code
Swim Sites	Bull Creek Sepulveda Basin	LALT200
	Eaton Canyon Natural Area Park	LALT204
	Tujunga Wash at Hansen Dam	LALT214
	Big Tujunga Delta Flat Day Use	LAUT206
	Switzer Falls	LAUT208
	Gould Mesa Campground	LAUT209
	Sturtevant Falls	LAUT210
	Hermit Falls	LAUT213
	Millard Falls	LAUT203

The State of California REC-1 bathing water standards (LARWQCB 2014) require that at least five samples be collected per month per site before the 30-day geometric mean standard can be applied. The 30-day geometric mean provides an indication of how persistent elevated bacterial concentrations are at a site. The standard overestimates persistent contamination when fewer than five samples are taken per month. Thus, the geometric means presented here may represent conservative estimates of this standard. During the summer survey in 2018, there was a goal to collect no fewer than five samples per month at each of the swim sites. However, site closure, safety considerations, and site conditions prevented the collection of five monthly samples at many sites.

3. Results

During the summer of 2018, a total of 160 water samples were successfully collected from nine recreational swim sites popular with visitors and residents of the LA River watershed (Table 21). Of the 160 samples, 33 exceeded the REC-1 standards, a slight decrease over the previous year. The greatest frequency of single sample exceedances occurred at Tujunga Wash at the Hansen Dam Rec Area (80%), followed by Bull Creek Sepulveda Basin (20%), Eaton Canyon (20%), and Gould Mesa Campground (20%).

Consistent with the pattern that we observed in single sample results, Tujunga Wash at Hansen Dam had the greatest number of exceedances. The site exceeded the 30-day geometric mean during all three months, followed by Bull Creek Sepulveda Basin, Eaton Canyon, and Gould Mesa Campground, all of which had exceeded the geometric mean during two months. Sturtevant Falls exceeded the standard during the month of June (Table 22). Switzer Falls, Millard, Hermit Falls and Big Tujunga Delta Flat did not exceed the geometric mean during any month, indicating that elevated *E. coli* concentrations are not persistent at these four sites

Based on a logistic regression statistical results, there was not a pattern of having an increased number of exceedances during holiday/weekends, when more visitors are present at sites, compared to weekdays (p = 0.93). Interestingly, despite the fact that Tujunga Wash at Hansen Dam exceeded the standards during all three months, Sturtevant Falls and Eaton Canyon had the highest number of people and animals on shore during the sampling period (Table 23). This could potentially be due to high equestrian or animal presence during non-sampling times, resulting in more fecal inputs at Tujunga Wash at the Hansen Dam Rec Area. Additionally, this site is sampled earlier in the day, when there are less people on shore, in comparison to later in the day, when more people and more refuse may be present.

Table 20. Indicator bacteria REC-1 standards for freshwaters.

Indicator	Single-Sample Standard	30-Day Geometric Mean
E. coli	235 MPN/100 mL	126 MPN/100 mL

Table 21. Single sample *E. coli* concentrations (MPN/100 mL) at recreational swim sites in the Los Angeles River Watershed from May through September 2018 (<10 MPN/100 mL = non-detect). Blank cells indicate that the site was not sampled on that date. Red-shaded cells indicate exceedance of single-sample REC-1 standard for *E. coli*.

	5/28/2018	5/29/2018	5/31/2018	6/4/2018	6/10/2018	6/14/2018	6/17/2018	6/23/2018	7/4/2018	7/5/2018	7/16/2018	7/24/2018	7/29/2018	8/4/2018	8/13/2018	8/18/2018	8/22/2018	8/26/2018	9/2/2018	9/3/2018	# Exceedance REC 1 Std.	n	% Exceedance REC 1 Std.
Bull Creek Sepulveda Basin	31	85	336	86	110	209	160	128	52	109	185	586	189	135	10	288	279	213	197	173	4	20	20
Eaton Canyon Natural Area Park	373	3080	218	20	3610	206	20	359	185	74	160										4	11	20
Switzer Falls	20	20	31	96	10	30	30	10	63	63	63	173	86	20	85	676	122	121	10	122	1	20	5
Gould Mesa Campground	41	30		31	31	41	31	20	63	109	345	369	211	1110	173	197	305				4	16	20
Sturtevant Falls	31	20	10	990	74	41	75	529	10	10	199	10	52	109							2	14	10
Millard	10	31	74	10	10	10	10	10	10	20	10	146	259	30	31	41	10	62	10	13000	2	20	10
Hermit Falls	10	20	31	10	10	10	10	98	109	109	72	20	41	31	74	20	63	31	52	110	0	20	0
Tujunga Wash at Hansen Dam Rec Area	313	323	327	199	556	393	328	109	201	1110	231	1620	336	613	583	1130	481	780	1014	670	16	20	80
Big Tujunga Delta Flat Day Use		30	52	10	31	74	63	20	63	41	122	74	134	131	122	148	109	63	74	75	0	19	0
# Exceedance REC 1 Std.	**2**	**2**	**2**	**1**	**2**	**1**	**1**	**2**	**0**	**1**	**1**	**3**	**2**	**2**	**1**	**3**	**3**	**1**	**1**	**2**	**33**		
n	**8**	**9**	**8**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**8**	**8**	**8**	**7**	**7**	**7**	**6**	**6**	**6**		**160**	
% Exceedance REC 1 Std.	**25**	**22**	**25**	**11**	**22**	**11**	**11**	**22**	**0**	**11**	**11**	**38**	**25**	**25**	**14**	**43**	**43**	**17**	**17**	**33**			**21**
Holiday																							
Weekday																							
Weekend																							

Table 22. 30 day geometric mean *E. coli* concentrations (MPN/100 mL) at recreational swim sites in the Los Angeles River Watershed in 2018.

Location	June	n =	July	n =	August	n =	# Exceedances of 30 day Average
Bull Creek Sepulveda Basin	132	5	163	5	118	5	2
Eaton Canyon Natural Area Park	161	5	130	3	NA	0	2
Switzer Falls	24	5	82	5	111	5	0
Gould Mesa Campground	30	5	179	5	328	4	2
Sturtevant Falls	164	5	25	5	109	1	1
Millard	10	5	38	5	30	5	0
Hermit Falls	16	5	59	5	39	5	0
Tujunga Wash at Hansen Dam Rec Area	274	5	489	5	686	5	3
Big Tujunga Delta Flat Day Use	31	5	79	5	110	5	0

Table 23. Site usage summary for recreational swim sites sampled in 2018.

Monitored Swim Site	Average Number of People on Shore	Average Number of Animals	Average Number of Bathers
Big Tujunga Delta Flat Day Use	1.47	0	0.47
Bull Creek Sepulveda Basin	0.53	0.63	0
Eaton Canyon Natural Area Park	11.55	1.91	1
Gould Mesa Campground	0.50	0	0.19
Tujunga Wash at Hansen Dam Rec Area	1.65	1.55	0.05
Hermit Falls	1.35	0.70	0.05
Millard Campground	1.35	0.05	0
Sturtevant Falls	16.79	2.23	0.64
Switzer Canyon	0.20	0	0.0

To better understand whether there was a relationship between usage patterns and the number of exceedances across sites, we conducted Spearman's ranked correlation. The number of exceedances did not generally correspond to site usage patterns and the presence of animals, as indicated by the low Spearman's rank correlation coefficients between *E. coli* and the number of bathers (r = 0.089), the number of people on shore (r =0.067), and the number of animals (r =0.210) (Table 24). Despite Sturtevant Falls and Eaton Canyon having the most people on shore (Table 23), they had less exceedances than Tujunga Wash at the Hansen Dam Rec Area, which averaged less than two people, animals, and bathers during the sampling period. It is important to note that many sites are sampled in the morning, prior to the arrival of large crowds and high usage, and bacteria concentrations may reflect usage patterns of the previous day. The monitoring program attempts to account for this by scheduling sampling on both holidays and the day after (including Memorial Day, the Fourth of July, and Labor Day).

Three observational variables correlated with *E. coli* concentrations across sites, including water temperature (r= 0.402), electrical conductivity (r= 0.324), and turbidity (r= 0.408), which were all weak, but significant ($p<0.05$), positive correlations Table 24. These results can be explained by the multiple stressors that bacteria face once outside a host. These stressors include osmotic stress, UV radiation, predation, and variable pH that can limit cell numbers and result in patchy distributions (Winfield and Groisman, 2003; EPA, 2010; Sinton et. al, 2002). Additionally, sediments and vegetation can serve as a reservoir of *E. coli*, where bacteria cells can persist longer than in open water (Alm et al. 2003; Garzio-Hadzick et al., 2010). Generally, patchy bacteria distributions can make it difficult to detect relationships between use patterns and environmental variables.

Monitoring crews observed large amounts of trash and pet waste at sites throughout the summer sampling period. There is agreement that human and pet sources may be the most easily controlled through outreach, education, and investment in site infrastructure like bathrooms, signage, and restrooms. Engagement with recreational users can provide a critical opportunity to connect communities to their watershed and to relate water quality to well-being, ecological health, and public health. Visitor surveys can be a key tool for identifying gaps in understanding and for pin pointing the most appropriate tools for better communicating monitoring data.

Table 24. Spearman correlation table analyzing relationship between *E. coli*, site usage, and in-situ measurements for all sites combined. Highlighted green values represent correlations ($r > 0.6$ or $r < 0.6$). Highlighted yellow values represent weak, but significant relationships ($r > 0.3$ or $r < 0.3$).

	Air Temp.	Water Temp.	EC	pH	Turbidity	People on	Animals	Bathers	Fishermen	E. coli
Air Temp.										
Water Temp.	0.681									
EC	0.131	0.443								
pH	0.057	-0.121	-0.291							
Turbidity	0.294	0.57	0.343	-0.144						
People on Shore	0.057	-0.017	-0.088	0.166	0.202					
Animals	0.069	-0.04	-0.067	0.192	0.087	0.429				
Bathers	0.07	0	-0.089	0.143	0.018	0.358	0.212			
Fishermen	**	**	**	**	**	**	**	**		
E. coli	0.16	0.402	0.324	-0.156	0.408	0.067	0.21	0.089	**	
** There were not enough data points to determine the correlation coefficient for these two parameters										

Chapter Summary

To assess the safety of recreational sites in the Los Angeles River Watershed, bacteria sampling was conducted at 9 sites known to be heavily used by the public during the summer of 2018. Major findings of this sampling effort are as follows:

- A total of 160 *E. coli* samples were collected from the nine sampling locations during the summer of 2018. About 20% of these samples exceeded the REC-1 bathing water standard (235 MPN/100 mL).

- Tujunga Wash at the Hansen Dam Recreation Area had persistently elevated *E. coli* concentrations. This site exceeded the REC-1 standard in 80% of the samples collected. This site is frequented by hikers, dogs, horses, and people wading in the stream, but heavy site use was not observed during time of sampling, which often occurred in the early morning.

- The only sites that had no exceedances during the sampling season were Hermit Falls and the Delta Flat Day Use site.

- On average, Sturtevant Falls and Eaton Canyon had the highest number of people, animals, and bathers' on-shore. However, the number of people on shore and the number of bathers did not have a strong correlation with *E. coli* concentrations.

- The sampling effort was focused on holidays and weekends to capture high-use recreational activity. However, the greatest number of exceedances occurred on July 24th, August 18th, and August 22nd of the 2018 sampling period. Interestingly, these dates were a weekend and a weekday (respectively). There was no significant pattern of elevated bacteria concentrations during the periods of high use that occur on weekends and holidays.

- Of all the environmental variables measured, only water temperature, electrical conductivity, and turbidity had relationships with *E. coli* concentrations. The relationships, however, were weakly positive.

Question 5: Are locally caught fish safe to eat?

1. Background

Question 5 addresses the human health risk associated with consuming contaminated fish caught at popular fishing locations in the watershed. The monitoring program focuses on one or two fishing sites each year with the goal of identifying the fish species and contaminant types that are of concern. Sites are selected based on the technical stakeholder group's input about popular fishing sites. Data will provide watershed managers with the information necessary to educate the public about the safety of consuming the fish they catch.

In 2016, the TSG authorized the collection of composite prey fish in tandem with sport fish as done by SWAMP since 2012. Efforts are focused on assessing the bio-magnification of mercury in wildlife. As part of SWAMP's efforts birds, sport fish, and prey fish (<100 mm in length) are collected and analyzed for mercury. Smaller prey fish are shorter lived, allowing less time for methylmercury accumulation compared to larger sport fish, but constitute a significant portion of the diet of higher trophic level fish, smaller piscivorous birds, and other wildlife (Palumbo and Iverson 2017). The results are being used to develop a bio-magnification factor that estimates mercury exposure in wildlife based on concentrations of mercury in lower trophic prey fish.

2. Methods

Sampling and Tissue Analysis

Sites for contaminant monitoring in fish populations revolve from year to year and have included various lake and river sites throughout the watershed. Lake and river sites are selected based on: angler surveys conducted at recreational sites throughout the watershed by Allen et al. (2008) and the recommendations of the Technical Stakeholder Group.

Fish were collected using a boat outfitted with electroshocking equipment, in accordance to OEHHA sport fish sampling and analysis protocols, which allowed specific species and size classes to be targeted (OEHHA 2005). OEHHA specifies that the muscle fillets from at least five individual fish of the same species and size class be combined to form a composite sample. LARWMP analyzes only the muscle tissue of the fish, which is common practice in regional regulatory programs and most fish testing labs. Other body parts, such as the skin, eyes, and organs of fish may contain higher levels of contaminants and are not recommended for consumption by the OEHHA. Four contaminants, mercury, selenium, total DDTs, and total PCBs, were selected for analysis based on their contribution to human health risk in California's coastal and estuarine fishes.

Mercury can transform in the environment, effecting its behavior and tendency for biological accumulation. It is widely assumed that nearly all (>95%) of the mercury present in fish is methyl mercury (Wiener et al. 2007). Consequently, monitoring programs usually analyze total mercury as a proxy for methyl mercury, as was done in this study. The U.S. EPA (2000) recommends using the conservative assumption that all mercury that is present is methyl mercury, since it is most protective of human health.

It is also important to note that this program component does not include rainbow trout, a popularly stocked and locally caught fish. Once rainbow trout are released to a waterbody they are caught very quickly and, therefore, have a very short residence time, reducing their potential to accumulate contaminants from that waterbody. There is still the potential for stocked fish to accumulate contaminants from the waterbody where they were raised, but that is not the focus of this study.

Advisory Tissue Levels

Concentrations of contaminants in each fish species were compared to State Fish Contaminant Goals (FCGs) and Advisory Tissue Levels (ATLs) for human consumption developed by the State of California's Office of Environmental Health Hazard Assessment (OEHHA 2008). The OEHHA Fish Contaminant Goals (FCGs) are estimates of contaminant levels in fish that pose no significant health risk to individuals consuming sport fish at a standard consumption rate of eight ounces per week (32 g/day), prior to cooking, and over a lifetime. This guidance assumes a lifetime risk level of 1 in one million for fishermen who consume an 8-ounce fish fillet containing a given amount of a specific contaminant.

The OEHHA Advisory Tissue Levels (ATLs), while still conferring no significant health risk to individuals consuming sport fish in the quantities shown over a lifetime, were developed with the recognition that there are unique health benefits associated with fish consumption and that the advisory process should be expanded beyond a simple risk paradigm to best promote the overall health of the fish consumer (Table 25 and Table 26). ATLs protect consumers from being exposed to more than the average daily reference dose for non-carcinogens or to a lifetime cancer risk level of 1 in 10,000 for fishermen who consume an 8-ounce fish fillet containing a given amount of a specific contaminant. For specific details regarding the assumptions used to develop the FCGs and ATLs, go to: http://oehha.ca.gov/fish/gtlsv/crnr062708.html (OEHHA, 2008).

Figure 32. Fish tissue sampling location for the 2018 bioaccumulation survey.

Table 25. Fish contaminant goals (FCGs) for selected fish contaminants based on cancerous and noncancerous risk * using an 8-ounce/week (prior to cooking) consumption rate (32 g/day). **

	FCGs (ppb, wet weight)
Contaminant Cancer Slope Factor (mg/kg/day)-1	
DDTs (0.34)	**21**
PCBs (2)	**3.6**
Contaminant Reference Dose (mg/kg-day)	
DDTs (5x10-4)	1600
Methylmercury (1x10-4)[S]	**220**
PCBs (2x10-5)	63
Selenium (5x10-3)	**7400**

*The most health protective Fish Contaminant Goal for each chemical (cancer slope factor-

**g/day represents the average amount of fish consumed daily, distributed over a 7-day

[S] Fish Contaminant Goal for sensitive populations (i.e., women aged 18 to 45 years and children aged 1 to 17 years.)

Table 26. OEHHA (2008) advisory tissue levels (ATLs) for selected fish contaminants based on cancer or non-cancer risk using an 8-ounce serving size (prior to cooking; ppb, wet weight)

Contaminant	**Three 8-ounce Servings* a Week**	**Two 8-ounce Servings* a Week**	**One 8-ounce Servings* a Week**	**No Consumption**
DDT[snc]**	≤520	>520-1,000	>1,000-2,100	>2,100
Methylmercury (Women aged 18-45 years and children aged 1-17 years)[nc]	≤70	>70-150	>150-440	>440
Methylmercury (Women over 45 years and men)[nc]	≤220	>220-440	>440-1,310	>1,310
PCBs[nc]	≤21	>21-42	>42-120	>120
Seleniumn[c]	≤2500	>2500-4,900	>4,900-15,000	>15,000

[c] ATLs are based on cancer risk

[nc] ATLs are based on non-cancer risk

*Serving sizes are based on an average 160 pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts (for

**ATLS for DDTs are based on non-cancer risk for two and three servings per week and cancer risk for one serving per week.

3. Results

A total of 17 fish were successfully collected from Echo Park (Table 27 and Figure 32). Echo Park Lake was emptied and restored in 2011 due to a buildup of sediments and contaminants. The Lake was refilled in 2013. This was the first revisit to the Lake since 2010.

Four species were collected at Echo Park including, common carp (*Cyprinus carpio*), bluegill sunfish (*Lepomis macrochirus)*, redear sunfish (*Lepomis microlophus*), and largemouth bass (*Micropterus salmonoides*). They were combined, by species, into four separate composites.

On average, the largest fish captured in the lake was common carp (4680 g), while the smallest fish caught was bluegill (39.5 g) (Table 27)

The feeding strategies for each of the five species are as follows:

- Common carp adults feed on bottom-dwelling invertebrates and aquatic plants that provide habitat for invertebrates (McGinnis 1984).
- Bluegill populations are bottom feeders, consuming all available food including largemouth bass eggs (McGinnis 2006). Their diet also includes aquatic insects and their larvae; up to 50% of their diet can consist of midge larvae (Page, 1991).
- Redear sunfish are a specialized molluscivorous species, having teeth that provide them with the ability to crush the shells of mollusks (Minckley, 1982). In a study conducted by Vanderkooy et al., it was found that redears typically feed on sediment-associated organisms which includes benthic macroinvertebrates like ostracoda, chironomidae, hydrobiidae, and dreissenidae as well as, mollusks and small fish.
- Largemouth bass has a diverse range of prey, ranging from benthic macroinvertebrates and zooplankton to amphibians and fishes. Their foraging is relatively opportunistic (Hodgson and Kitchell, 1987). As young fry, however, they feed on ostracods and small insect larvae, adding other small fish to their diet before the end of their first growing season (Hatch and Paulson, 2002).

During the 2018 monitoring season, levels of contaminants in common carp, bluegill sunfish, redear sunfish, and largemouth bass at Echo Park were assessed. It was determined that common carp, blue gill, redear sunfish, and largemouth bass are all safe to eat. However, the frequency and recommended servings size do vary by species, based on the fish tissue contaminant levels (Table 28).

Table 27. Number, average standard weight, and length of the individual and composite fish samples collected in 2018.

Waterbody	Comp #	Sample Type	n	Species Name	CommonName	Avg. Weight (g)	Standard Length			Total Length		
							Avg. (mm)	Min (mm)	Max (mm)	Avg. (mm)	Min (mm)	Max (mm)
Echo Park (LALT300)	1	Consumption	5	*Cyprinus carpio*	common carp	4680.0	604.2	546	648	675.6	577	737
	1	Consumption	4	*Lepomis macrochirus*	bluegill	39.5	103.8	101	106	128.0	124	132
	1	Consumption	4	*Lepomis microlophus*	redear sunfish	367.5	200.8	193	212	251.8	239	270
	1	Consumption	4	*Micropterus salmoides*	largemouth bass	2525.0	434.3	420	444	516.3	503	529

Total Fish 17
Total Composites 4

Table 28. Sport fish consumption chemistry results: concentration of contaminants in fish tissues relative to the OEHHA ATL thresholds.

Fish Consumption
Echo Park Lake - LALT300

Common Name	Comp. #	Mercury (ppb)	Selenium (ppb)	DDTs (ppb)	PCBs (ppb)
bluegill	1	13	610	11.1	36.15
common carp	1	22	480	37.0	20.35
largemouth bass	1	193*	410	38.9	40.83
redear sunfish	1	27	550	5.7	2.77

Three 8-oz servings a week ATL
Two 8-oz servings a week ATL
One 8-oz serving a week ATL
No consumption ATL.

*One 8-oz serving a week is recommended for women aged 18-45 and for children 1-17. Three 8-oz servings a week are allowed for men and women over the age of 45.

Sportfish

Of the four contaminants measured in each of the composites of fish tissue, mercury exceeded the OEHHA ATL threshold (for women aged 18-45 years old and for children age 17 and under) of one serving per week for largemouth bass. PCBs exceeded the two-serving threshold in bluegill and largemouth bass (Table 28). Selenium and DDT concentrations did not exceed any ATL thresholds in any of the species tested.

When compared to the OEHHA ATL thresholds for mercury, the mercury concentrations found in largemouth bass from Echo Park Lake indicate that it is safe for men and women over 45 years old to have three 8-oz servings per week, while children and women 18-25 years old should limit themselves to one 8-oz serving per week. Due to elevated PCB levels, one should limit their consumption of largemouth bass and bluegill to two 8-oz servings per week. Of the common carp and redear sunfish captured for this survey, all were safe to eat based on the contaminants tested, at a consumption level of three 8-oz servings a week.

Bluegill, redear sunfish, and common carp are trophic level three and largemouth bass are trophic level four (LARWQCB, 2017). Both trophic level four fish and trophic level three fish are some of the most common fish that recreational anglers catch and consume (Palumbo and Iverson 2017).

The concentrations of harmful contaminants are generally consistent with predictions based on size, trophic position, and feeding ecology. According to the State Water Resources Control Board, methylmercury concentration in fish tissue is often directly related to fish length and, for methyl mercury, trophic position. Due to being the highest on the food chain and to bio-magnification, trophic level 4 fish accumulate more mercury than trophic level 3 fish. Largemouth bass is a predatory, trophic level 4 fish, and its composite had the highest mercury concentrations. Largemouth bass' trophic level and carnivorous feeding habits likely explain these high concentrations.

Additionally, while it is not uncommon for fish consumers to consume many parts of the fish they catch, it is important to note that the results of this report are based on the concentration of contaminants in fish filet. According to OEHHA, contaminants can be much higher in the eggs, guts, liver, skin, and fatty parts of fish. They do not recommend consuming these parts of the fish because of the increased risk of contaminant exposure. Interestingly, a study by Regine et al. (2006) found that fish who feed on bacteria and small benthic invertebrates had higher organ to muscle ratios of mercury in their liver and kidneys. Fish who fed on other fish had higher ratios of mercury in their muscle tissue.

Chapter Summary

The monitoring design for Question 5 is focused on assessing whether the consumption of recreationally caught fish in the Los Angeles River Watershed is safe. During the 2018 monitoring season, 17 individual fish representing four different species were collected from Echo Park Lake. Four composite samples were analyzed for total mercury, selenium, total DDT, and total PCB.

- Consumption of largemouth bass from Echo Park should be limited to once per week for women 18-45 years old and children 1-17 years old based on its elevated mercury levels. Based on PCB levels, largemouth bass and bluegills should be limited to two 8-oz servings per week.
- Of the common carp and redear sunfish captured for this survey, all were safe to eat based on the contaminants tested, at a consumption level of three 8-oz servings a week.
- OEHHA recommends eating smaller fish as they generally are younger and contain lower levels of contaminants. If consuming a larger fish, OEHHA suggests freezing and eating the fish in smaller portions and spaced out over time. They also recommend eating only the filet of the fish and avoiding the skin, organs, guts, and eggs.

Caution should be taken in applying these recommendations, as OEHHA recommendations are based on a higher number of composite fish samples.

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Appendix A – Quality Assurance/Quality Control

LARWMP includes an emphasis on QA/QC for each phase of the program including the standardization of data formats so that monitoring results can be shared with local, state, and federal agencies. The data quality objectives for the program are outlined in LARWMP's QAPP and were finalized prior to the 2009 survey and it was updated each year thereafter (https://www.watershedhealth.org/resources). Therefore, the data reported herein from the 2018 survey were based on field sampling and laboratory analysis protocols agreed upon by the participants.

Measurement or Data Quality Objectives (MQOs or DQOs) are quantitative or qualitative statements that specify the tolerable levels of potential errors in the data and ensure that the data generated meet the quantity and quality of data required to support the study objectives. The DQOs for LARWMP are detailed in the Program QAPP (CWH 2018). The MQOs for the processing and identification of benthic macroinvertebrate samples are summarized in LARWMP's QAPP and detailed in the Southern California Regional Watershed Monitoring Program: Bioassessment Quality Assurance Project Plan, Version 1.0 (SCCWRP 2009). The DQOs and MQOs focused on five aspects of data quality: completeness, precision, accuracy, representativeness, and sensitivity.

Completeness

Completeness describes the success of sample collection and laboratory analysis (biology, chemistry, and toxicity) which should be sufficient to fulfill the statistical criteria of the project. One estuary, 1 lake, 10 randomly selected, and 4 targeted sites were sampled in 2018.

Freshwater targeted and random analysis completeness was 100% for general chemistry, nutrients, major ions, and bioassessment. The only exception was turbidity, which had 71% completeness due to sampling crew error (Table A-1).

Percent completeness for bioaccumulation samples analyzing organochlorine pesticides was 100% in 2018. PCB's were 100% complete for 43 constituents. Due to missing standards, 24 PCB analytes were 0% (Table A-2-2 and Table A-2-3). The sampling team and laboratories were notified of completeness deficiencies.

Accuracy

Accuracy provides an estimate of how close a laboratory or field measurement of a parameter is to the true value. Field sampling accuracy was assessed by calibration of the water quality probes with standards of known concentration. The accuracy of physical habitat measurements was assessed during a field audit conducted by the Southern California Coastal Water Research Project (SCCWRP) as part of the Stormwater Monitoring Coalitions (SMC) Southern California Regional Monitoring Survey, field calibration exercise. BMI sorting accuracy was assessed by a recount of 10% of sorted materials. The MQO of 95% was met for each lab reporting results for this program. Taxonomic identification accuracy was assessed through the independent re-identification of 10% of samples by the Department of Fish and Games Aquatic Biology Laboratory. MQOs for taxa count, taxonomic identification, and individual identification rates were met.

Analytical chemistry accuracy measures how close measurements are to the true value. For analytical chemistry samples Certified Reference Materials (CRM), matrix spike / matrix spike duplicates and laboratory control standards are used to assess method accuracy and precision. LARWMP followed SWAMP protocols, which allow one of these elements to fail in a batch and still be compliant. If data fails accuracy checks, it is noted in data and an accuracy qualifier is associated with that result.

Precision

Field duplicates were collected for chemistry, toxicity, and benthic macroinvertebrates at 10% of the random sites visited in 2010. The MQO for field duplicates was a relative percent difference (RPDs) <25%, except for benthic macroinvertebrates. At this time, no MQO has been developed for benthic macroinvertebrate duplicate samples. For analytical chemistry results matrix spike (MS), matrix spike duplicates (MSD), and laboratory duplicates (DUP) were used to assess laboratory precision. RPDs <25% for either the MS/MSD or DUPs were considered acceptable. Of the analytes measured in 2018, 2 did not meet the precision criteria (Table A-4).

Toxicity testing precision is measured through the development of control charts that include 20 reference toxicant tests for each organism. Each new reference toxicant test must fall within ± 2 standard deviations (SD) of the control chart average to be acceptable. All tests met this criterion.

Taxonomic precision was assessed using three error rates: random errors which are misidentifications that are made inconsistently within a taxon; systemic errors occur when a specific taxon is consistently misidentified; taxonomic resolution errors occur when taxa are not identified to the proper taxonomic level. Error rates of <10% are considered acceptable and all precision requirements were met.

Laboratory Blanks

Laboratory blanks were used to demonstrate that the analytical procedures do not result in sample contamination. The MQO for laboratory blanks were those with values less than the Method Detection Limit (MDL) for the analyte. During the 2018 surveys, there were no laboratory blanks with concentrations above the MDL (Table A-3).

Program Improvements and Standardization

An intercalibration study was conducted in 2006 sampling season by the Stormwater Monitoring Coalition's (SMC) Chemistry Workgroup. This intercalibration included all participating laboratories and covered nutrient and metal analyses. Intercalibration studies will be ongoing as part of the SMC Regional Monitoring Program.

Sampling procedures for each field team collecting samples for LARWMP were audited by biologists from the Southern California Coastal Water Research Project during summer surveys. The audit covered the SWAMP bioassessment and physical habitat protocols, including algae and benthic macroinvertebrate collection, and CRAM assessment (Ode, 2007, Fetscher *et al.,* 2009, CWMW 2012, and CWMW 2013). Each team passed their audit.

Table A-1. Percent completeness and nondetects by watershed sub-region for water chemistry samples collected in 2018.

Analyte	2018					
			Number of Non-Detects (<MDL)			
	Number of Sites	Completeness (%)	Effluent (n=3)	Natural (n=5)	Urban (n=6)	Total
General Chemistry						
Alkalinity as CaCO3	14	100	0	0	0	0
Hardness as CaCO3	14	100	0	0	0	0
Total Suspended Solids	14	100	0	0	0	0
Turbidity	14	71	0	0	0	0
Chlorophyll a	10	100	0	0	0	0
Ash-Free Dry Mass	10	100	0	0	0	0
Nutrients						
Ammonia as N	14	100	0	5	2	7
Dissolved Organic Carbon	14	100	0	0	0	0
Nitrate as N	14	100	0	1	3	4
Nitrite as N	14	100	2	5	6	13
OrthoPhosphate as P	14	100	0	1	2	3
Phosphorus as P	14	100	0	0	1	1
Total Nitrogen (calculated)	14	100	0	0	0	0
Total Organic Carbon	14	100	0	0	0	0
Major Ions						
Chloride	14	100	0	0	0	0
Sulfate	14	100	0	0	0	0
Metals						
Arsenic	14	100	0	0	0	0
Cadmium	14	100	0	5	2	7
Chromium	14	100	0	0	0	0
Copper	14	100	0	0	0	0
Iron	14	100	0	0	0	0
Lead	14	100	0	0	0	0
Mercury	14	100	3	5	4	12
Nickel	14	100	0	0	0	0
Selenium	14	100	0	5	0	5
Zinc	14	100	0	0	0	0
Bioassessment						
Benthic Macroinvertebrate ID	14	100	NA	NA	NA	NA
Algae ID	10	100	NA	NA	NA	NA

Table A-2 1 Percent completeness and non-detects for bioaccumulation samples collected in 2018.

Bioaccumulation	2018		
	Number of Samples	% Completeness	Number of Non-Detects (<MDL)
General Chemistry			
Lipids	4	100	0
Metals			
Mercury	4	100	0
Selenium	4	100	0
Organochlorine Pesticides			
Aldrin	4	0	NA
Chlordane, cis-	4	0	NA
Chlordane, trans-	4	0	NA
DDD(o,p')	4	100	4
DDD(p,p')	4	100	0
DDE(o,p')	4	100	4
DDE(p,p')	4	100	0
DDT(o,p')	4	100	4
DDT(p,p')	4	100	4
Dieldrin	4	0	NA
Endosulfan I	4	0	NA
Endosulfan II	4	0	NA
Endosulfan Sulfate	4	0	NA
Endrin	4	0	NA
Endrin Aldehyde	4	0	NA
HCH, alpha	4	0	NA
HCH, beta	4	0	NA
HCH, delta	4	0	NA
HCH, gamma	4	0	NA
Heptachlor	4	0	NA
Heptachlor Epoxide	4	0	NA
Methoxychlor	4	0	NA
Mirex	4	0	NA
Nonachlor, cis-	4	0	NA
Nonachlor, trans-	4	0	NA
Oxychlordane	4	0	NA
Toxaphene	4	0	NA

Table A-2 2 Percent completeness and non-detects for bioaccumulation samples collected in 2018 (continued)

Bioaccumulation	2018 Number of Samples	2018 % Completeness	2018 Number of Non-Detects (<MDL)
PCBs			
PCB 003	4	0	NA
PCB 008	4	0	NA
PCB 018	4	100	3
PCB 027	4	0	NA
PCB 028	4	100	1
PCB 029	4	0	NA
PCB 031	4	0	NA
PCB 033	4	0	NA
PCB 037	4	100	3
PCB 044	4	100	2
PCB 049	4	100	3
PCB 052	4	100	2
PCB 056	4	0	NA
PCB 056/060	4	0	NA
PCB 060	4	0	4
PCB 064	4	0	NA
PCB 066	4	100	2
PCB 070	4	100	0
PCB 074	4	100	1
PCB 077	4	100	4
PCB 081	4	100	4
PCB 087	4	100	4
PCB 095	4	0	NA
PCB 097	4	0	NA
PCB 099	4	100	4
PCB 101	4	100	2
PCB 105	4	100	3
PCB 110	4	100	4
PCB 114	4	100	4
PCB 118	4	100	0
PCB 119	4	100	4
PCB 123	4	100	4

Table A-2 3 Percent completeness and non-detects for bioaccumulation samples collected in 2018 (continued)

Bioaccumulation	2018		
	Number of Samples	% Completeness	Number of Non-Detects (<MDL)
PCB 126	4	100	4
PCB 128	4	100	2
PCB 128/167	4	100	2
PCB 137	4	0	NA
PCB 138	4	100	2
PCB 141	4	0	NA
PCB 146	4	0	NA
PCB 149	4	100	4
PCB 151	4	100	4
PCB 153	4	100	3
PCB 156	4	100	2
PCB 157	4	100	4
PCB 158	4	100	4
PCB 167	4	100	4
PCB 168	4	100	4
PCB 168/132	4	0	NA
PCB 169	4	100	4
PCB 170	4	100	3
PCB 174	4	0	NA
PCB 177	4	100	4
PCB 180	4	100	4
PCB 183	4	100	3
PCB 187	4	100	4
PCB 189	4	100	4
PCB 194	4	100	4
PCB 195	4	0	NA
PCB 198/199	4	0	NA
PCB 200	4	100	4
PCB 201	4	100	3
PCB 203	4	0	NA
PCB 206	4	100	4
PCB 209	4	0	NA

Table A-3 Lab Blanks

Analyte	Sampling Year	Sample Type	Batch ID	Result	Unit	Minimum Detection Limit	Reporting Limit
Nutrients							
Iron	2018	LabBlank	2986	0.0141	mg/L	0.005	0.02
Arsenic	2018	LabBlank	3203	0.02	ug/L	0.02	1
Lead	2018	LabBlank	3203	0.02	ug/L	0.02	0.5
Mercury	2018	LabBlank	3261	0.004	ug/L	0.003	0.003
Selenium	2018	LabBlank	3094	0.19	ug/L	0.1	1
Total Kjeldahl Nitrogen	2018	LabBlank	5820	0.1	mg/L	0.1	0.1

Table A-4 QA/QC Table. Bold type indicates values that did not meet quality control criteria.

Analyte	Station ID	Sample Date	Batch ID	Sample Type	Recovery DQO	% Recovery	Dup % Recovery	RPD	RPD DQO
PCBs (tissue)									
PCB 037	LALT300	27-Jun-19	1044	MS	50 - 150 %	**201**	103	**63**	25%
PCB138	LALT300	27-Jun-19	1044	MS	50 - 150 %	90	**267**	**99**	25%

Appendix B – Biotic Condition Index Scores for the CSCI & CRAM

Table B-1. CSCI and CRAM scores, including sub-metrics, for each random station sampled from 2009 to 2018.

Stratum	Station	Station Description	CSCI	CSCI Percentile	MMI	MMI Percentile	O/E	O/E Percentile	Overall CRAM Score	Biotic Structure	Buffer and Landscape Context	Hydrology	Physical Structure
2009													
Effluent	LAR00436	Los Angeles River	0.62	0.01	0.49	0	0.74	0.09	27	8	6	12	6
	LAR02228	Los Angeles River	0.70	0.03	0.55	0.01	0.84	0.21	27	8	6	12	6
Urban	LAR00440	Aliso Canyon Wash	0.80	0.1	0.60	0.01	0.99	0.48	64	25	21	18	12
	LAR00756	Tujunga Wash	0.68	0.02	0.51	0	0.85	0.21	37	8	15	12	6
	LAR01004	Arroyo Seco	0.67	0.02	0.51	0	0.83	0.19	29	8	8	12	6
Natural	LAR00476	Little Bear Canyon	1.22	0.92	1.16	0.82	1.28	0.93	99	34	24	36	24
	LAR00520	Big Tujunga Creek	1.02	0.55	0.77	0.1	1.27	0.92	80	33	20	21	21
	LAR00924	Arroyo Seco	1.35	0.99	1.43	0.99	1.27	0.93	87	33	20	30	21
	LAR01040	Big Tujunga Creek	1.21	0.91	1.10	0.72	1.32	0.95	89	33	24	27	21
	LAR06216	Big Tujunga Creek	0.85	0.17	0.73	0.07	0.97	0.43	64	23	20	21	12
2010													
Effluent	LAR00318	Los Angeles River	0.35	0	0.19	0	0.51	0.01	36	8	16	9	6
	LAR02622	Los Angeles River	0.44	0	0.37	0	0.52	0.01	36	8	16	9	6
Urban	LAR01208	Los Angeles River	0.54	0	0.58	0.01	0.50	0	38	8	16	12	6
	LAR01452	Eaton Wash	0.37	0	0.30	0	0.44	0	36	10	16	9	6
	LAR01716	Bull Creek	0.43	0	0.48	0	0.39	0	38	8	16	12	6
	LAR01972	Bull Creek	0.42	0	0.44	0	0.40	0	38	8	16	12	6
Natural	LAR00080	Lynx Gulch	0.75	0.06	0.64	0.02	0.86	0.23	55	17	18	21	9
	LAR00520	Big Tujunga Creek	0.75	0.06	0.73	0.07	0.76	0.11	63	15	22	24	12
	LAR00924	Arroyo Seco	0.68	0.02	0.55	0.01	0.81	0.16	70	20	24	27	12
	LAR01096	Big Tujunga Creek	0.65	0.01	0.59	0.01	0.71	0.06	63	15	20	27	12
	LAR01196	Big Tujunga Creek	0.82	0.13	0.79	0.12	0.85	0.21	65	21	22	21	12
	LAR01320	Big Tujunga Creek	0.69	0.03	0.62	0.02	0.77	0.12	66	21	22	27	9
	LAR01544	Big Tujunga Creek	0.84	0.15	0.77	0.1	0.90	0.3	66	18	22	30	9
2011													
Effluent	LAR02804	Los Angeles River	0.72	0.04	0.55	0.01	0.88	0.27	39	13	15	12	6
Urban	LAR00632	Tarzana	0.44	0	0.33	0	0.55	0.01	32	15	7	12	6
	LAR00684	Rio Hondo Spillway	0.44	0	0.43	0	0.44	0	38	8	16	12	6
	LAR00748	Rubio Wash, Rosemead	0.25	0	0.27	0	0.24	0	35	10	15	9	6
	LAR00830	Rio Hondo	0.43	0	0.47	0	0.39	0	38	8	16	12	6
	LAR01358	Compton Creek	0.37	0	0.23	0	0.51	0.01	37	8	15	12	6
Natural	LAR00080	Lynx Gulch	0.89	0.25	0.81	0.14	0.98	0.45	78	20	22	36	15
	LAR00520	Big Tujunga Creek	0.80	0.1	0.75	0.08	0.85	0.21	71	15	20	30	18
	LAR00924	Arroyo Seco	0.79	0.1	0.80	0.13	0.79	0.13	76	19	22	30	18
	LAR01692	Arroyo Seco	0.83	0.15	0.67	0.03	0.99	0.48	63	16	18	30	12
	LAR01808	Alder Creek	0.87	0.21	0.80	0.14	0.93	0.37	86	26	23	36	18
	LAR02088	Big Tujunga Creek	0.86	0.2	0.71	0.05	1.02	0.54	66	14	20	33	12
	LAR02092	Big Tujunga Creek	0.88	0.23	0.72	0.06	1.04	0.58	77	21	22	30	18
2012													
Effluent	LAR04532	Los Angelese River	0.68	0.02	0.51	0	0.85	0.21	47	13	16	21	6
Urban	LAR01464	Aliso Canyon Wash	0.70	0.03	0.60	0.01	0.80	0.14	34	8	7	21	6
	LAR01656	Cabarello Creek	0.69	0.03	0.52	0	0.86	0.22	36	13	12	12	6
	LAR01772	Alhambra Wash	0.60	0.01	0.52	0	0.67	0.04	39	12	15	12	6
	LAR01912	Santa Susana Creek	0.36	0	0.32	0	0.39	0	34	8	13	12	6
	LAR02028	Arroyo Seco	0.68	0.02	0.57	0.01	0.78	0.13	34	10	12	12	6
Natural	LAR00080	Lynx Gulch	0.85	0.17	0.85	0.2	0.85	0.21	79	25	24	30	15
	LAR00520	Big Tujunga Creek	1.01	0.52	1.03	0.57	0.99	0.47	61	16	18	27	12
	LAR00924	Arroyo Seco	0.82	0.13	0.87	0.23	0.77	0.11	74	20	22	30	15
	LAR02568	Big Tujunga Creek	0.97	0.42	0.91	0.31	1.02	0.55	79	23	22	30	18
	LAR02712	Pacoima Canyon	1.04	0.59	0.84	0.18	1.24	0.89	77	21	24	27	18
	LAR04204	Santa Anita Wash	0.99	0.48	0.81	0.14	1.18	0.83	69	25	22	27	9
	LAR04880	Big Tujunga Creek	1.04	0.6	0.83	0.17	1.25	0.91	82	20	23	36	18

Table B-1. continued.

Stratum	Station	Station Description	CSCI	CSCI Percentile	MMI	MMI Percentile	O/E	O/E Percentile	Overall Score	Biotic Structure	Buffer and Landscape Context	Hydrology	Physical Structure
2013													
Effluent	LAR03646	Los Angeles River	0.61	0.01	0.48	0	0.73	0.08	38	25	67.67	33.33	25
Urban	LAR02232	Limekiln Canyon Wash	0.24	0	0.30	0	0.18	0	40	25	50	58.33	25
	LAR02484	Tujunga Wash	0.56	0	0.55	0.01	0.56	0.01	30	36.11	25	33.33	25
	LAR02488	Wilbur Wash	0.21	0	0.30	0	0.12	0	40	25	50	58.33	25
	LAR02796	Rubio Wash	0.28	0	0.28	0	0.29	0	27	25	25	33.33	25
	LAR02936	Bell Creek Tributary	0.46	0	0.46	0	0.46	0	37	27.78	55.17	41.67	25
Natural	LAR05020	Arroyo Seco	0.95	0.37	0.90	0.29	1.00	0.49	84	69.44	93.29	100	75
	LAR05640	Big Tujunga Creek	0.92	0.31	0.95	0.39	0.89	0.29	81	77.78	93.29	91.67	62.5
	LAR05848	Gold Creek	0.91	0.28	0.87	0.23	0.95	0.4	84	77.78	100	83.33	75
	LAR06044	Arroyo Seco	1.13	0.79	1.10	0.72	1.15	0.79	84	75	93.29	91.67	75
2014													
Effluent	LAR05694	Los Angeles River	0.45	0	0.45	0	0.45	0	35	25	58.54	33.33	25
Urban	LAR02680	Los Angeles River	0.41	0	0.34	0	0.48	0	38	25	67.67	33.33	25
	LAR02988	Sawpit Wash	0.70	0.03	0.69	0.04	0.72	0.07	36	25	62.5	33.33	25
	LAR02996	Big Tujunga Wash	0.47	0	0.38	0	0.55	0.01	34	25	62.5	25	25
Natural	LAR00520	Big Tujunga Creek	0.86	0.2	0.81	0.14	0.92	0.34	74	61.11	90.29	83.33	62.5
	LAR00924	Arroyo Seco	1.13	0.79	1.02	0.55	1.24	0.89	81	86.11	93.29	83.33	62.5
	LAR06188	Big Tujunga Wash	1.11	0.75	0.95	0.38	1.27	0.92	83	97.22	93.29	66.67	75
	LAR06216	Big Tujunga Creek	0.92	0.31	0.84	0.18	1.01	0.51	81	88.89	90.29	83.33	62.5
	LAR06252	Santa Anita Wash	0.82	0.13	0.88	0.25	0.76	0.1	83	83.33	85.38	75	87.5
	LAR07128	Pacoima Canyon	1.05	0.63	0.99	0.48	1.11	0.72	90	97.22	96.54	91.67	75
2015													
Effluent	LAR0232	Los Angeles River	0.66	0.02	0.50	0	0.82	0.17	36	25	62.5	33.33	25
	LAR08597	Los Angeles River	0.69	0.03	0.48	0	0.89	0.28	38	25	67.67	33.33	25
	LAR08599	Los Angeles River	0.70	0.03	0.51	0	0.89	0.28	45	33.33	62.5	58.33	25
	LAR08602	Los Angeles River	0.38	0	0.28	0	0.47	0	39	33.33	62.5	33.33	25
	LAR0616	Los Angeles River	0.68	0.02	0.58	0.01	0.77	0.12	36	25	62.5	33.33	25
	LAR0732	Los Angeles River	0.59	0	0.42	0	0.75	0.1	36	25	62.5	33.33	25
Natural	LAR0552	Arroyo Seco	0.98	0.45	0.89	0.27	1.07	0.64	79	75	93.29	83.33	62.5
	LAR00520	Big Tujunga Creek	0.92	0.3	0.83	0.17	1.01	0.51	77	80.56	82.92	83.33	62.5
	LAR0896	Big Tujunga Creek	0.93	0.33	0.87	0.24	0.98	0.47	85	77.78	100	75	87.5
2016													
Effluent	LAR0232	Los Angeles River	0.65	0.01	0.54	0	0.76	0.1	39	33.33	62.5	33.33	25
Natural	LAR0552	Arroyo Seco	0.91	0.28	0.91	0.31	0.91	0.31	75	69.44	93.29	75	62.5
	LAR00520	Big Tujunga Creek	0.94	0.35	0.90	0.28	0.98	0.46	76	63.89	82.92	83.33	75
	LAR00924	Arroyo Seco	1.00	0.51	0.96	0.42	1.05	0.59	84	63.89	93.29	91.67	87.5
	LAR01096	Big Tujunga Creek	0.77	0.08	0.71	0.05	0.84	0.2	84	88.89	90.29	83.33	75
	LAR01544	Big Tujunga Creek	0.87	0.21	0.72	0.06	1.02	0.55	85	77.78	90.29	83.33	87.5
	LAR08610	Santa Anita Wash	0.97	0.43	0.89	0.27	1.05	0.6	84	66.67	93.29	100	75
	LAR08622	Eaton Wash	1.01	0.52	0.90	0.3	1.12	0.73	77	52.78	93.29	75	87.5
Urban	LAR08608	Bull Creek	0.50	0	0.49	0	0.52	0.01	61	61.11	75	58.33	50
	LAR08615	Los Angeles River	0.67	0.02	0.56	0.01	0.77	0.12	39	33.33	62.5	33.33	25
	LAR08616	Arroyo Calabasas	0.53	0	0.63	0.02	0.43	0	34	25	62.5	25	25
	LAR0020	Alhambra Wash	0.29	0	0.30	0	0.28	0	34	25	62.5	25	25
	LAR0040	Bull Creek	0.59	0.01	0.55	0.01	0.62	0.02	39	25	62.5	41.67	25

Table B-1. continued.

Stratum	Station	Station Description	CSCI	CSCI Percentile	MMI	MMI Percentile	O/E	O/E Percentile	Overall Score	Biotic Structure	Buffer and Landscape Context	Hydrology	Physical Structure
2017													
Effluent	LAR0232	Los Angeles River	0.72	0.04	0.60	0.01	0.83	0.19	36	25	62.5	33.33	25
	LAR00436	Los Angeles River	0.68	0.02	0.63	0.02	0.74	0.08	38	25	67.67	33.33	25
	LAR08627	Los Angeles River	0.35	0	0.20	0	0.51	0.01	38	25	67.67	33.33	25
Urban	LAR0052	Los Angeles River	0.51	0	0.43	0	0.58	0.01	39	25	62.5	41.67	25
	LAR08630	Alhambra Wash	0.27	0	0.31	0	0.24	0	33	25	50	33.33	25
	LAR08632	Santa Susana Pass Wash	0.41	0	0.54	0.01	0.27	0	36	25	62.5	33.33	25
Natural	LAR0552	Arroyo Seco	0.97	0.41	1.01	0.51	0.93	0.35	78	61.11	93.29	83.33	75
	LAR00520	Big Tujunga Creek	0.78	0.08	0.69	0.04	0.87	0.24	78	72.22	82.92	83.33	75
	LAR00924	Arroyo Seco	0.95	0.38	1.00	0.5	0.90	0.3	77	66.67	93.29	75	75
	LAR08638	Arryo Seco	0.99	0.48	1.07	0.65	0.91	0.32	77	66.67	93.29	75	75
2018													
Effluent	LAR0232	Los Angeles River	0.71	0.03	0.63	0.02	0.78	0.12	25	62.5	33.33	36	25
	LAR08599	Los Angeles River	0.59	0	0.65	0.02	0.52	0.01	50	67.67	58.33	53	37.5
	LAR08642	Los Angeles River	0.72	0.04	0.58	0.01	0.87	0.24	25	67.67	33.33	38	25
	LAR08643	Los Angeles River	0.33	0	0.18	0	0.48	0	33.33	67.67	33.33	40	25
Urban	LAR08640	Aliso Canyon Wash	0.33	0	0.31	0	0.35	0	25	62.5	33.33	36	25
	LAR00440	Aliso Canyon Wash	0.64	0.01	0.50	0	0.78	0.12	50	82.92	58.33	67	75
	LAR00756	Tujunga Creek	0.52	0	0.52	0	0.52	0.01	25	62.5	33.33	36	25
Natural	LAR0552	Arroyo Seco	0.77	0.07	0.58	0.01	0.96	0.41	66.67	93.29	91.67	79	62.5
	LAR02092	Big Tujunga Creek	1.07	0.67	0.88	0.24	1.27	0.92	72.22	93.29	75	79	75
	LAR02568	Big Tujunga Creek	1.13	0.79	1.03	0.56	1.24	0.89	69.44	93.29	83.33	83	87.5
	LAR02088	Big Tujunga Creek	1.01	0.52	0.89	0.27	1.12	0.74	83.33	93.29	91.67	80	50

Appendix C – Analyte List, Detection Limits and Methods

Table C-1 Analyte list and method for each program element in 2015.

Analyte	Method	Units	Reporting Limit
Conventional Water Chemistry			
Temperature	Probe	°C	-5
pH	Probe	None	NA
Specific Conductivity	Probe	mS/cm	2.5
Dissolved Oxygen	Probe	mg/L	N/A
Salinity	Probe	ppt	N/A
Water Chemistry: freshwater			
Alkalinity as CaCO3	SM 2320 B	mg/L	10
Hardness as CaCO3	SM 2340 B	mg/L	1.32
Turbidity		NTU	
Suspended Solids	SM 2540 D	mg/L	3
Nutrients			
Ammonia as N	EPA 350.1	mg/L	0.1
Nitrate as N	EPA 300.0	mg/L	0.1
Nitrite as N	EPA 300.0	mg/L	0.1
TKN	EPA 351.2 (1° Method) or SM4500-NH3 C (2° Method)	mg/L	0.1
Total Nitrogen	Calculated	NA	NA
Total Organic Carbon	SM 5310 C	mg/L	0.1
Dissolved Organic Carbon	SM 5310 C	mg/L	0.1
OrthoPhosphate as P	SM 4500-P E	mg/L	0.1
Phosphorus as P	SM 4500-P E	mg/L	0.1
Major Ions			
Chloride	EPA 300.0	mg/L	1.0
Sulfate	EPA 300.0	mg/L	1.0
Taxonomy: Freshwater			
Benthic Macroinvertebrate	SWAMP (2007), SAFIT STE	Count	NA
Qualitative Algae	SWAMP, In Development	Count	NA
Quantitative Diatom	SWAMP, In Development	NA	NA
Quantitative Algae	SWAMP, In Development	NA	NA
Habitat Assessments: Freshwater			
Freshwater Bioassessments	SWAMP (2007)	NA	NA
Freshwater Algae (collected in conjunction with bioassessments)	SWAMP (2010)	NA	NA
California Rapid Assessment Method (CRAM)	Collins et al., 2008	NA	NA

Water Chemistry: Estuary Seawater			
Alkalinity as CaCO3	SM 2320 B	mg/L	10
Hardness as CaCO3	SM 2340 B	mg/L	1.32
Suspended Solids	SM 2540 D	mg/L	3
Dissolved Solids	SM 2540 C	mg/L	37
Nutrients			
Ammonia	SM 4500-NH3 B&C; EPA 350.1	mg/L	0.1
Nitrate	EPA 300.0 or EPA 353.2	mg/L	0.1
Nitrite	EPA 300.0 or EPA 353.2	mg/L	0.1
TKN	EPA 351.2 (1° Method) or SM4500-NH3 C (2° Method)	mg/L	0.1
Dissolved Organic Carbon	SM 5310 C	mg/L	0.1
Total Organic Carbon	SM 5310 B	mg/L	0.1
OrthoPhosphate as P	SM 4500-P E	mg/L	0.1
Phosphorus as P	SM 4500-P E	mg/L	0.1
Metals (Total & Dissolved)			
Arsenic	SM 3114 B	mg/L	1
Cadmium	EPA 200.8 or 200.7	mg/L	0.2
Chromium	EPA 200.8 or 200.7	mg/L	0.5
Copper	EPA 200.8 or 200.7	mg/L	0.5
Iron	EPA 200.8 or 200.7	mg/L	50
Lead	EPA 200.8 or 200.7	mg/L	0.5
Mercury	SM 3112 B	mg/L	0.2
Nickel	EPA 200.8 or 200.7	mg/L	1
Selenium	SM 3114 B	mg/L	1
Zinc	EPA 200.8 or 200.7	mg/L	1
Organics			
Pyrethroid Pesticides	EPA 625-NCL	µg/L	0.002-0.005
Sediment Chemistry: Estuary			
Sediment Particle Size (% fines)	SM 2560 D	um	<2000->0.2
Metals			
Arsenic	EPA 6010 B	mg/Kg dw	1
Cadmium	EPA 6010 B	mg/Kg dw	1
Chromium	EPA 6010 B	mg/Kg dw	1
Copper	EPA 6010 B	mg/Kg dw	1
Iron	EPA 6010 B	mg/Kg dw	100
Lead	EPA 6010 B	mg/Kg dw	0.5
Mercury	EPA 7471 A	mg/Kg dw	0.01
Nickel	EPA 6010 B	mg/Kg dw	2
Selenium	EPA 6010 B	mg/Kg dw	1

Zinc	EPA 6010 B	mg/Kg dw	2
Nutrients			
Total Kjeldahl Nitrogen (TKN)	EPA 351.2; SM4500-N ORG B	mg/Kg dw	0.5
Total Organic Carbon	SM 5310 B	mg/Kg dw	0.05
Phosphorus as P	SM 4500-P E	mg/Kg dw	0.05
Organics			
Organochlorine Pesticides (DDTs)	EPA 8081A	µg/Kg dw	1.7-83.3
Polychlorinated Biphenyl (PCBs)	EPA 8082	µg/Kg dw	0.5
Polynuclear Aromatic Hydrocarbons (PAHs)	EPA 8270C	µg/Kg dw	1.7
Sediment Toxicity: Estuary			
Chronic *Eohaustorius* sp. (sediment) 10 day survival	EPA 600/R-94/025	% survival	N/A
Chronic *Mytilus* Sediment Water Interface	EPA 600/R-95-136m	% development	N/A
Taxonomy: Sediment			
Infauna	SCCWRP (2008)*, SCAMIT STE	N/A	N/A
Habitat Assessments: Estuary			
California Rapid Assessment Method (CRAM)	Collins et al., 2008	NA	NA
Tissue Chemistry: Fish			
Percent Lipids	Bligh, E.G. and Dyer ,W.J. 1959.	%	NA
Metals			
Mercury	EPA 7471A	mg/kg ww	0.02
Selenium	EPA 6010B	mg/kg ww	0.25
Organics			
Organochlorine Pesticides (DDTs)	EPA 8081A	µg/kg ww	1.7-83
Polychlorinated Biphenyl (PCBs)	EPA 8082	µg/kg ww	2
Indicator Bacteria			
Total Coliform and E. coli	SM 9223 B	MPN/100mL	10
Enterococcus	SM 9230 D (21st ed. on line)	MPN/100mL	10

* Southern California Regional Monitoring Program, 2008 Field and Laboratory Operating Procedures, SCCWRP.