Los Angeles River Watershed Monitoring Program
2019 Annual Report

environment
LA SANITATION
CITY OF LOS ANGELES

L.A. Regional Water Quality Control

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COUNCIL FOR WATERSHED HEALTH

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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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List of Acronyms

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
STV	Statistical Threshold Value
TDS	Total Dissolved Solids
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 2019 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 macroinvertebrates (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 (channel alteration, nutrients, and temperature) 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.

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 sites and riparian areas. 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 have revealed that most confluence sites, at one point, have had sharp increase in the concentration of measured analytes. These spikes are not always sustained over time and concentrations can vary considerably between sampling periods. In 2019, sulfate increased 2.64 times over the previous year at the Arroyo Seco confluence site. Hardness at the Arroyo Seco also jumped 2.75 times over the previous year. At the Rio Hondo confluence site, suspended solids increased 8.1 times over the previous year in 2019. Orthophosphate and phosphorus at Compton Creek (LALT 502) and nitrate at the Arroyo Seco (LALT 501) have been nearly consistently elevated compared to other confluence sites. The concentrations of orthophosphate and total phosphorus at the Compton Creek site were 3.9 to 2.2 higher, respectively, than other confluence sites. Nitrate at the Arroyo Seco was at least 1.74 times higher than other confluence sites that were sampled in 2019. Overall, however, phosphorus at Compton Creek has had a gently declining trend since 2016.

All targeted sites are altered and continued to be altered/very likely altered condition in 2019 based on CSCI scores. The Rio Hondo has consistently scored in the lower 'very likely altered' CSCI category and continued to score in this category in 2019. While the Arroyo Seco and Lewis MacAdams Park sites were among the better performing sites but still within the 'likely altered' category. Percent canopy, sand fines, epifaunal substrate, and sediment deposition all declined at the Compton Creek Site in 2019. Compton Creek is still distinct from other confluence sites. Specifically, it has more canopy cover, smaller particle sizes, no concrete or asphalt substrate, less channel alteration, and more epifaunal substrate cover and sediment deposition. Better physical habitat and higher CRAM scores at Compton Creek have not translated to improved biological condition, as compared to other confluence sites. The Lewis MacAdams site, which was dredged in 2018, had reduced percent concrete and improved scores for channel alteration and epifaunal substrate one year after dredging. Dredging activities at the Lewis MacAdams site in 2018 have not resulted in markedly negative impacts to biotic condition, as captured by stable CSCI and CRAM scores.

High value sites assessed for riparian habitat condition in 2019 included Alder Creek (LAUT 403), Tujunga Sensitive Habitat (LAUT 401), and Sepulveda Basin (LALT 405) sites. Habitat conditions at the two burn sites are variable between sampling periods but generally well above the 10th percentile of the reference distribution. The Sepulveda Basin site is in degraded condition but the scores at this site have been stable since their initial decline in 2014.

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 60% of downstream samples compared to 85% of upstream samples at D.C. Tillman Water Reclamation Plant. At the Burbank Water Reclamation plant, the water quality objective for *E. coli* was met by 10% of downstream samples compared to 25% of upstream samples. However, concentrations of *E. coli* in the effluent of both POTWs are consistently below regulatory objectives. Effluent from the Los Angeles Glendale Water Reclamation Plant had a dilution effect, reducing bacteria concentration in downstream sites (80% of samples) compared to upstream sites (45% of samples). 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 generally below the California Toxics Rule (CTR) chronic and acute thresholds for every type of metal. Copper concentrations downstream of DCTWRP discharge exceeded the chronic threshold on one occasion. Selenium concentrations upstream of DCTWRP exceeded chronic thresholds on four occasions and samples taken downstream of the receiving waters exceeded chronic thresholds 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. 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). Switzer Falls, Gould Mesa Campground, Sturtevant Falls and Hansen Dam Recreation Lake did not exceed the REC-1 standards during summer sampling.

During the 2019 recreation season, a total of 226 samples were collected from kayak zones in the Sepulveda Basin Recreation Zone and the Elysian Valley Recreation Zone. Of the samples collected, the Upper Elysian Valley exceeded the LREC-1 single sample maximum the most (18% of samples), followed by the Lower Sepulveda Basin Zone (11% of samples). The Upper Elysian Valley exceeded the 30-day geometric mean LREC-1 standards in June, July, and August.

Site usage, such as the presence of animals and the number of people, did not have a strong correlation with *E. coli* concentrations. Two sites, Bull Creek Sepulveda Basin and Tujunga Wash at Hansen Dam, had less on shore activity during sampling but had more bacteria exceedances than sites with less people/animals. The cause of elevated FIB at these sites is unknown and may be due to high equestrian use, homeless population upstream of the sampling location, or early morning sampling that bypasses large crowds.

The relationship between periods of high use (weekends and holidays) and number of bacteria exceedances was not significant. However, we did note that bacteria concentrations reached their highest values during Memorial Day and Labor Day. Thus, sampling during weekends and holidays is important. There were weak, but statistically significant relationships between pH, 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. Bacteria distributions are also sensitive to environmental factors that impact cell viability, such as pH.

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 2019 revealed that common carp, bluegill, and green sunfish found in Sepulveda Basin were all safe to eat 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.

Introduction

1. Background: The Los Angeles River Watershed

The Los Angeles River watershed (Figure 1) is a highly urbanized watershed that encompasses western and central portions of Los Angeles County. Los Angeles River's headwaters originate in the Santa Monica, Santa Susana, and San Gabriel Mountains and bound the River to the north and west. 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.

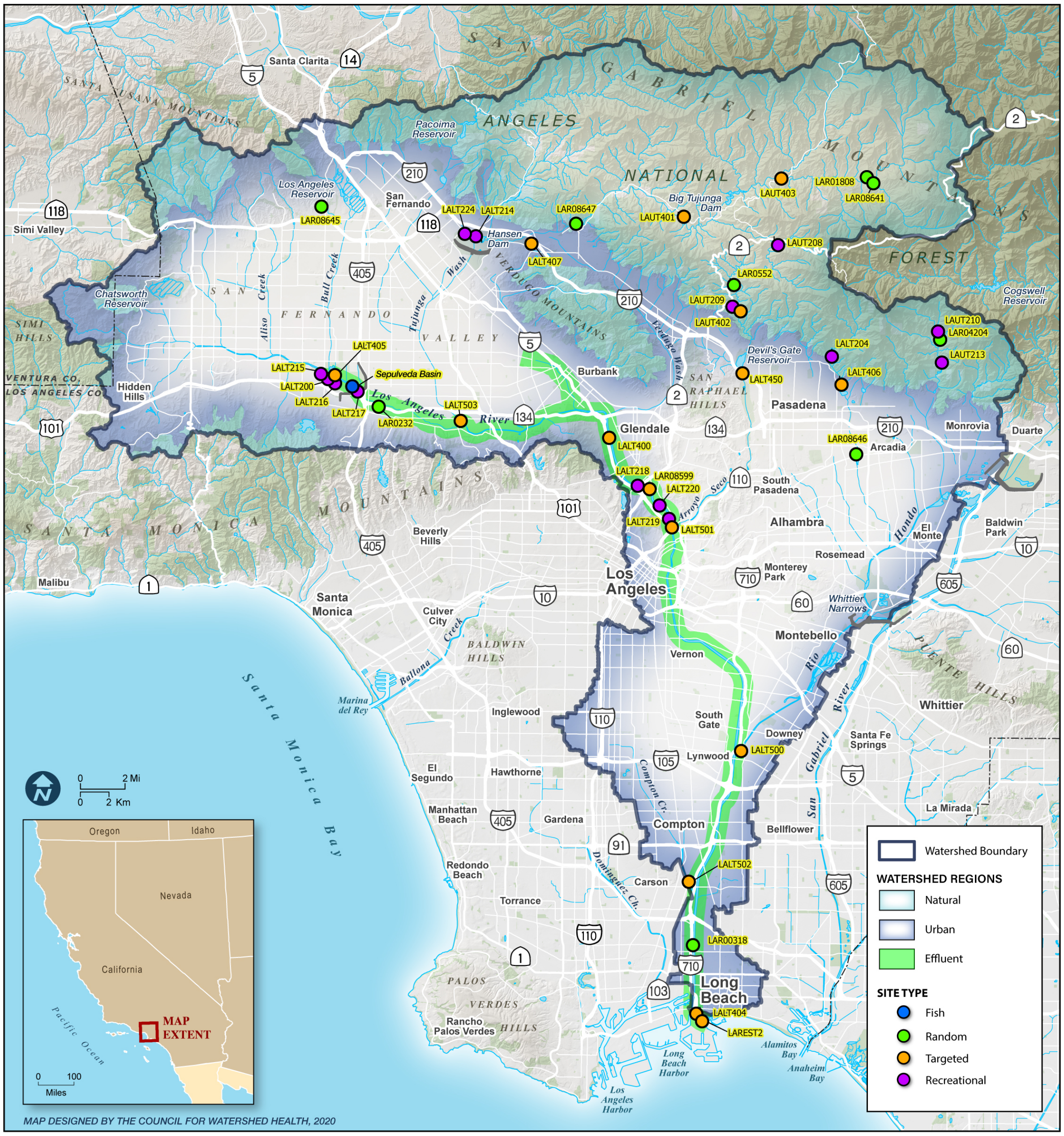


Figure 1. 2019 sampling sites in the Los Angeles River Watershed. Map include fish, random, targeted, recreational, and high-value sites. Note that targeted sites are sampled on a rotating basis. Not all targeted sites are sampled within a single year.

The 824 mi^2 of the Los Angeles River Watershed encompasses forests, natural streams, urban tributaries, residential neighborhoods, and industrial land uses. Approximately 324 mi^2 of the watershed is open space or forest, located mostly in the upper watershed. 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. While most of the river is lined with concrete, the unlined bottoms of the Sepulveda Flood

Control Basin, the Glendale Narrows, Compton Creek, and LA River estuary provide riparian habitat that enhances the ecological and recreational value of these areas.

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

In 2007, local, state, and federal stakeholders formed LARWMP, a collaborative monitoring effort shared by partnering agencies, permittees, and conservation organizations. Partners lend technical expertise, guidance, and support monitoring efforts and lab analysis through funding or in-kind services. The 2019 monitoring efforts for bioassessments, habitat assessment, bacteria testing, and fish tissue bioaccumulation, detailed in this report, were supported by five sampling teams, three laboratories, funding from the Cities of Los Angeles and 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 in the watershed were focused on point source NPDES compliance monitoring and little was known about the ambient condition of streams in the rest of the watershed. Recognizing this shortfall, the Los Angeles Water Quality Control Board (LAWQCB) negotiated with the NPDES permittees to reduce their sampling efforts at redundant sampling sites and to lower sampling frequencies in exchange for greater sampling coverage throughout the watershed. LARWMP's sampling design provides the ability to assess ambient condition throughout the watershed using probabilistically chosen sites and to track trends at fixed (target) 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 natural and urban streams, the main channel, estuarine habitats, and downstream of treatment works. The strategies of this program often mirror the activities of the larger region-wide monitoring program led by the Stormwater Monitoring Coalition (SMC). This report summarizes the monitoring activities and results for 2019. 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. Stakeholders also ensure that 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, 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 2019.

Spring/Summer 2019 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	-	-	-	-	-	-	-	-	-	-	-
Los Angeles River at Marsh Park	LAR08599	ABC	EMD	Cities	Weston	Weston	LACFLD	-	-	-	ABC	Cities
Random Samples												
Big Tujunga Creek (Natural)	LAR08641	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Bull Creek (Urban)	LAR08645	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Eaton Wash (Urban)	LAR08646	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Big Tujunga Creek (Natural)	LAR08647	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												
Alder Creek (Natural)	LAR01808	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Santa Anita Wash (Natural)	LAR04204	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Arroyo Seco (Urban)	LAR01004	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities
Los Angeles River (Effluent)	LAR00318	ABC	EMD	Cities	ABC	ABC	Cities	ABC	Rhithron	Citeis	ABC	Cities

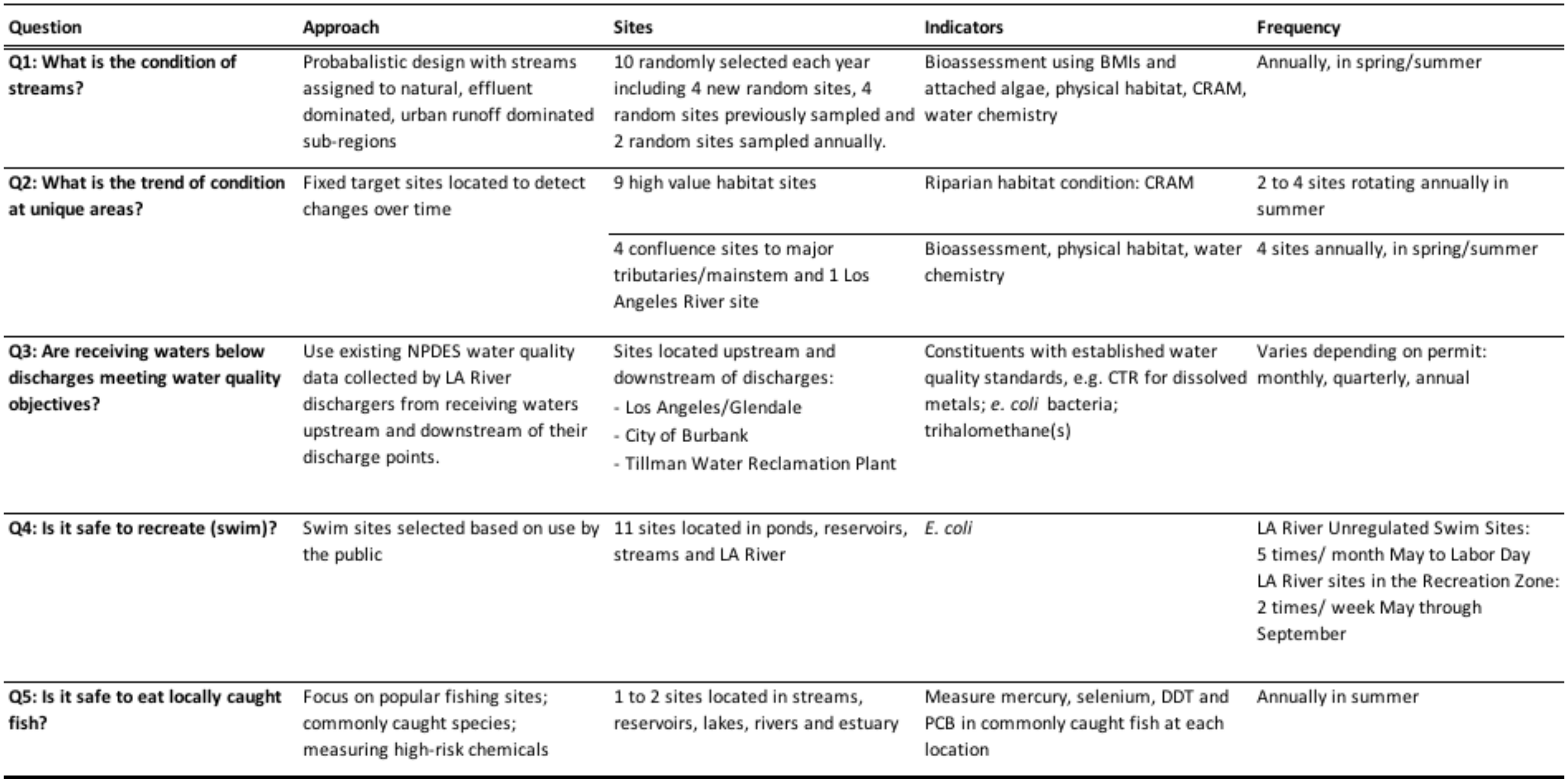
Table 2. Sampling and laboratory analysis responsibilities for bacteria monitoring in 2019.

Spring/Summer Sampling	Site ID	Microbiology sampling	 lab analysis	 funding
Swimming Sites				
Bull Creek Sepulveda Basin	LALT200	ABC	EMD	Cities
Eaton Canyon Natural Area Park	LALT204	CWH	EMD	Cities
LA-Glendale R7	LALT207	EMD	EMD	Cities
Hansen Dam at Tujunga Wash	LALT214	ABC	EMD	Cities
Hansen Dam	LALT224	ABC	EMD	Cities
Los Angeles River	LALT218	EMD	EMD	Cities
Los Angeles River	LALT219	EMD	EMD	Cities
Oakwilde Campground or Switzer Falls/Campground	LAUT208	ABC	EMD	Cities
Gould Mesa Campground	LAUT209	ABC	EMD	Cities
Sturtevant Falls	LAUT210	CWH	EMD	Cities
Hermit Falls	LAUT213	CWH	EMD	Cities

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

Fish Tissue Bioaccumulaiton 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
Sepulveda Basin (River)	LALT314	2019	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 including 4 new random sites, 4 random sites previously sampled and 2 random sites sampled annually.	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 and 1 Los Angeles River site	Bioassessment, physical habitat, water chemistry	4 sites annually, in spring/summer
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 (swim)?	Swim sites selected based on use by the public	11 sites located in ponds, reservoirs, streams and LA River	*E. coli*	LA River Unregulated Swim Sites: 5 times/ month May to Labor Day LA River sites in the Recreation Zone: 2 times/ week May through September
Q5: Is it safe to eat locally caught fish?	Focus on popular fishing sites; commonly caught species; measuring high-risk chemicals	1 to 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 interest to the TSG or relatively isolated, unique habitat

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

Reach	Reach Segment	Ammonia	Benthic Community	Copper	Lead	Nutrients (algae)	Cadmium	Indicator Bacteria	Zinc	pH	Selenium	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 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 (Reach 3 and 5).[1]

Reach	Reach Segment	IND	GWR	NAV	COMM	WARM	EST	MAR	WILD	RARE	MIGR	SPWN	WET	REC1	REC2
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 Basin		▨			▨			▨				▨	▨	▨

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[1] Beneficial uses include: IND = Inland ; GWR = Groundwater ; NAV = Navigation ; COMM = Commercial and Sport Fishing; WARM = Warm Freshwater Habitat, EST = Estuarine Habitat, MAR = Marine Habitat; WILD = Wildlife Habitat , RARE = Rare, Threatened, and Endangered, MIGR = Migration, SPWN = Spawn, Reproduction, and Early Development, WET = Wetland Habitat , REC1 = Water Contact Recreation, REC2 = Non-Contact Recreation

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 11 annual surveys from 2009 through 2019 (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 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. One random site known to be a non-perennial stream was also 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).

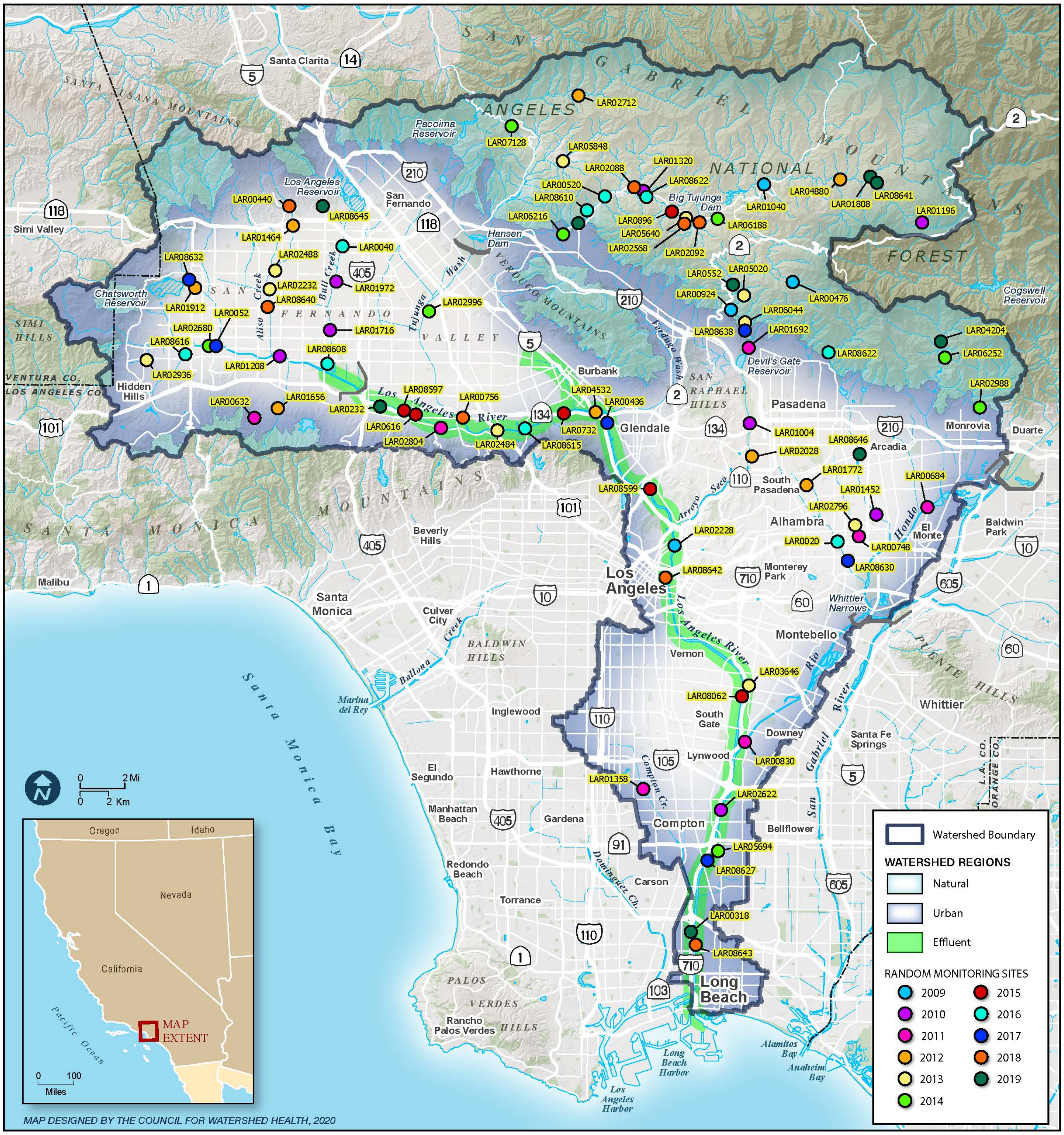


Figure 2. Location of random sites sampled from 2009 to 2019.

2. Methods

LARWMP employed benthic macroinvertebrates (BMIs), California Stream Condition Index (CSCI), Southern California Algae Index (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 *et al*. (2016). 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.

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.

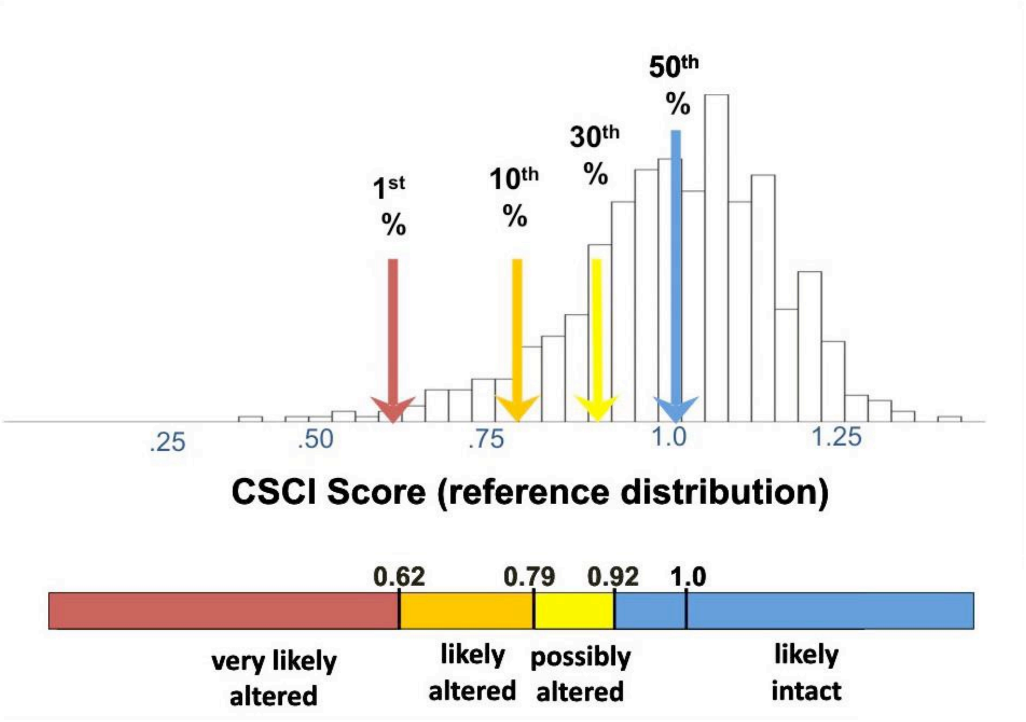


Figure 3. Distribution of CSCI scores at CA reference sites with thresholds and condition categories (Rhen et al., 2015).

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. which 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 macroinvertebrate 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 (*et al.* 2016).

f. Aquatic Chemistry

Nutrients, dissolved metals, 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. 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 2009-2019. 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 2010-2019 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, as demonstrated by higher scores, in the natural regions of the watershed compared to the effluent dominated and urban reaches is consistently seen in CSCI, Algal IBI, and CRAM (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, the majority of sites are not in reference condition and have altered biological condition. Over the 2009-2019 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 65-70% 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 2009-2019 range from 0.33 to 1.35 at natural sites, 0.35 to 1.01 at effluent dominated sites, and 0.21 to 1.07 for urban sites, showing the wide variability in benthic macroinvertebrate community condition within natural and urban regions (Table 7).

The CSCI incorporates two indices, the multi-metric index which is 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, on average, 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). Interestingly, measures of algal biomass varied; ash free dry mass was higher at natural sites but chlorophyll a was higher at effluent-dominated and urban sites (Figure 9). Algal growth is encouraged by environmental conditions, such as nutrients, warm temperatures, and sunlight. These conditions are found in urban and effluent dominated regions due to reduced canopy cover and increased nutrient inputs (Table 7). However, natural sites generally have more organic material than urban, channelized streams. Organic inputs from surrounding vegetation, often lacking or reduced in urban areas, may explain the increased ash free dry mass in natural areas.

The CRAM results underscore the contrast between the highly urbanized lower watershed and the relatively natural conditions found in the upper watershed (Figure 8). 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 concrete-lined channels and lacked vegetative cover. Intermediate to these extremes are the effluent dominated sites along less disturbed soft bottom reaches. There intermediate sites include the Glendale Narrows and Sepulveda Basin for example. These soft bottom sites tended to have higher attribute scores for buffer and biotic condition, though overall habitat condition scores were still in the likely altered category.

Development in the lower watershed has virtually eliminated natural streambed habitat and adjacent buffer zones and altered stream hydrology. In most cases, the natural riparian vegetation has either been eliminated or replaced by invasive or exotic species. These conditions have led to lower habitat condition scores.

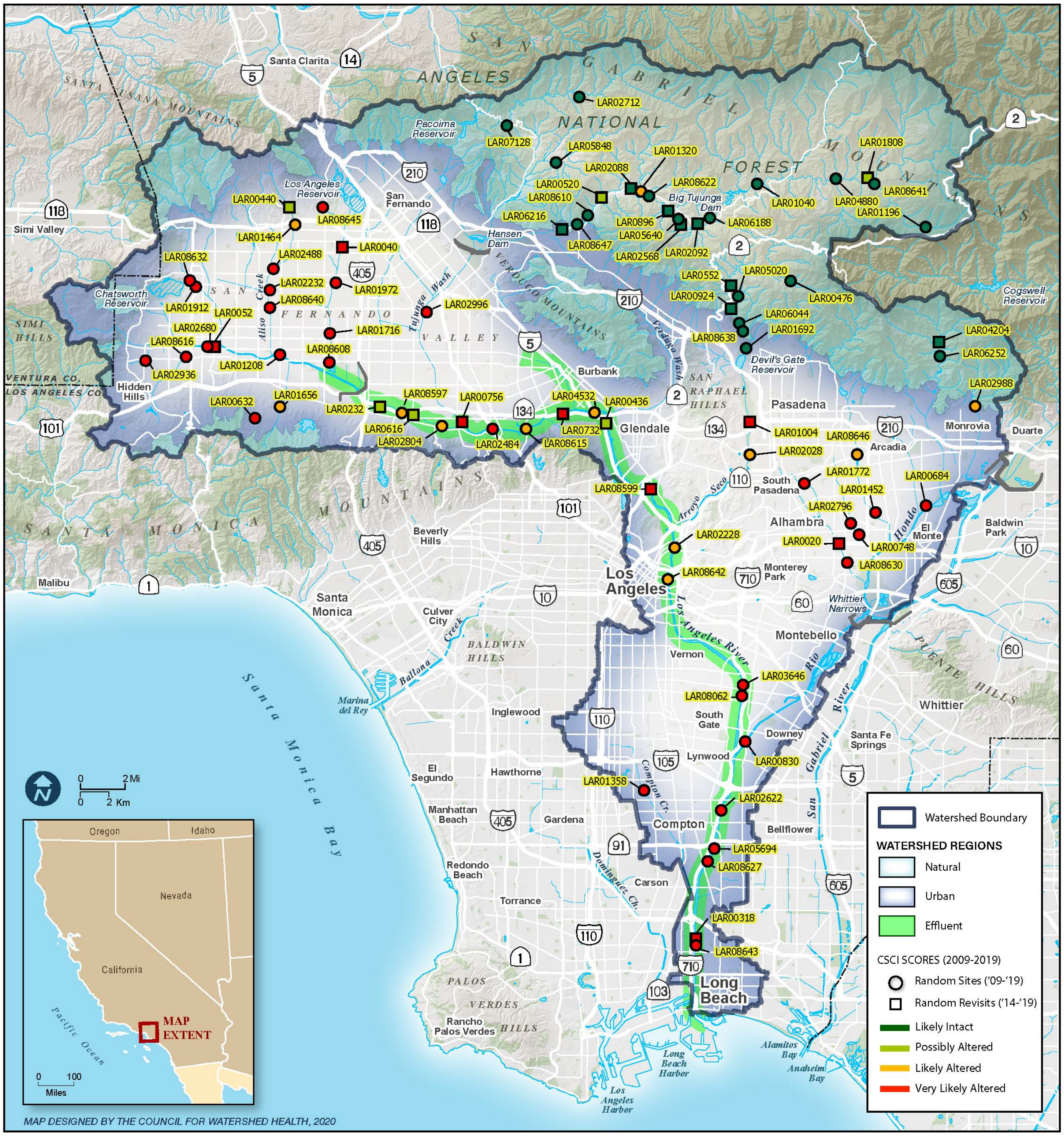


Figure 4. CSCI scores based on probabilistic sites sampled from 2009 to 2019. Likely intact condition = CSCI ≥0.92; possibly altered condition = CSCI 0.91 to 0.80; likely altered condition = CSCI 0.79 to 0.63; very likely altered condition = CSCI ≤0.62.

Figure 5. So Ca Algal IBI Scores for LARWMP probabilistic sites sampled from 2009 to 2019. Sites with scores >57 are in reference condition. Sites with N/A scores were not sampled for soft algae.

Figure 6. CRAM scores based on probabilistic sites sampled from 2009 to 2019. 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.

Table 7. Summary statistics for biotic conditions and water quality analytes at all random sites combined, collected from 2009 to 2019.

	Watershed				Urban				Effluent				Natural			
Analyte	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)	115	0.72 ± 0.25	0.21	1.35	38	0.50 ± 0.18	0.21	1.07	25	0.62 ± 0.15	0.35	1.01	52	0.92 ± 0.16	0.33	1.35
MMI	115	0.64 ± 0.25	0.18	1.43	38	0.45 ± 0.14	0.18	0.88	25	0.50 ± 0.14	0.19	0.89	52	0.85 ± 0.18	0.31	1.43
O/E	115	0.79 ± 0.28	0.12	1.32	38	0.55 ± 0.24	0.12	1.27	25	0.75 ± 0.16	0.45	1.12	52	1.00 ± 0.19	0.35	1.32
Attached Algae (So CA IBI)	94	45 ± 21	9	95	30	35 ± 16	11	80	19	27 ± 14	9	54	45	60 ± 15	32	95
D18	94	49 ± 25	4	100	30	38 ± 22	6	92	19	28 ± 18	4	62	45	66 ± 18	26	100
S2	95	44 ± 20	13	100	31	38 ± 16	13	75	19	30 ± 10	17	48	45	54 ± 20	17	100
Riparian Habitat Score (CRAM)	113	56 ± 21	27	99	38	38 ± 9	27	67	25	38 ± 5	27	53	50	79 ± 7	63	99
Biotic Structure	113	47 ± 24	22	97	38	30 ± 12	22	69	25	28 ± 6	22	50	50	70 ± 15	39	97
Buffer Landscape	113	74 ± 19	25	100	38	58 ± 14	25	88	25	61 ± 11	25	68	50	92 ± 5	75	100
Hydrology	113	57 ± 25	25	100	38	37 ± 10	25	58	25	36 ± 9	25	58	50	83 ± 11	58	100
Physical Structure	113	46 ± 24	25	100	38	28 ± 10	25	75	25	26 ± 3	25	38	50	70 ± 15	38	100
InSitu Measurements																
Temperature (C°)	114	21.17 ± 5.68	10.97	36.69	38	24.39 ± 6.32	13.84	36.69	25	23.69 ± 4.47	16.30	32.80	51	17.55 ± 3.06	10.97	25.03
Dissolved Oxygen (mg/L)	115	9.26 ± 2.45	3.72	17.45	38	10.22 ± 2.91	5.30	16.81	25	10.11 ± 2.89	3.72	17.45	52	8.15 ± 1.01	5.46	10.48
pH	115	8.31 ± 0.70	6.99	10.80	38	8.77 ± 0.88	7.34	10.80	25	8.41 ± 0.46	7.42	9.15	52	7.92 ± 0.36	6.99	8.51
Salinity (ppt)	114	0.45 ± 0.35	0.13	1.93	38	0.71 ± 0.48	0.14	1.93	24	0.51 ± 0.07	0.32	0.60	52	0.24 ± 0.06	0.13	0.37
SpecificConductivity (us/cm)	115	895 ± 647	8	3681	38	1366 ± 884	8	3681	25	1038 ± 106	736	1154	52	482 ± 120	245	762
General Chemistry																
Alkalinity as CaCO3 (mg/L)	115	225 ± 409	40	4520	38	295 ± 708	40	4520	25	138 ± 26	93	206	52	215 ± 39	119	276
Hardness as CaCO3 (mg/L)	109	302 ± 306	94	2540	36	476 ± 487	94	2540	25	228 ± 44	166	310	48	209 ± 47	96	370
Chloride (mg/L)	110	91 ± 99	5	554	37	164 ± 117	11	554	25	139 ± 18	109	163	48	10 ± 3	5	18
Sulfate (mg/L)	110	164 ± 307	3	2360	37	342 ± 477	17	2360	25	161 ± 26	123	222	48	29 ± 25	3	135
TSS (mg/L)	98	41 ± 155	0	1330	31	102 ± 264	2	1330	23	31 ± 45	6	218	44	3 ± 3	0	17
Nutrients																
Ammonia as N (mg/L)	115	0.2 ± 0.9	0.03	10.0	38	0.3 ± 1.6	0.0	10.0	25	0.13 ± 0.11	0.03	0.42	52	0.04 ± 0.06	0.03	0.40
Nitrate as N (mg/L)	115	1.2 ± 1.8	0.01	6.5	38	1.2 ± 1.6	0.0	6.5	25	3.74 ± 1.41	0.98	5.87	52	0.08 ± 0.11	0.01	0.53
Nitrite as N (mg/L)	115	0.0 ± 0.1	0.01	0.4	38	0.0 ± 0.0	0.0	0.2	25	0.07 ± 0.11	0.01	0.41	52	0.01 ± 0.00	0.01	0.01
NitrogenTotal (mg/L)	115	3.3 ± 4.8	0.00	38.8	38	5.4 ± 7.0	0.2	38.8	25	5.90 ± 1.45	2.71	8.00	52	0.53 ± 0.97	0.00	6.46
OrthoPhosphate as P (mg/L)	115	0.1 ± 0.1	0.03	1.1	38	0.1 ± 0.2	0.0	0.8	25	0.13 ± 0.12	0.03	0.48	52	0.07 ± 0.14	0.03	1.06
Phosphorus as P (mg/L)	115	0.2 ± 0.3	0.01	2.2	38	0.4 ± 0.4	0.0	2.2	25	0.26 ± 0.16	0.12	0.77	52	0.10 ± 0.18	0.01	1.33
Dissolved Organic Carbon (mg/L)	113	6.7 ± 6.4	1.2	37.6	38	11.3 ± 9.0	1.5	37.6	25	6.96 ± 0.65	5.55	8.37	50	3.09 ± 1.39	1.20	6.87
Total Organic Carbon (mg/L)	113	8.4 ± 11.6	0.2	102.2	38	12.7 ± 10.5	1.6	42.0	25	7.89 ± 1.28	6.48	11.20	50	5.43 ± 14.14	0.18	102.22
Algal Biomass																
AFDM (mg/cm^2)	96	5.67 ± 13.43	0.07	113.38	31	6.67 ± 11.67	0.16	48.25	20	8.64 ± 24.83	0.07	113.38	45	3.66 ± 4.64	0.17	26.63
Chl-a (ug/cm^2)	96	6.21 ± 6.64	0.41	37.00	31	7.18 ± 7.08	0.41	34.00	20	10.03 ± 8.43	0.50	37.00	45	3.84 ± 4.15	0.41	25.00
Dissolved Metals																
Arsenic (ug/L)	77	1.7 ± 1.3	0.0	6.5	29	2.3 ± 1.4	0.1	6.5	14	1.7 ± 0.8	0.3	3.5	34	1.2 ± 1.2	0.0	5.4
Cadmium (ug/L)	81	0.1 ± 0.1	0.0	0.4	31	0.1 ± 0.1	0.0	0.3	14	0.2 ± 0.1	0.0	0.4	36	0.0 ± 0.1	0.0	0.4
Chromium (ug/L)	79	0.3 ± 10.2	-88.0	7.5	29	1.8 ± 1.7	0.2	7.5	14	1.1 ± 0.7	0.4	2.5	36	-1.2 ± 14.9	0.0	7.3
Copper (ug/L)	81	6.1 ± 6.9	0.0	30.6	31	11.3 ± 8.2	0.6	30.6	14	6.7 ± 2.8	1.5	13.1	36	1.4 ± 0.8	0.0	3.1
Iron (ug/L)	81	160.4 ± 1016.5	0.0	9180.0	31	58.8 ± 64.4	0.0	253.0	14	32.9 ± 39.4	0.0	156.0	36	297.5 ± 1524.0	0.0	9180.0
Lead (ug/L)	81	0.2 ± 0.2	0.0	1.3	31	0.3 ± 0.3	0.0	1.3	14	0.3 ± 0.1	0.1	0.5	36	0.1 ± 0.0	0.0	0.2
Mercury (ug/L)	81	0.004 ± 0.008	0.001	0.047	31	0.006 ± 0.011	0.001	0.047	14	0.002 ± 0.001	0.001	0.004	36	0.003 ± 0.007	0.001	0.041
Nickel (ug/L)	81	4.4 ± 10.2	0.4	78.0	31	7.9 ± 15.8	0.7	78.0	14	4.6 ± 1.7	1.7	7.8	36	1.3 ± 0.8	0.4	3.9
Selenium (ug/L)	81	1.0 ± 1.7	0.1	11.5	31	1.8 ± 2.5	0.1	11.5	14	1.1 ± 0.4	0.2	1.6	36	0.2 ± 0.2	0.1	0.7
Zinc (ug/L)	81	9.5 ± 11.1	0.5	47.6	31	8.2 ± 5.9	1.5	21.5	14	29.4 ± 10.7	8.4	47.6	36	2.9 ± 2.1	0.5	13.2

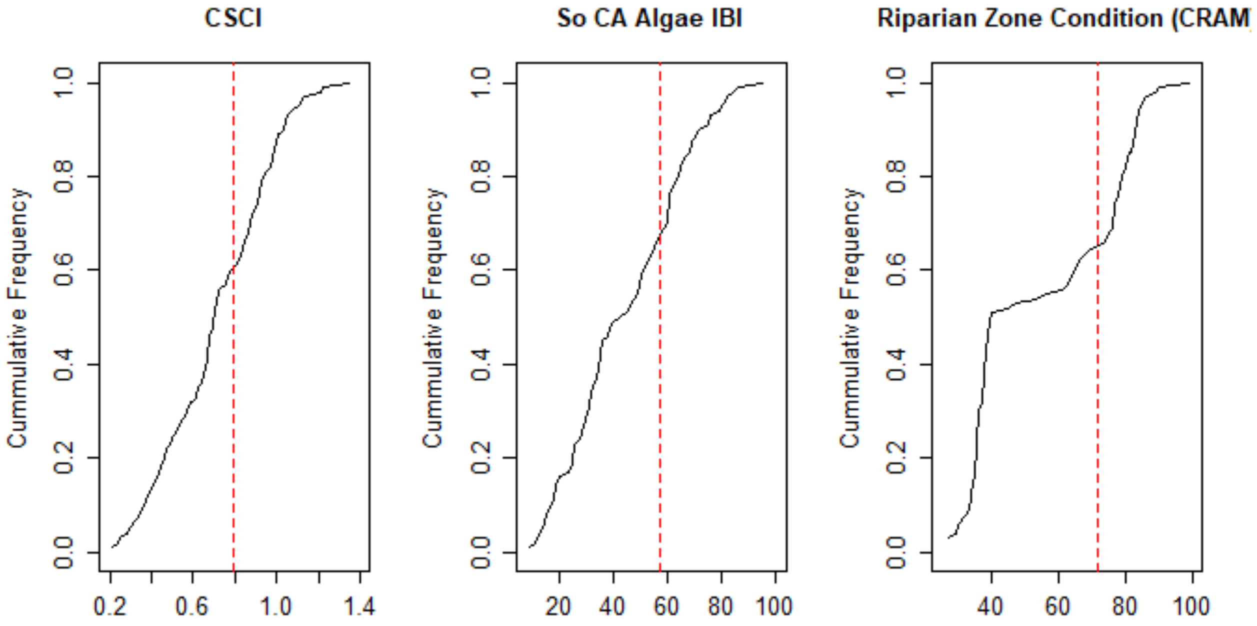


Figure 7. Cumulative frequency distribution of CSCI, Algal IBI, and CRAM scores at random sites from 2009-2019.

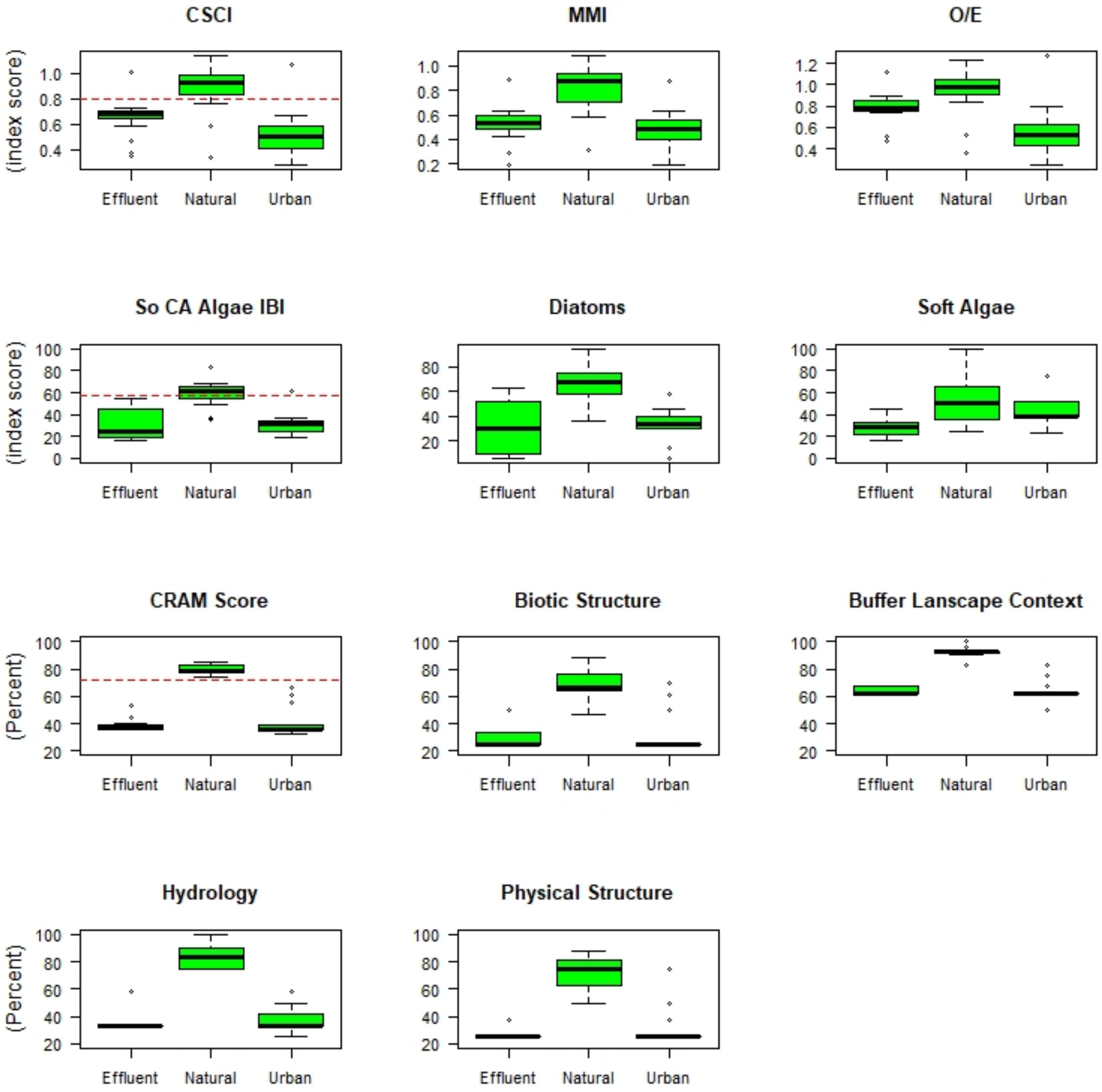


Figure 8. CSCI, Algal IBI, and CRAM scores and attribute scores for effluent, natural, and urban random sites from 2009-2019. CRAM attribute scores include measures of biotic structure, buffer landscape context, hydrology, and physical structure.

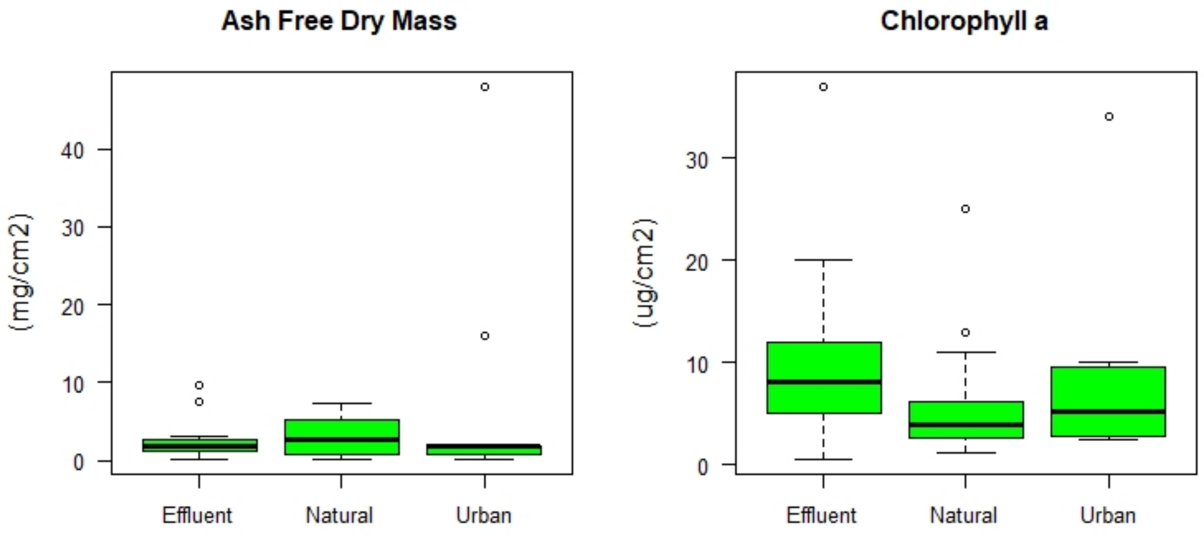


Figure 9. Ash free dry mass and chlorophyll A concentrations, both methods that quantify algal biomass, in effluent, natural, and urban regions in the watershed.

Figure 10 shows the proportion of BMI feeding groups represented in each of the three watershed sub-regions for all random sites from 2008 to 2019. 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 and urban sites had five feeding groups each. 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, although still dominated by collectors. 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 local studies have been done on this BMI feeding assemblage to date.

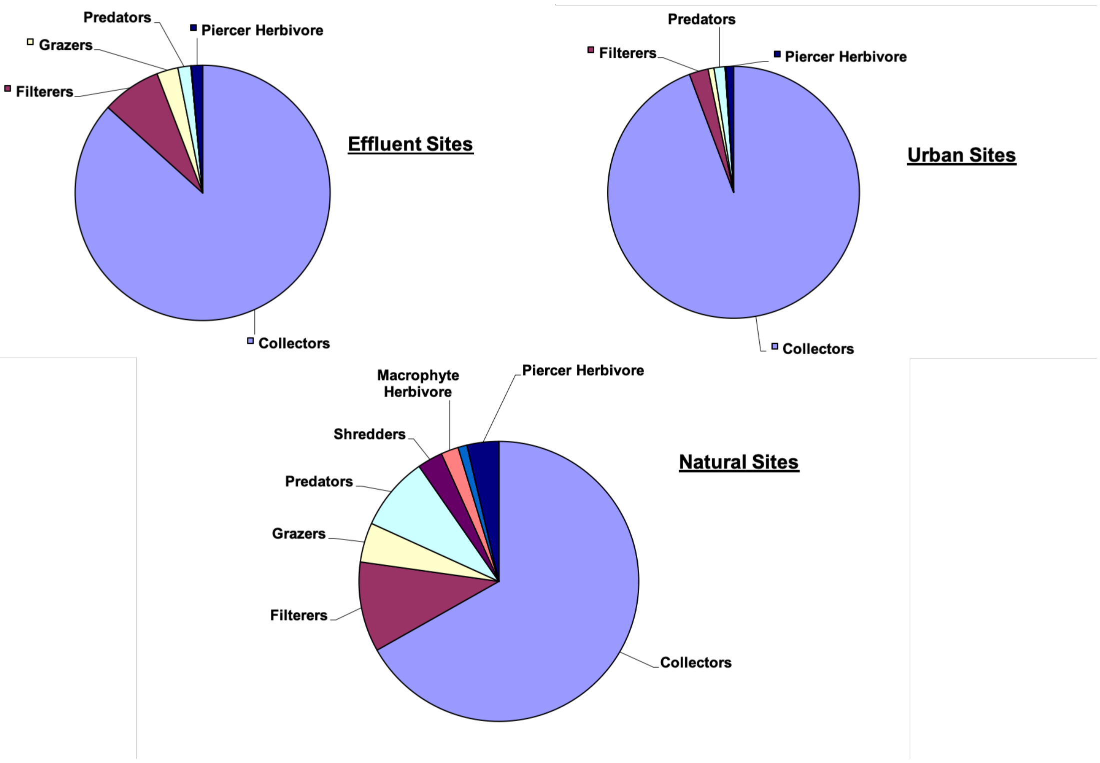


Figure 10. Relative proportion of benthic macroinvertebrate functional feeding groups in each watershed sub-region for 2008-2019 random sites.

b. *Aquatic Chemistry and Physical Habitat*

The differences in nutrient concentrations between watershed subregions 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 subregion, 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 select water quality parameters that showed large differences between natural and effluent/urban sub-regions included temperature, sulfate, and chloride—all were lowest at natural sites (Table 7).

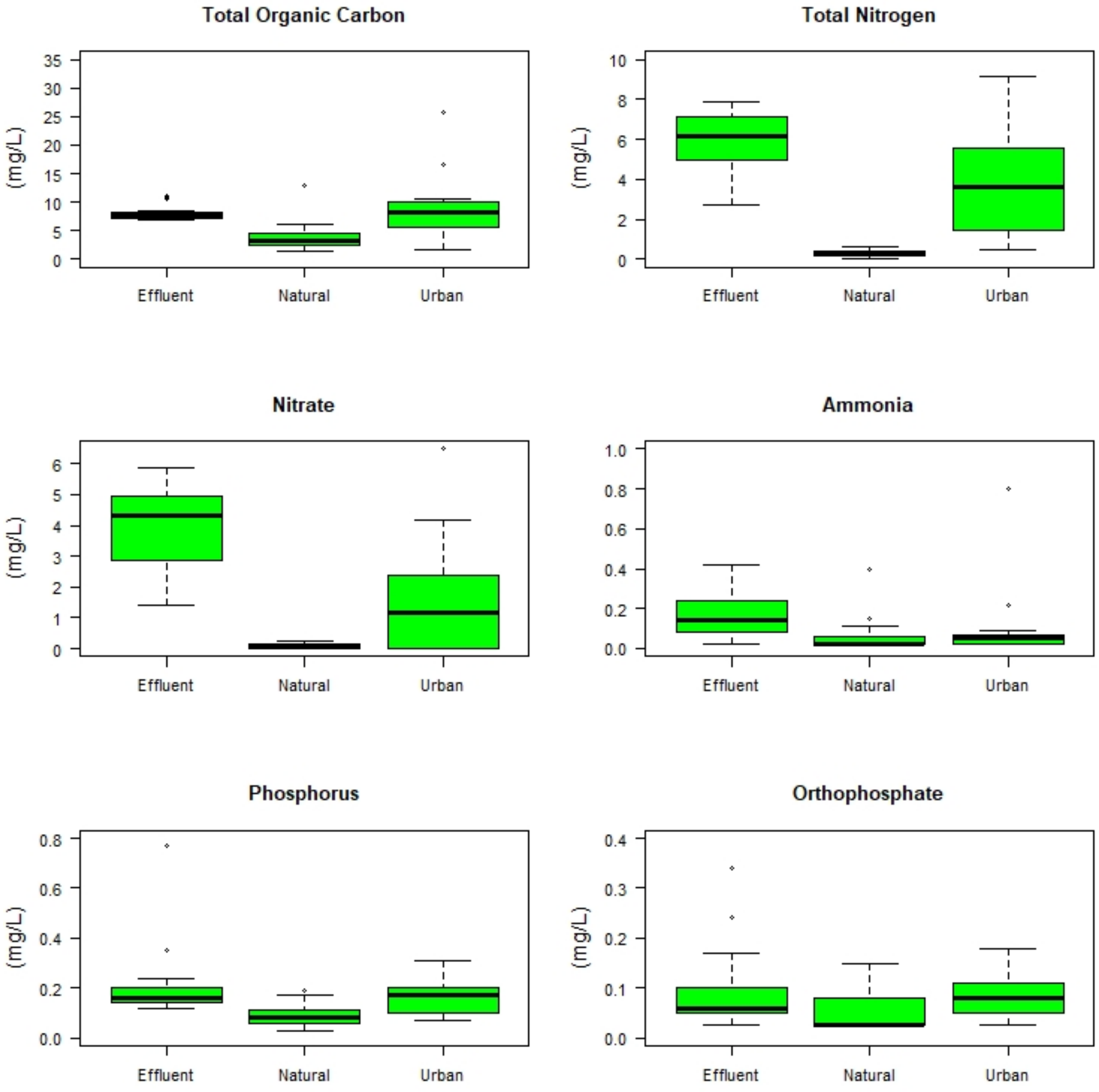


Figure 11. Box-and-whisker plots showing the median and range of representative nutrients measures in each of the three Los Angeles River watershed regions from 2009-2019.

c. Physical Habitat Assessments

Physical habitat was assessed using SWAMP (Ode et al. 2016) protocols, which focus on streambed quality and the condition of the surrounding riparian zone out to 50 meters. Physical habitat conditions were best in the upper watershed compared to the lower watershed (Figure 12), specifically in terms of percent canopy, channel alteration, and epifaunal substrate cover. The epifaunal substrate, which was markedly higher in natural sub-regions, 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 scores, where low sediment deposition is represented by high scores, should be interpreted cautiously in urban and effluent-dominated reaches due to the high degree of channelization and channel alteration limiting erosional processes.

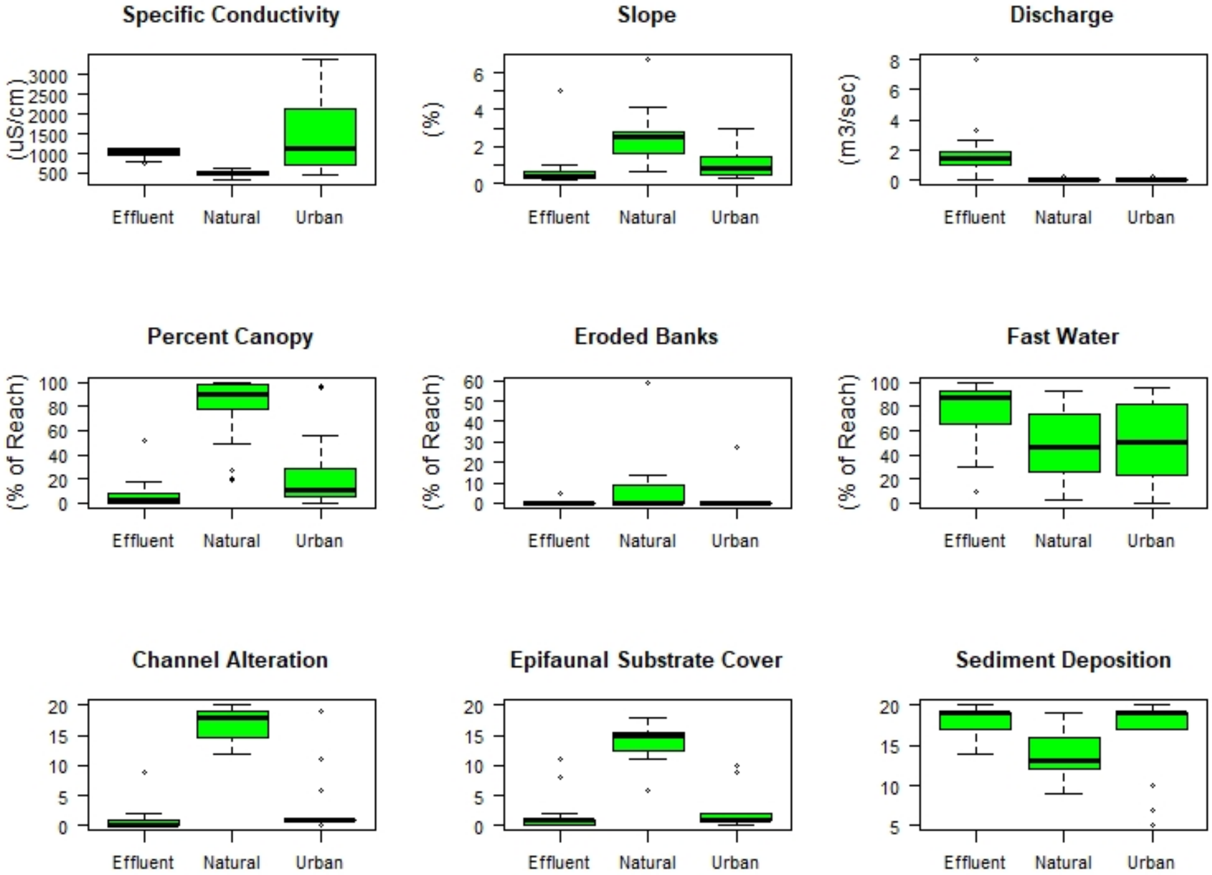


Figure 12. Box-and-whisker plots showing the median and range of representative physical habitat parameters measured in each of the three Los Angeles River watershed regions from 2009-2019. Channel alteration, epifaunal substrate cover, and sediment deposition are scored assessments, higher scores denote better condition. Channelized streams are an exception. Channelization of streams decreases sedimentation, which results in higher sediment deposition scores. This does not indicate that these sites have better physical habitat.

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 are clustered around water chemistry and some physical habitat variables that are altered/ elevated—such as nutrients, temperature, and percent concrete asphalt-- 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. Channel alteration, nitrate as N, and temperature were the most important variables according to the random forest model predictions of CSCI scores (Figure 14).

Ionic strength and percent vulnerability 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 percent stability (Figure 16). Soft algae scores were more closely associated with biotic structure, specific conductivity, and nutrient variables (Figure 17).

Stressors, as defined by this report, are chemical or physical factors or environmental conditions that are associated with, and may 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 = 114, normalization transformation, stress = 0.0981).

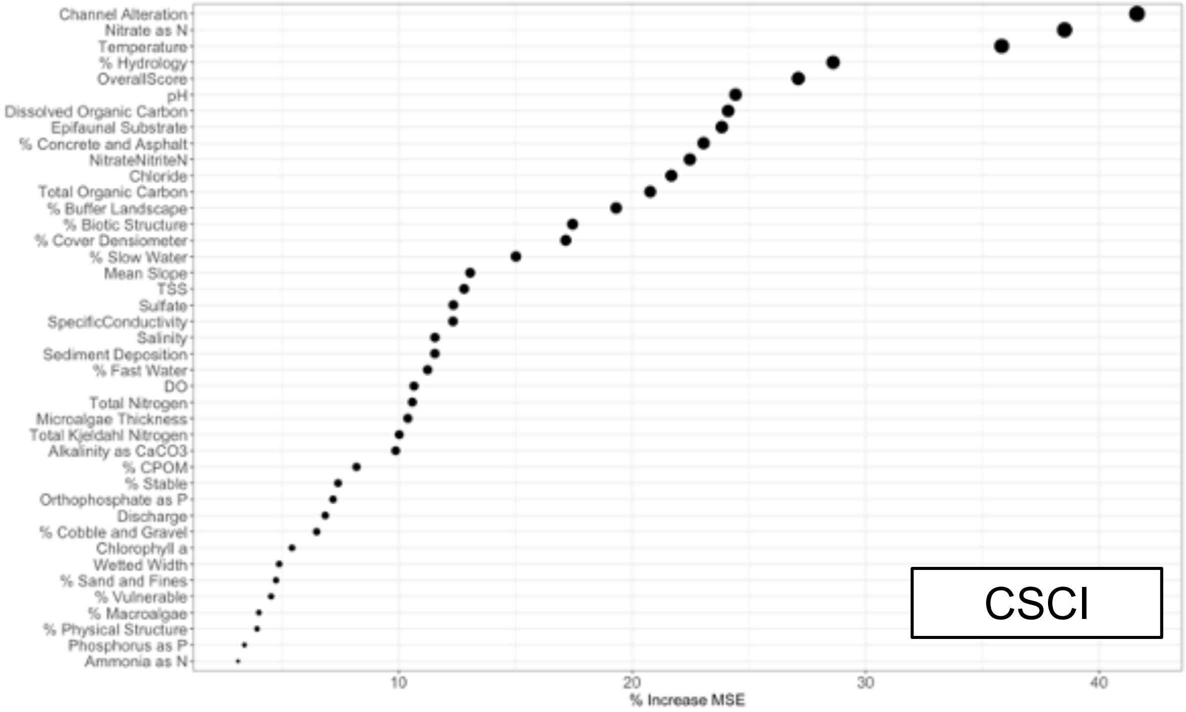


Figure 14. Variable importance plot showing an evaluation of the strength of association of the environmental variables to the biological condition using a random forest model that was created using physical habitat data (2009-2019) to predict CSCI scores (N = 114, square root transformation).

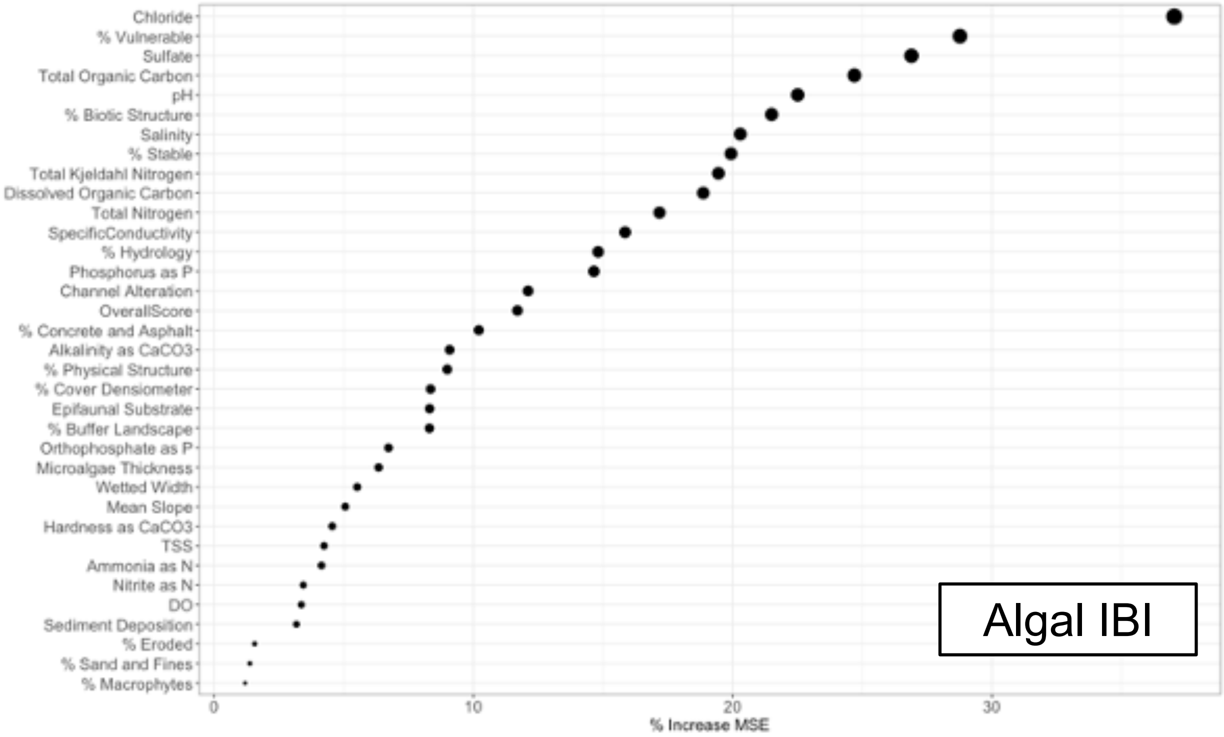


Figure 15. Variable importance plot showing an evaluation of the strength of association of the environmental variables to the biological condition using a random forest model that was created using physical habitat data (2009-2019) to predict algal IBI scores (N =93, normalization transformation).

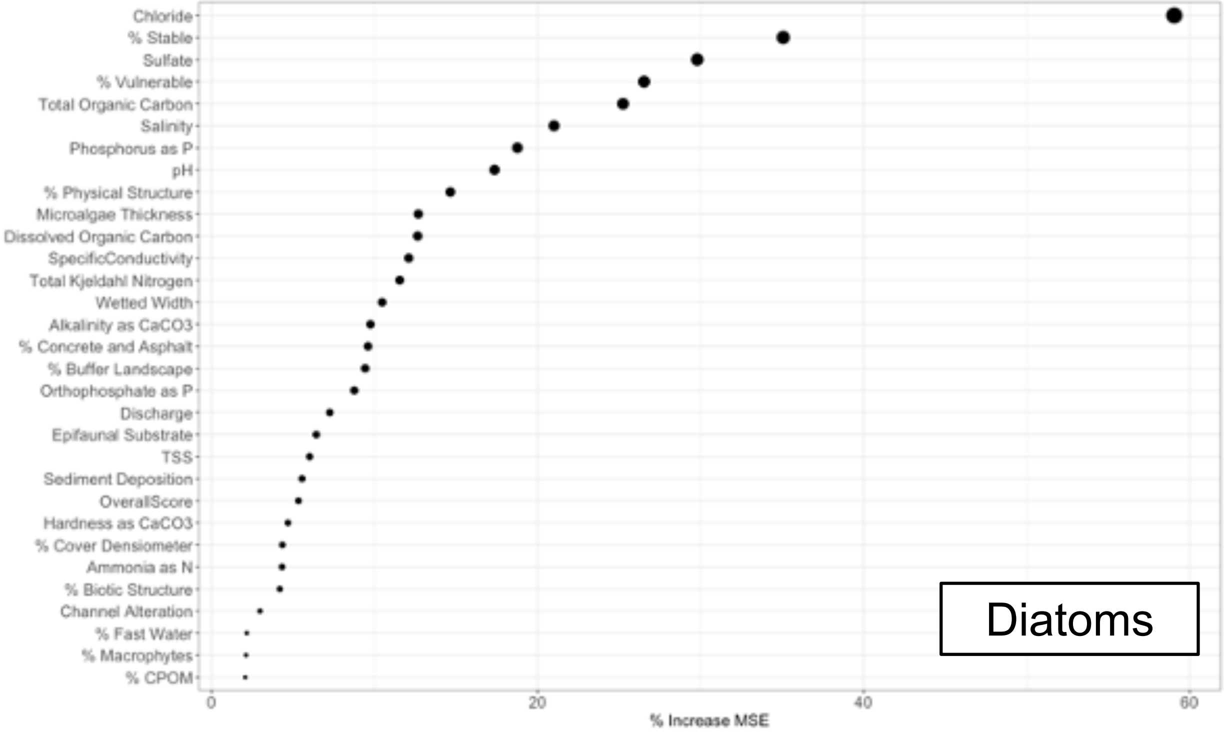


Figure 16. Variable importance plot showing an evaluation of the strength of association of the environmental variables to diatom scores using a random forest model that was created using physical habitat data (2009-2019, N=93, normalization transformation).

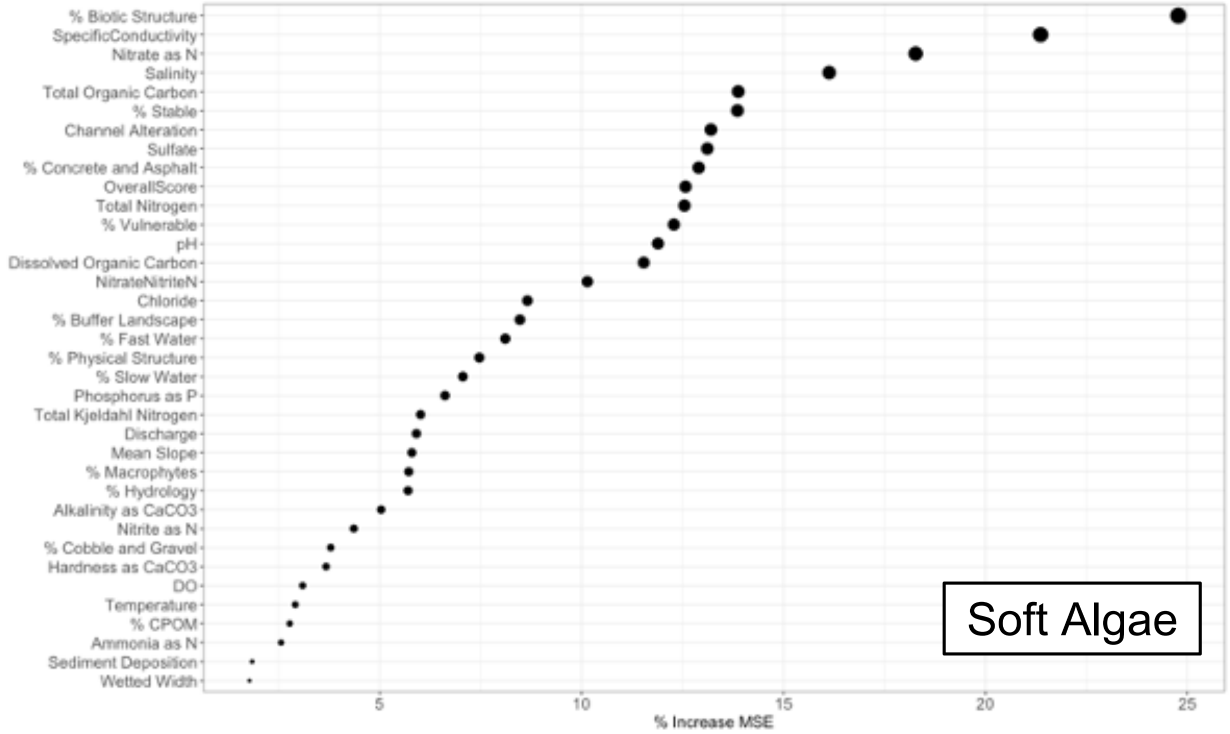


Figure 17. Variable importance plot showing an evaluation of the strength of association of the environmental variable to soft algae scores using a random forest model created using physical habitat data (2009-2019, N = 94, normalization transformation).

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:

- Trends at freshwater target sites: Four target sites were established on lower watershed tributaries upstream of their confluence points with the Los Angeles River to monitor water chemistry and assess biological, riparian, and physical habitat condition (Figure 18). These sites differ from the random sites used to assess ambient watershed condition in that their locations are fixed and sites are sampled regularly. Over time these data are being used to assess trends and to determine if changes in these trends can be attributed to natural, anthropogenic, or watershed management changes. Due to the amount of data that has been collected from confluence sites, in 2018 the TSG included another site of interest. This site will be semi-regularly sampled along with other confluence sites on an alternating basis. The 2019 monitoring program included Lewis McAdams Park, a random site that was sampled in 2015, dredged in 2018, and revisited in 2019.

- The Los Angeles River Estuary: is located at the terminus of the Los Angeles River main stem, where it discharges to the Harbor. This monitoring was designed to determine if Estuary sediments are meeting the sediment quality objectives (SQOs) developed by SWAMP, using a multiple lines of evidence approach (Bay et al. 2014).

- High-value habitat sites: nine locations were chosen to assess trends in riparian zone condition at sites deemed by the workgroup to be unique. The emphasis of these assessments is on riparian habitat conditions using CRAM. Riparian zone conditions at these sites provide trend data and valuable baseline data for potential habitat restoration or protection efforts.

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.

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 2019 (Figure 18 and Table 8). In 2018, the TSG agreed to begin monitoring near Lewis MacAdams Park, a site that would aid the TSG in understanding the impact of sediment removal to stream health. 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 three sub-regions of the watershed.

Figure 18. Location of bioassessment, CRAM, and estuary sites.

Table 8. Location of targeted confluence sites sampled from 2009 through 2019

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
Lewis MacAdams Park	Unlined	LAR08599	34.10603	-118.24338

a. Aquatic Chemistry

In 2019, the Lewis MacAdams, Compton Creek, Rio Hondo, and Arroyo Seco sites were monitored. Aquatic chemistry results have been highly variable for most constituents during the ten-year monitoring period. Concentrations of general chemistry analytes can oscillate considerably from year to year with no consistent increasing or decreasing patterns (Figure 19). The Tujunga Wash site (LALT503) had sharp increases in hardness, specific conductivity, chloride and sulfate in either 2015 or 2016. The Arroyo Seco site (LALT501) had similar increases in hardness in 2015 and 2019, but not for conductivity, chloride or sulfate. In 2014 the Rio Hondo (LALT500) had a six fold increase in suspended solids but returned to previous concentrations in 2015. Compton Creek (LALT502) and the newly added Lewis MacAdams Park site (LAR08599) are notable in the general stability of constituent concentrations from year to year.

Nutrient concentrations have also been variable from year to year (Figure 20). Total organic carbon concentrations were similar and low at each site over time, with the exception of the Tujunga Wash (LALT503) which was up to four times greater than other sites in 2010, 2016 and 2017. Ammonia was low across all sites, except in 2010 and 2015 when concentrations spiked to over 1.0 mg/L at Tujunga Wash. The Arroyo Seco (LALT 501) and Lewis MacAdams Park (LAR08599) had nitrate and total nitrogen concentrations that were 4 to 6 times greater than concentrations observed at other sites, respectively. Total nitrogen follows a similar trend. In contrast, the Tujunga Wash (LALT503) which had low concentrations of nitrate, had elevated total nitrogen concentrations over time indicating that nitrogen at the Tujunga Wash was partitioned into its organic form. Nitrate concentrations at all sites have been below the water quality thresholds specified in the Los Angeles Basin Plan (<10 mg/L; LARWQCB 2019) since 2009. In 2019, the concentrations of orthophosphate and total phosphorus at the Compton Creek site (LALT502) were 3.9 to 2.2 higher, respectively, compared to the other confluence sites. Both have declined slightly since 2014. Orthophospate and total phosphorus spiked at Tujunga Wash in 2010, but both have dereased to low concentrations in 2019. Similarily, total phosphorus spiked in 2009 at the Rio Hondo and then declined.

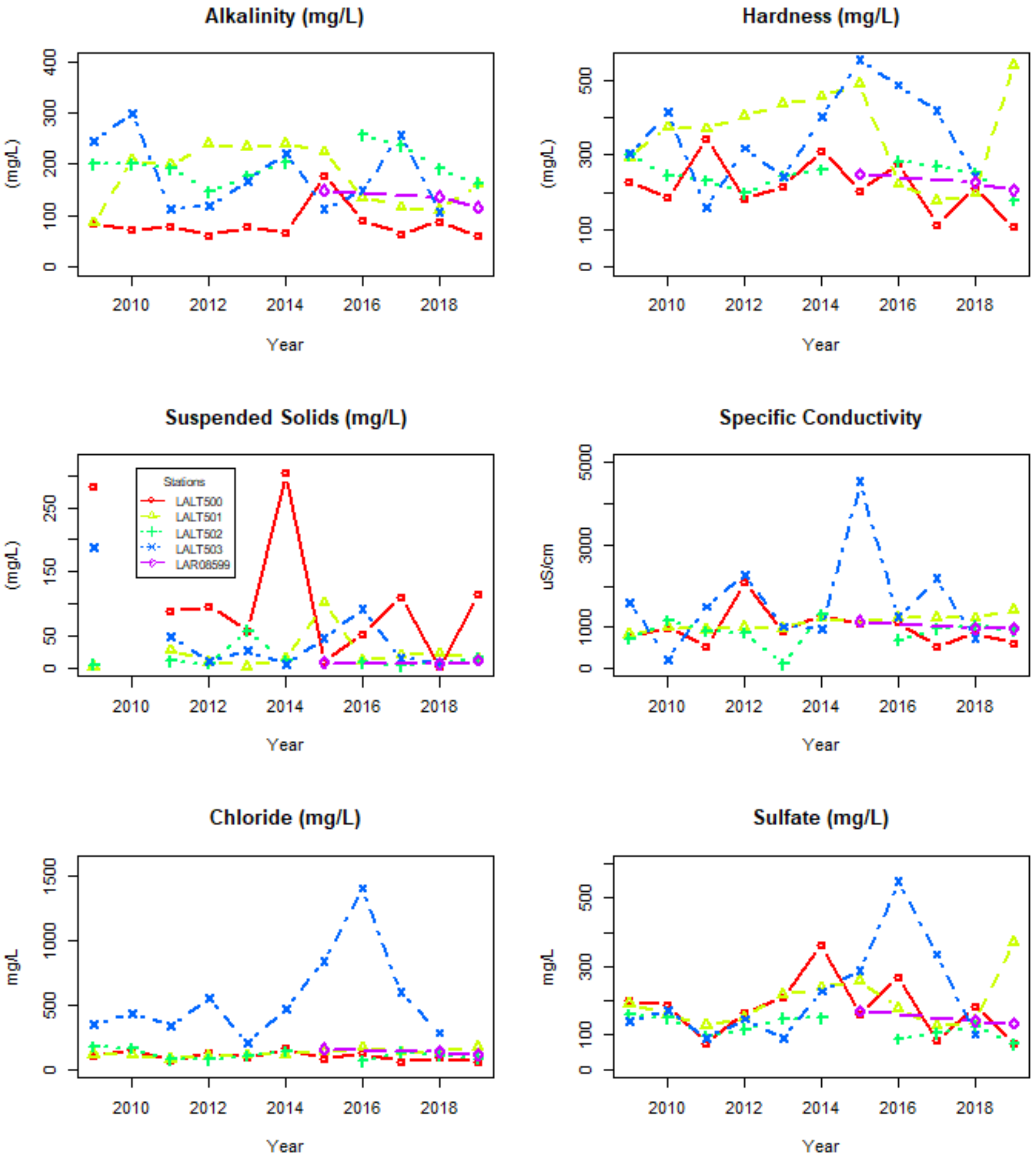
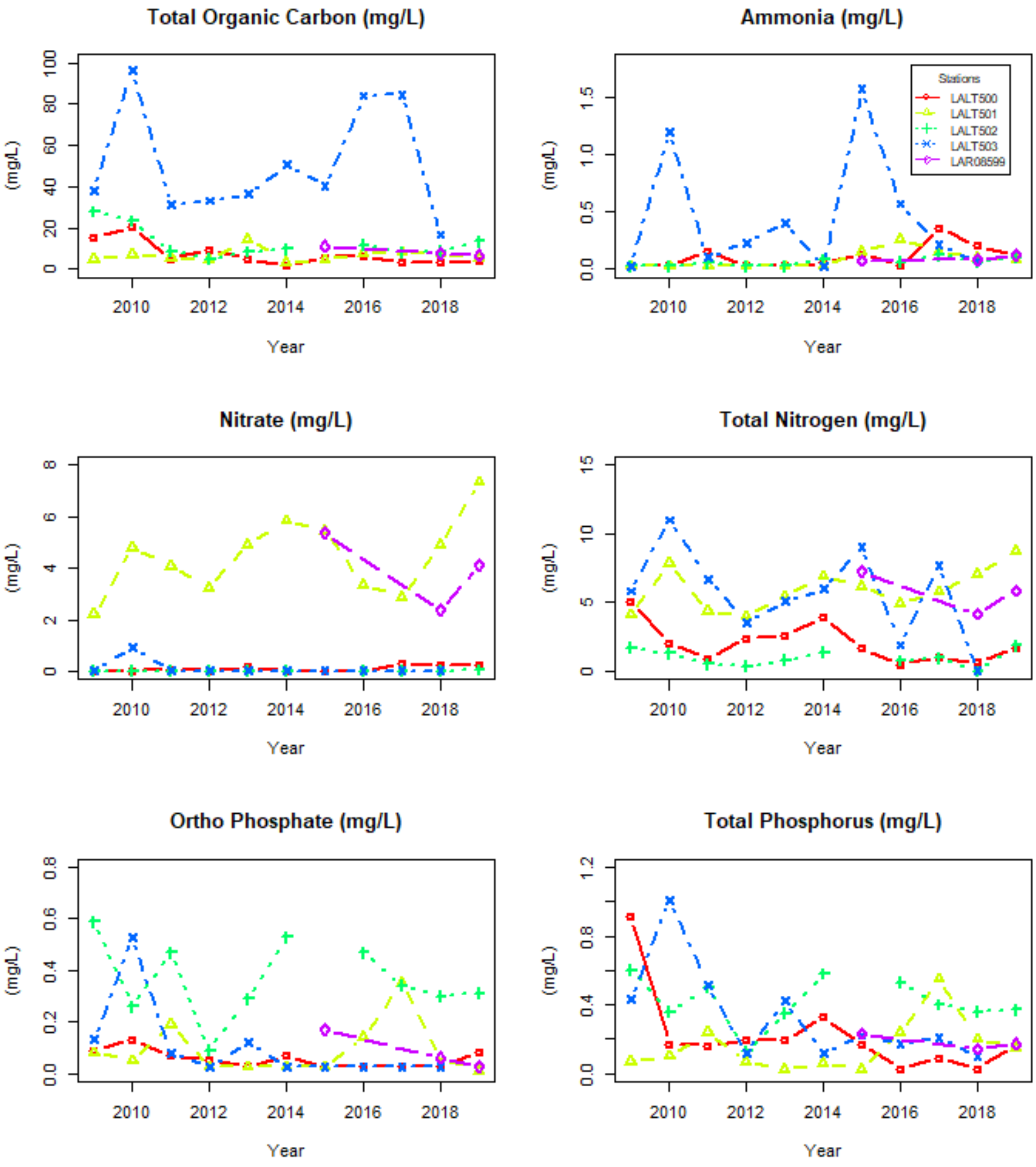


Figure 19. General chemistry at confluence sites sampled annually from 2009 to 2019 (Red = LALT500; Yellow= LALT501; Green = LAL502; Blue = LALT503; Purple = LAR08599).


Total Organic Carbon (mg/L)

Ammonia (mg/L)

Nitrate (mg/L)

Total Nitrogen (mg/L)

Ortho Phosphate (mg/L)

Total Phosphorus (mg/L)

Figure 20. Nutrient concentrations at confluence sites sampled annually from 2009 to 2019 (Red = LALT500; Yellow= LALT501; Green = LAL502; Blue = LALT503; Purple = LAR08599).

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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 2019. 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 Tujunga Wash (LALT 503) from 2015 to 2016), all targeted sites scored in the likely and very likely altered categories (CSCI <0.79) and continued to be altered/very likely altered condition in 2019. The Rio Hondo and Compton Creek sites have consistently scored in the lower CSCI 'very likely altered' range. The Arroyo Seco and Lewis MacAdams park sites have, on the other hand, consistently scored within the 'likely altered' category. Dredging at the Lewis MacAdams site in 2018 has not resulted in markedly negative impacts to biotic condition, as captured by stable CSCI and CRAM scores.

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 the 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. CRAM scores at the Lewis MacAdams park site, a soft-bottom portion of the river, are among the highest but habitat condition at this site still falls into the impaired category.

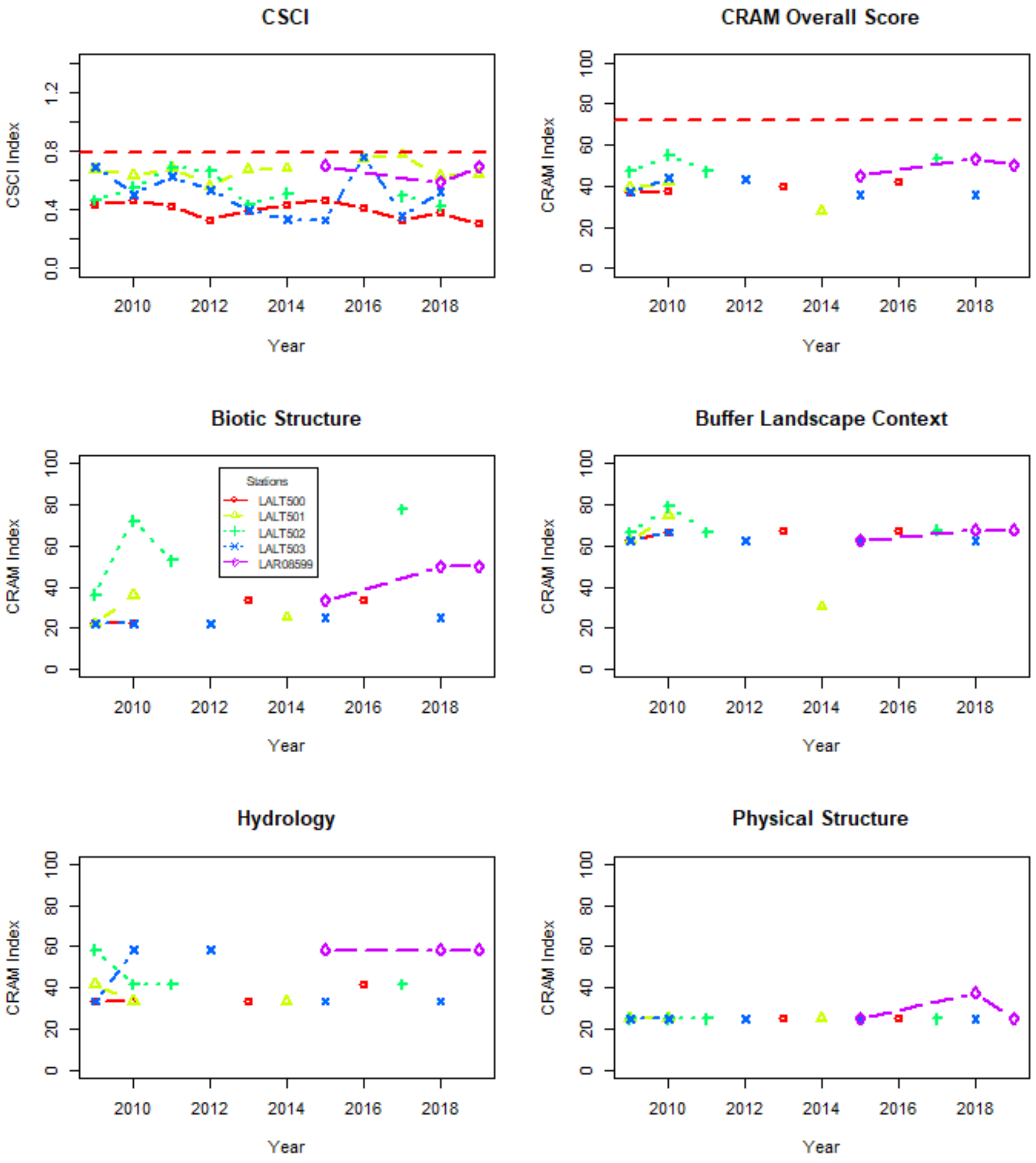

Figure 21. CSCI and CRAM scores (overall and attribute) at confluence sites sampled annually from 2009 to 2019. The red dashed horizontal lines on the CSCI and CRAM Overall Score graphs indicate the threshold, below which the site is in non-reference condition (0.79 for CSCI and 72 for overall CRAM score) (Red = LALT500; Yellow= LALT501; Green = LAL502; Blue = LALT503; Purple = LAR08599).

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. It is important to note that though visual physical habitat assessments are standardized as much as possible, they still may vary between users. As a result, only large changes in these assessments should be considered as reflecting changing conditions at a site.

The physical habitat conditions at Rio Hondo and Tujunga Wash are generally stable from year to year, including 2019. Sediment depositions scores vary considerable across all sites vary from year to year. Additionally, conditions at Compton Creek also vary widely from year to year. For example, percent canopy, sand fines, epifaunal substrate, and sediment deposition all declined at the Compton Creek Site in 2019, potentially due to dredging and other maintenance activities. However, despite dredging activities at the Lewis MacAdams park site, some physical habitat metrics post dredging suggested negligible changes or improved physical habitat conditions. For example, epifaunal substrate was more prevalent at the site after dredging while percent canopy cover remained stable. Percent concrete and channel alteration increased since the site was initially assessed in 2015, as dredging likely uncovered more of the site's concrete bottom.

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, albeit CRAM scores are still below reference condition, has not translated to the site having better biological condition.

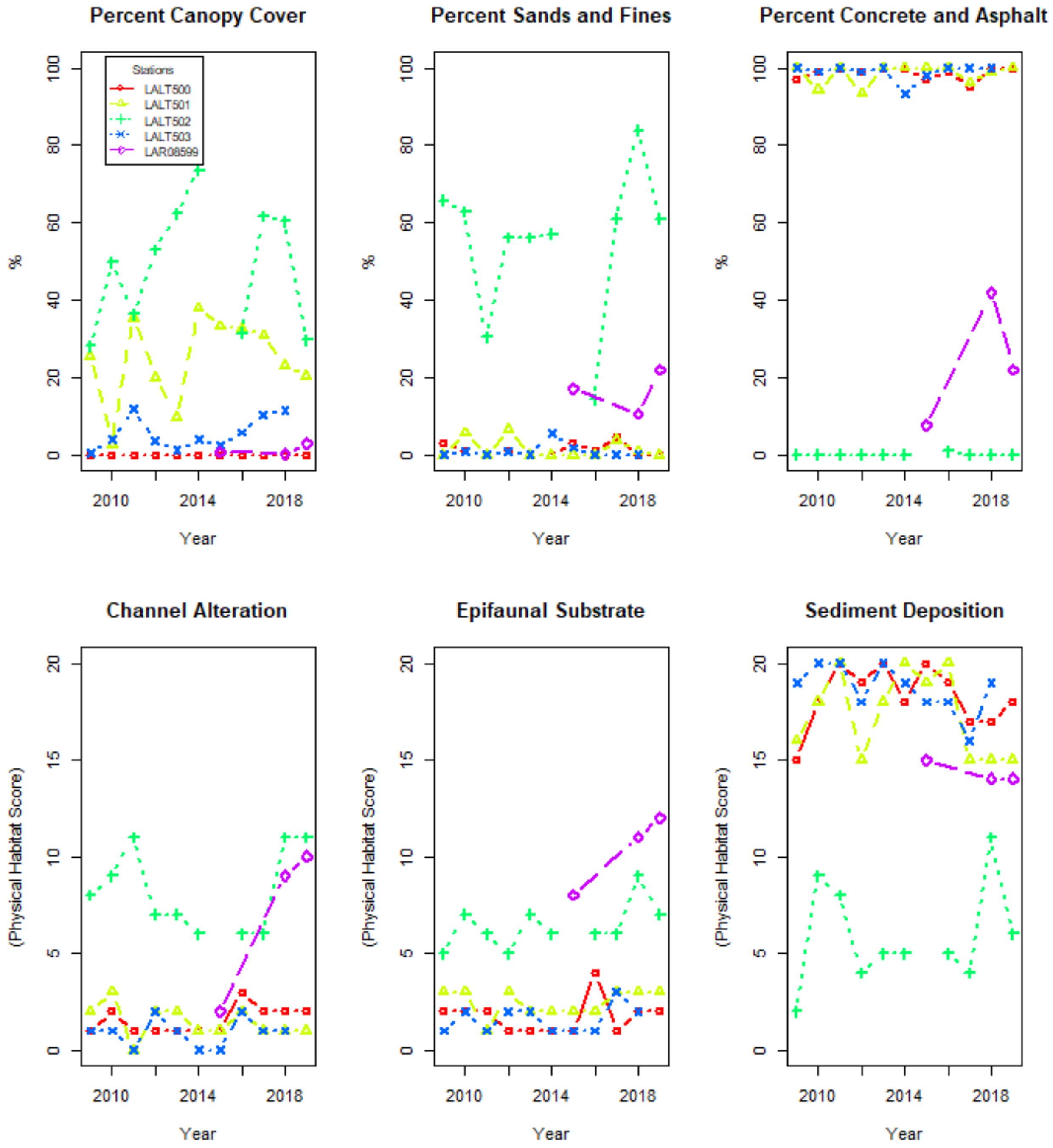

Figure 22. Physical habitat at confluence sites sampled annually from 2009 to 2019 (Red = LALT500; Yellow= LALT501; Green = LAL502; Blue = LALT503; Purple = LAR08599).

3. Los Angeles River Estuary

LARWMP monitored sediment at the LA River estuary to ensure sediment quality was suitable for aquatic life and was 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). Sediment chemistry testing included the suite of metals and organic constituents specified in the Sediment Quality Objectives (SQO) program (Bay *et al*., 2014) and toxicity testing. From 2009 to 2016, component scores varied from year to year as storms, scouring, and sediment deposition altered sediment quality. For the years when integrated scores could be calculated, EST2 ranked from 'unimpacted' to 'clearly impacted'.

The LARWMP program discontinued monitoring activities at the Los Angeles River Estuary in 2018. However, these data are collected and reported by the Long Beach Nearshore Watershed WMP/EWMP group and are publicly available. Reporting from the Long Beach Nearshore Watershed Group notes that the Los Angeles River Estuary is meeting protective conditions as described in compliance frameworks for the Harbor Toxics TMDL.

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 9). 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.

Since sampling began, most of the CRAM scores at the lower watershed sites (prefix LALT) have fallen below the 10th percentile of the reference distribution of sites throughout California, indicating they are 'likely altered'. 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. These sites include the Tujunga Wash (LALT401), Arroyo Seco USGS Gage site (LALT450), and Haines Creek Pools and Stream (LALT407).

The best riparian zone conditions have been found consistently at sites located in the upper watershed (prefix LAUT). However, the 2009 Station Fire created the opportunity for the LARWMP program to better understand the impact of fire to riparian habitats and recovery. Upper watershed sites that burned included LAUT401, LAUT402, and LAUT403—located in the Tujunga Sensitive Habitat, Upper Arroyo Seco, and Alder Creek.

Sites assessed for riparian habitat condition in 2019 included Alder Creek (LAUT 403), Tujunga Sensitive Habitat (LAUT 401), and Sepulveda Basin (LALT 405) sites. Figure 23 shows the individual CRAM scores from these sites for the period of 2009 to 2019. Habitat conditions at the two burn sites, Alder Creek and Tujunga Sensitive Habitat site, have improved since the sites burned in 2009. CRAM scores at the sites are more or less stable, they have varied by less than 5 points since they were previously sampled, and are well above the 10th percentile of the reference distribution. The Sepulveda Basin site is in degraded condition but the scores at this site have been stable since their decline in 2014.

The impact of fire on riparian systems vary 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 9. 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

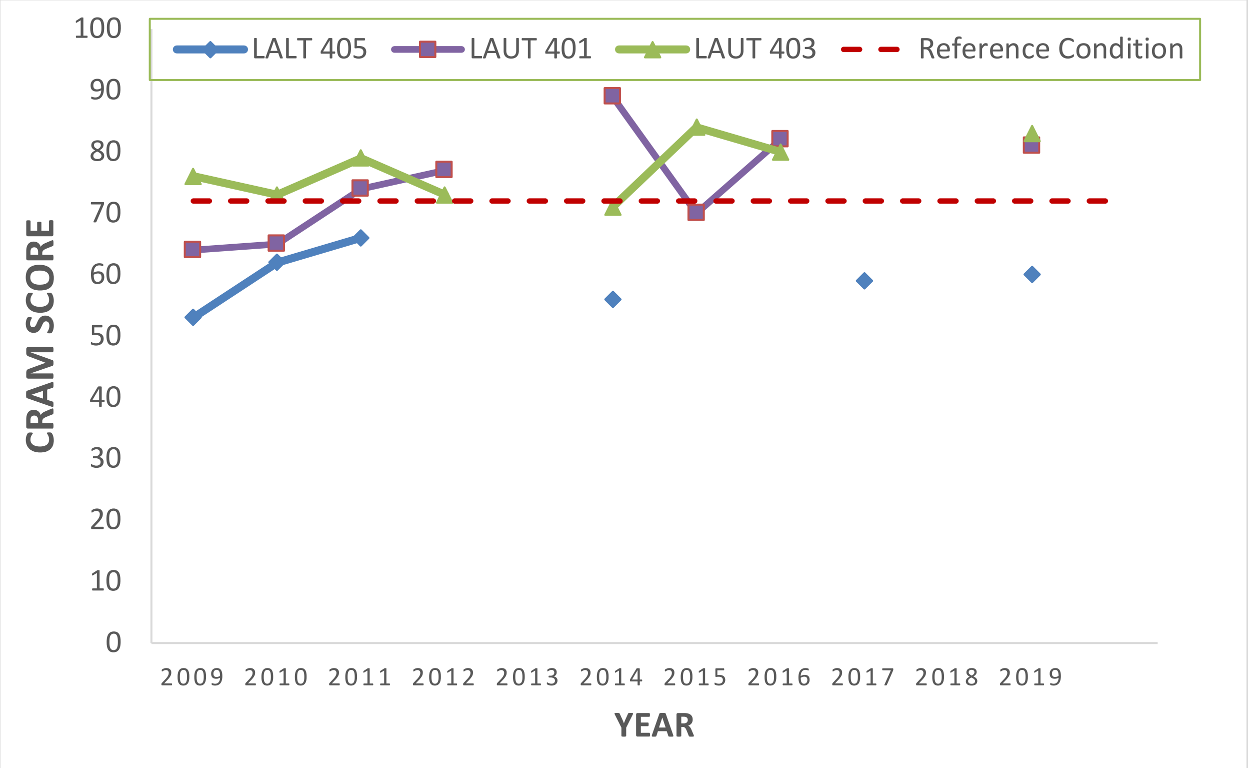

Figure 23. Riparian zone condition (CRAM scores) at select high-value sites from 2009-2019. The red horizontal line represents the 10th percentile of the reference distribution of sites in California. Scores below this line represent 'likely altered' habitat.

5. Los Angeles River Estuary Bacteria

Starting 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. The Long Beach Nearshore report notes that during 2018 dry weather sampling, the estuary exceeded the enterococci water quality objective.

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 potentially 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 2019 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 10 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 11).

Table 10. 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	RSW-002U	RSW-002D

Table 11. **Water Quality Objectives for nutrients in the Los Angeles Regional Water Quality Control Board Basin Plan and plan amendments, updated in May 2019. Ammonia (NH_3) objectives are based on the average pH of each discharge site in 2019.**

	Nitrate Nitrogen (mg/L)	Nitrite Nitrogen (mg/L)	Ammonia Nitrogen (mg/L)
DCTWRP	10	1	4.7
LAGWRP	10	1	14.4
BWRP	10	1	3.2

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

6. 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 statistical threshold value (STV) water quality objective of 320 MPN/100mL for REC-1 beneficial use was attained for approximately 85% of upstream samples and 60% of the downstream samples during the 2019 sampling year. However, effluent data from DCTWRP showed that *E. coli* concentrations were less than 1 MPN/100mL on all occasions. The increase in *E. coli* downstream of the POTW discharge is most likely due to urban runoff or in channel activities and not due to the DCTWRP facility.

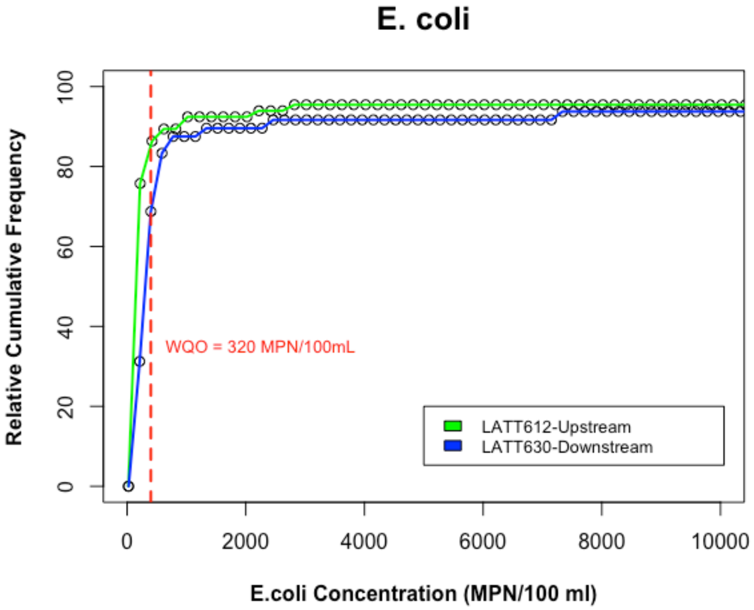

Figure 25. Cumulative frequency distributions of *E. coli* concentrations above and below the DCTWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

Table 12 and Table 13 shows the range in nutrient concentrations observed at a site upstream and downstream of DCTWRP discharge. Nitrate, nitrite, and ammonia were tested weekly. Organic and total nitrogen were tested one to two times a month. Upstream and downstream nutrient concentrations at DCTWRP did not exceed 30-day average regulatory thresholds. The range in nitrite, ammonia, and total nitrogen concentrations downstream of POTWs are larger (with the exception of a slight decrease in maximum total nitrogen) when compared to 2009-2019 summary statistics for all random sites (Table 7). While under the regulatory thresholds, the concentrations for nitrate, nitrite, organic nitrogen, and total nitrogen increased downstream of DCTWRP.

Table 12. Range of nutrient concentrations upstream of DCTWRP discharge in 2019.

	Nitrate Nitrogen (mg/L) (n= 53)	Nitrite Nitrogen (mg/L) (n= 53)	Ammonia Nitrogen (mg/L) (n= 53)	Organic Nitrogen (mg/L) (n= 12)	Total Nitrogen (mg/L) (n= 12)
MIN	0.03	0.03	0.03	0.60	2.90
MAX	3.63	0.39	0.62	1,5	4.60
MEAN	2.26	0.06	1.19	1.16	3.58

Table 13. Range of nutrient concentrations downstream of DCTWRP discharge in 2019.

	Nitrate Nitrogen (mg/L) (n= 53)	Nitrite Nitrogen (mg/L) (n= 53)	Ammonia Nitrogen (mg/L) (n= 53)	Organic Nitrogen (mg/L) (n= 12)	Total Nitrogen (mg/L) (n= 12)
MIN	2.4	0.1	0.3	1.1	4.3
MAX	5.9	0.4	1.3	2.4	7.7
MEAN	4.41	0.16	0.41	1.52	6.37

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 (ug/L)	Site	2/20/19	8/13/19
Bromodichloromethane	LATT630	0.63	ND
Bromoform	LATT630	ND	ND
Chloroform	LATT630	2.52	0.27
Dibromochloromethane	LATT630	0.16	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. The Water Effects Ratio (WER) for copper at Tillman was equal to 1. 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 arsenic, zinc, lead, and cadmium were below both chronic and acute CTR criteria. Copper exceeded the chronic threshold on one of the four sampling occasions downstream of POTW discharge points. Selenium concentrations upstream of the discharge exceeded the CTR chronic threshold on all four occasions and in one downstream sample.

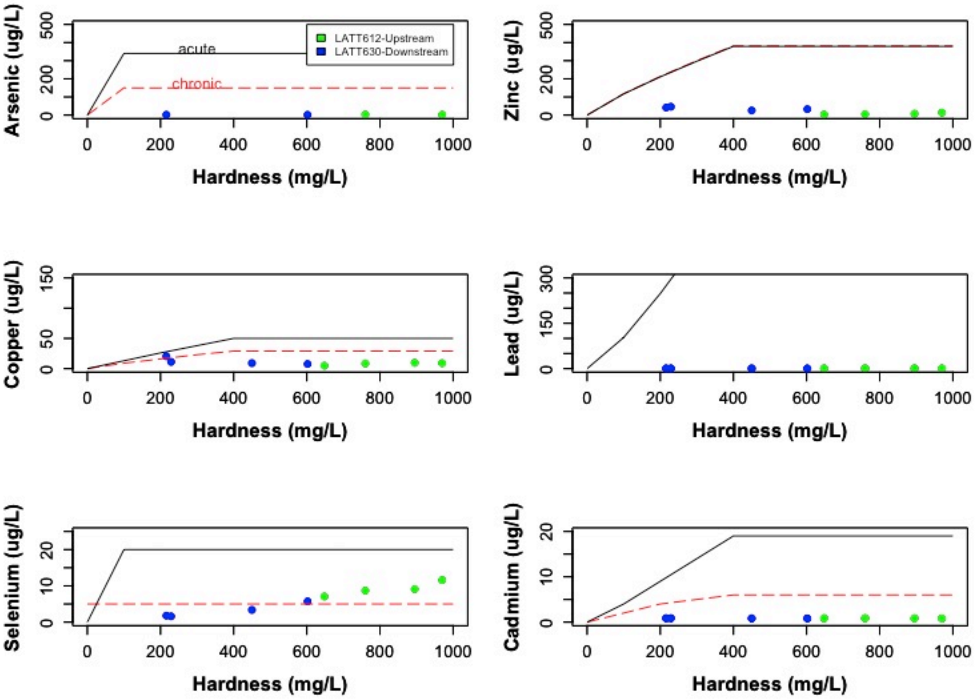

Figure 26. Converted dissolved metals concentrations above and below the DCTWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Black lines indicate acute CTR thresholds and red line indicates chronic CTR thresholds. Data includes estimated values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

7. 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 40% of the *E. coli* samples met the WQO at the upstream site, while approximately 85% 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.

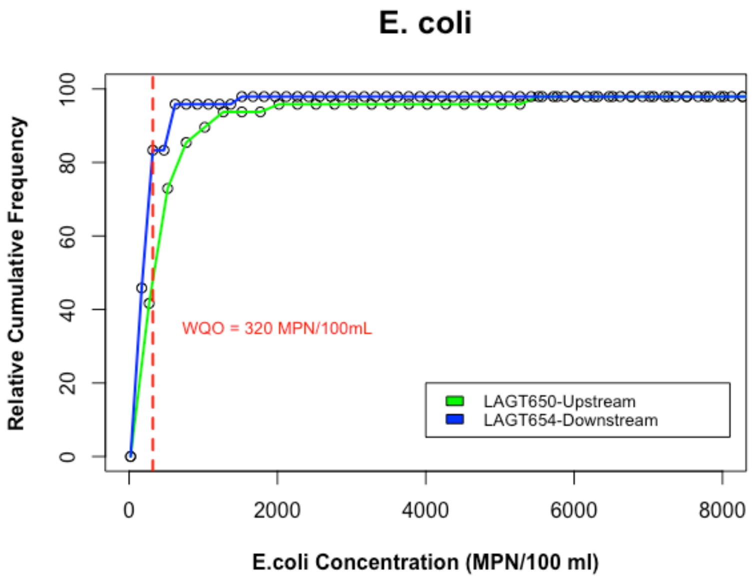

Figure 27. Cumulative frequency distribution of *E. coli* above and below the LAGWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

Table 15 and Table 16 shows the range in nutrient concentration measured above and below the LAGWRP discharge. Nitrate, nitrite, and ammonia were tested weekly. Organic and total nitrogen were tested one to two times a month. Most of the nitrogen downstream of the POTW was in the form of nitrate-nitrogen. Nutrient concentrations were below regulatory thresholds. Average concentrations for ammonia and organic nitrogen increased downstream of LAGWRP. The range in nutrient concentrations downstream of LAGWRP in 2019, for nitrite, ammonia, and total nitrogen, were larger when compared to 2009-2019 summary statistics for all random sites (Table 7).

Table 15. Range of nutrient concentrations upstream of LAGWRP discharge in 2019

	Nitrate Nitrogen (mg/L) (n= 53)	Nitrite Nitrogen (mg/L) (n= 53)	Ammonia Nitrogen (mg/L) (n= 53)	Organic Nitrogen (mg/L) (n= 12)	Total Nitrogen (mg/L) (n= 12)
MIN	1.43	0.10	0.12	0.60	3.10
MAX	6.78	0.72	0.98	1.90	9.60
MEAN	4.53	0.25	0.45	1.44	6.55

Table 16. Range of nutrient concentrations downstream of LAGWRP discharge in 2019

	Nitrate Nitrogen (mg/L) (n= 53)	Nitrite Nitrogen (mg/L) (n= 53)	Ammonia Nitrogen (mg/L) (n= 53)	Organic Nitrogen (mg/L) (n= 12)	Total Nitrogen (mg/L) (n= 12)
MIN	1.42	0.1	0.12	0.7	2.8
MAX	6.35	0.68	1	1.9	9.1
MEAN	4.25	0.22	0.49	1.48	6.26

Total recoverable metals were measured both upstream and downstream of the LAGWRP discharge (Figure 28). Concentrations for each metal were below the CTR thresholds for both upstream and downstream sites on all four occasions. The copper WER ratio for reach 3 of the River, where LAGWRP is located, is 3.97 and CTR criteria are adjusted accordingly. All metal concentrations were below the WER adjusted CTR thresholds both upstream and downstream of the wastewater outfalls. Treated wastewater from LAGWRP is not causing elevated concentrations of metals downstream.

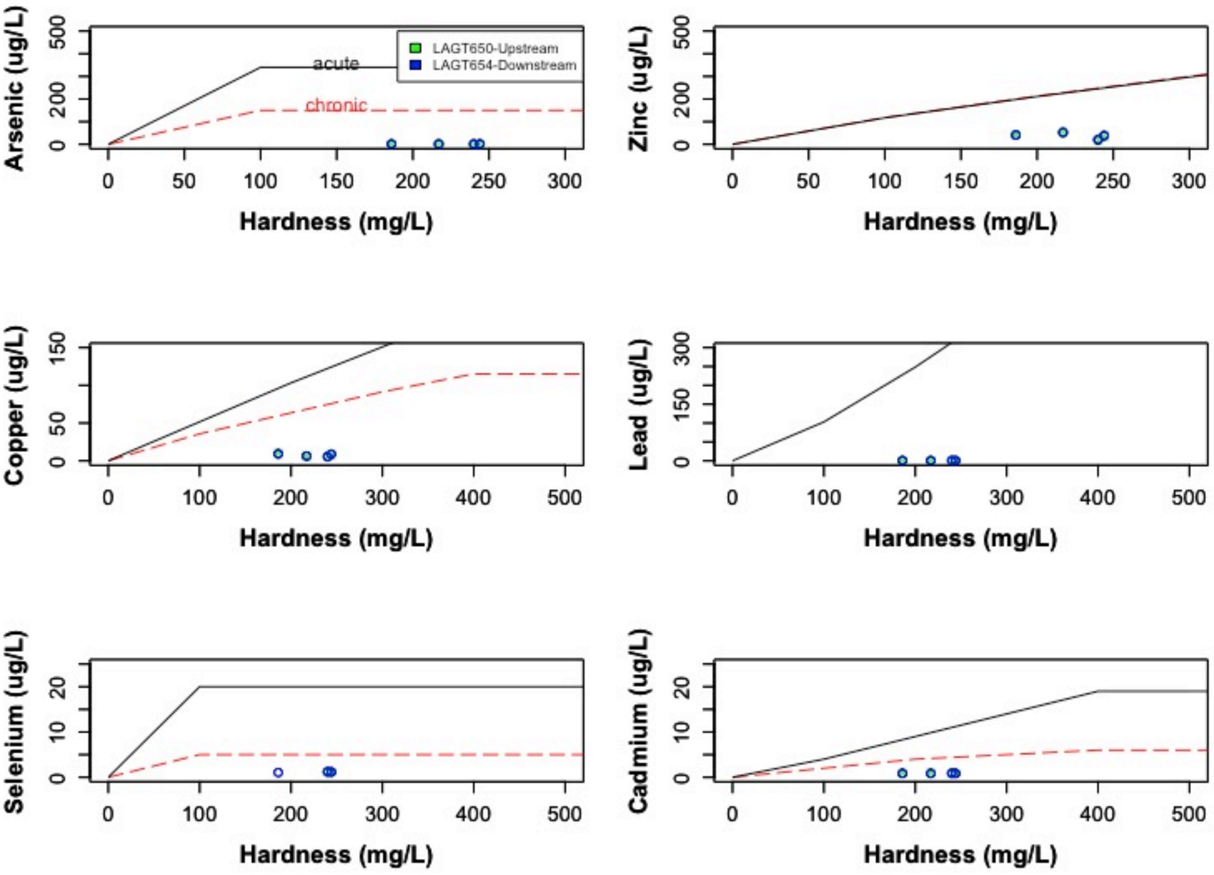

Figure 28. Converted dissolved metals concentrations above and below the LAGWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Downstream and upstream concentrations are close in value, as a result is may be difficult to see both green and blue dots on the graph. Black lines indicate acute CTR thresholds and redlines indicate chronic CTR thresholds. CTR criteria is adjusted with the site specific WER. Data 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 17).

Table 17. Concentrations of trihalomethanes below the LAGWRP discharge (LAGT654).

Trihalomethanes (ug/L)	Site	2/20/19	8/13/19
Bromodichloromethane	LAGT654	0.38	ND
Bromoform	LAGT654	ND	ND
Chloroform	LAGT654	1.64	0.23
Dibromochloromethane	LAGT654	ND	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).

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 25% of upstream samples met the WQO, while approximately 10% of the downstream samples met the WQO. However, effluent data from BWRP showed that *E. coli* concentrations were less than 1 MPN/100mL on all occasions. The increase in *E. coli* exceedances downstream of the BWRP outfall is likely not due to the BWRP facility.

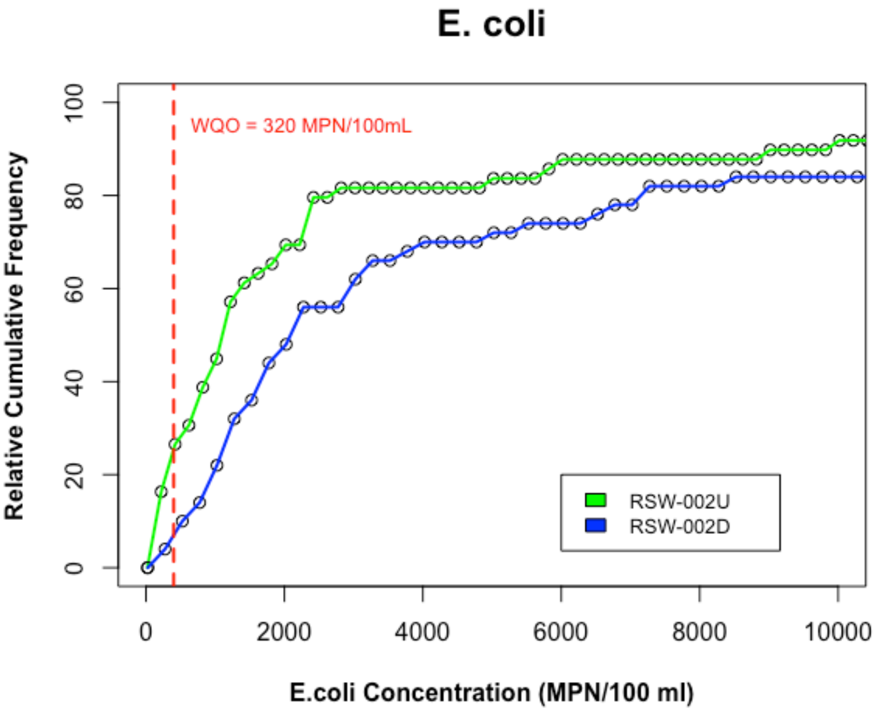

Figure 29. Cumulative frequency distributions for *E. coli* above and below the BWRP discharge. The single-sample WQO is denoted by the vertical dashed red line.

Table 18 and Table 19 shows the range in nutrient concentration measured above and below the BWRP discharge. Nutrients were measured approximately every week. The majority of measured nitrogen was in the form of organic nitrogen. Average concentrations for nitrate, ammonia, and total nitrogen were higher downstream. However, for upstream and downstream samples, no water quality objectives were exceeded.

Table 18. Range of concentrations of nitrogenous compounds upstream of the BWRP discharge point (RSW-002U) in 2019.

	Nitrate Nitrogen (mg/L) (n= 50)	Nitrite Nitrogen (mg/L) (n= 50)	Ammonia Nitrogen (mg/L) (n= 39)	Organic Nitrogen (mg/L) (n= 50)	Total Nitrogen (mg/L) (n= 50)
MIN	0.41	0.01	0.03	0.39	1.2
MAX	9.2	0.64	4	12	24
MEAN	3.26	0.23	0.51	1.93	5.71

Table 19. Range of concentrations of nitrogenous compounds downstream of the BWRP discharge point (RSW-002D) in 2019.

	Nitrate Nitrogen (mg/L) (n= 50)	Nitrite Nitrogen (mg/L) (n= 50)	Ammonia Nitrogen (mg/L) (n= 39)	Organic Nitrogen (mg/L) (n= 50)	Total Nitrogen (mg/L) (n= 50)
MIN	1.4	0.01	0.55	0.1	3.5
MAX	9.6	0.45	4.5	10	22
MEAN	4.12	0.2	1.81	1.7	6.62

Figure 30 shows the hardness adjusted dissolved metal concentrations compared to their CTR chronic and acute standards. The copper WER for this reach of the Burbank Channel is 4.75 and CTR criteria were adjusted accordingly. Metal concentrations were below the CTR chronic and acute standards for all metals, on all occasions. Wastewater discharge from Burbank is not causing metal exceedances in this reach of the River.

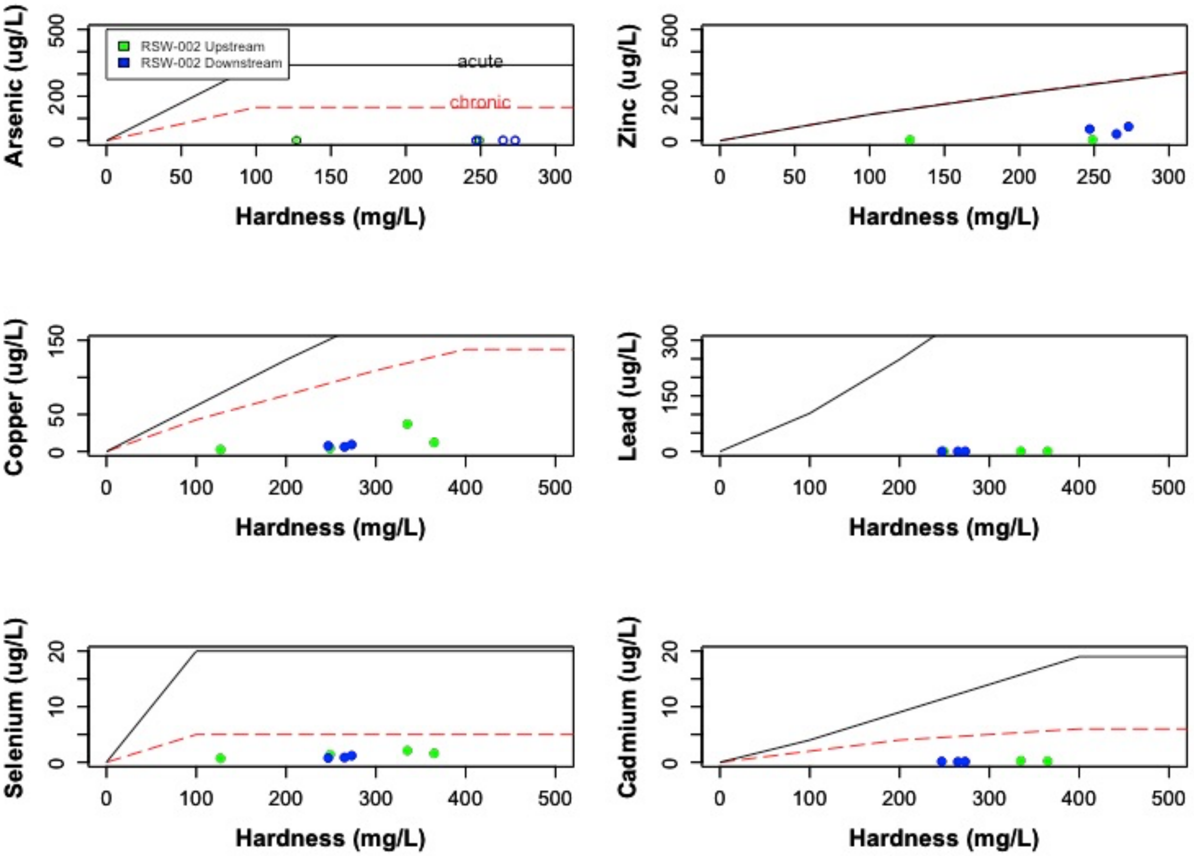

Figure 30. Dissolved metals concentrations above and below the BWRP discharge compared to hardness-adjusted, total recoverable CTR thresholds for acute and chronic effects. Only copper has a reach specific WER and CTR criteria are adjusted. Black lines indicate acute thresholds and red lines indicate chronic thresholds. Estimated values for low concentrations that exceeded the method detection limit but did not meet the laboratory's reporting limit are included.

Trihalomethanes were not detected above the discharge location (RSW-002U) or below the discharge location (RSW-002D) on February 7, 2019. They were detected below the discharge location (RSW-002D) on August 1, 2019, but the concentration was well below the EPA water quality objective 80 ug/L (Table 20).

Table 20. Trihalomethane concentrations above (RSW-002U) and below (RSW-002D) the BWRP discharge.

	Site	2/7/19	8/1/19
Total Trihalomethanes (ug/L)	RSW-002U	ND	ND
Total Trihalomethanes (ug/L)	RSW-002D	ND	1.3

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).

Question 4: Is it safe to recreate?

1. Background

Thousands of people 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 both permitted and informal 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). Until methods improve and become cost-effective, the safe to recreate effort within the LARWMP will continue to measure FIB at recreational sites in the watershed.

2. Methods

LARWMP's bacteria-monitoring program samples for *E. coli* five times a month at each recreational swim site during the summer (Memorial Day to Labor Day) (Figure 31 and Table 21). The kayak sites are monitored from Memorial Day through September. 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 deploy during the morning and collect grab samples at recreational sites. Observational data are also recorded at each site including information on flow habitats, number of visitors and swimmers, animals present, wind direction, and site refuse. Handheld 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 and LREC-1 standards (LARWQCB 2014) (

Table **22**, Table 23).

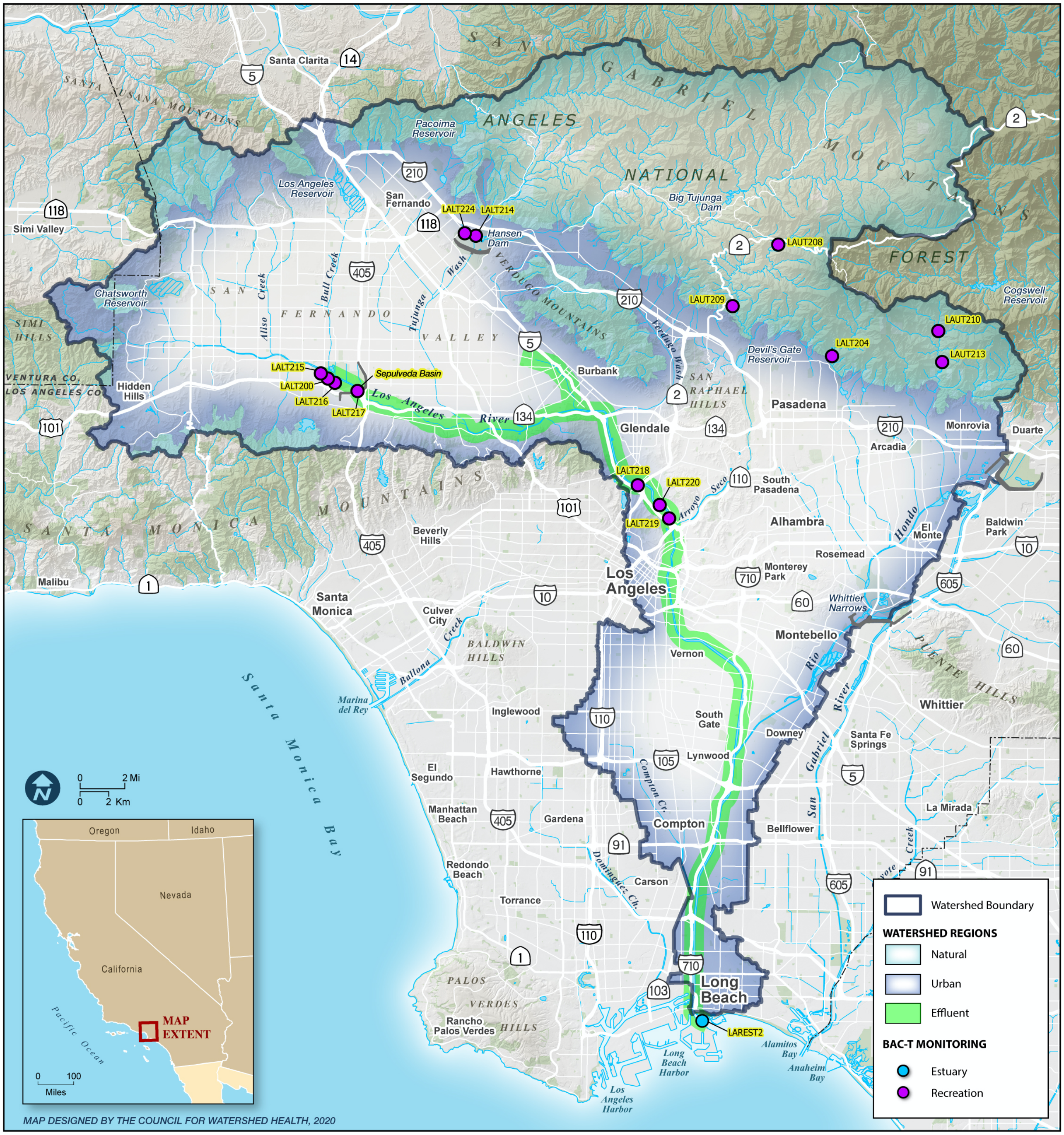

Figure 31. Recreational swim site locations in 2019.

Table 21. Sampling locations and site codes for indicator bacteria.

Program Element	Sampling Sites	Site Code
Recreational Swim Sites	Hansen Dam Recreation Lake	LALT224
	Bull Creek Sepulveda Basin	LALT200
	Eaton Canyon Natural Area Park	LALT204
	Tujunga Wash at Hansen Dam	LALT214
	Switzer Falls	LAUT208
	Gould Mesa Campground	LAUT209
	Sturtevant Falls	LAUT210
	Hermit Falls	LAUT213
Recreational Kayak Sites	Upper Sepulveda Basin Zone	LALT215
	Middle Sepulveda Basin Zone	LALT216
	Lower Sepulveda Basin Zone	LALT217
	Upper Elysian Valley Zone	LALT218
	Middle Elysian Valley Zone	LALT220
	Lower Elysian Valley Zone	LALT219

Table 22. Indicator bacteria REC-1 standards for freshwaters.

Indicator	Statistical Threshold Value	Six Week Rolling Geometric Mean
E. coli	320 MPN/100 mL	100 MPN/100 mL

Table 23. Indicator bacteria LREC-1 standards for freshwaters.

Indicator	Single Sample Maximum Value	30 Day Geometric Mean
E. coli	576 MPN/100 mL	126 MPN/100 mL

The State of California describes REC-1 (LARWQCB 2020) as they apply to recreational activities where ingestion is reasonably possible and LREC-1 standards as they apply to activities where ingestion is infrequent. A standard making use of the geometric mean can be applied to both beneficial uses and provides an indication of how persistent elevated bacterial concentrations are at a site, accounting for the high temporal variability in concentrations. Recent updates to the basin plan required a 6-week rolling geometric mean be applied at REC-1 sites and statistical threshold value applied to single samples. LREC-1 standards consist of a single sample and geometric mean-based limits. The single sample and geometric mean LREC-1 standards were applied to kayak sites since recreators have limited water contact when kayaking. REC-1 standards were applied to swim sites. In order to apply the geometric mean, at least 5 samples per month are required. During the summer survey in 2019, 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 select sites.

3. Results

During the summer of 2019, a total of 156 water samples were successfully collected from nine recreational swim sites popular with visitors and residents of the LA River watershed. The concentrations of *E. coli* were compared to water quality objectives described in the basin plan for full contact and limited contact recreation. Despite an update to water quality objectives in the Basin Plan, the REC-1 single sample maximum (235 MPN/100mL) was used to show exceedances across sites so as to be comparable to previous years (Table 24). Of the 156 samples, 23 exceeded the REC-1 standards (15%), a decrease from the previous year (21%). The greatest frequency of single sample exceedances occurred at Tujunga Wash at the Hansen Dam Rec Area (45%), followed by Eaton Canyon (25%), and Bull Creek Sepulveda Basin (25%).

Since LARWMP's sampling period aims to capture the occasions when the greatest numbers of people are swimming, a two-tailed t-test of equal variance was used to investigate the relationship between bacteria levels and days with expected higher usage (weekdays vs. weekends/ holidays). No significant pattern between elevated bacteria concentrations and high use days ($p > 0.05$).

Table 24. Single sample *E. coli* concentrations (MPN/100 mL) at recreational swim sites in the Los Angeles River Watershed from May through September 2019 (<10 MPN/100 mL = non-detect). NS indicates the site was not sampled on that date. For the sake of comparison, the REC-1 Single Sample Maximum (235 MPN/100mL) was used to compare the number of exceedances across sites, like in previous year.

Location	5/27/19	5/28/19	5/31/19	6/5/19	6/8/19	6/14/19	6/16/19	6/22/19	7/4/19	7/5/19	7/16/19	7/27/19	7/29/19	8/4/19	8/13/19	8/17/19	8/22/19	8/25/19	9/1/19	9/2/19	# Exceedance REC 1 Std.	n	% Exceedance REC 1 Std.
Bull Creek	683	120	31	218	110	201	181	145	122	189	122	110	134	480	246	480	132	187	243	158	5	20	25
Eaton Canyon	5790	63	120	31	98	10	97	620	332	30	75	195	109	265	187	161	52	75	201	3080	5	20	25
Switzer Falls	10	10	<10	41	10	10	20	10	10	20	20	98	<10	10	10	98	10	63	20	683	1	20	5
Gould Mesa	NS	10	10	20	41	20	<10	41	<10	10	10	52	52	<10	<10	<10	<10	<10	<10	10	0	19	0
Sturtevant Falls	10	41	171	63	98	84	20	NS	148	41	10	98	20	20	63	63	31	NS	315	75	1	18	5
Hermit Falls	121	41	10	31	86	20	331	NS	20	20	31	<10	373	109	20	20	75	20	135	31	2	19	38
Tujunga Wash at Hansen Dam R	292	457	10	52	41	122	175	85	228	63	195	521	259	345	231	228	345	272	573	4880	9	20	45
Hansen Dam Recreation Lake	10	31	52	<10	10	10	73	<10	<10	<10	<10	<10	<10	<10	<10	10	<10	<10	<10	<10	0	20	0
# Exceedance REC 1 Std.	3	1	0	0	0	0	1	1	1	0	0	1	2	3	1	1	1	1	3	3	**23**		
n	7	8	8	8	8	8	8	6	8	8	8	8	8	8	8	8	8	7	8	8		**156**	
% Exceedance REC 1 Std.	42	13	0	0	0	0	13	17	13	0	0	13	25	38	13	13	13	14	38	38			**15**
Holiday																							
Weekday																							
Weekend																							

Table 25. The percentage of exceedances at recreational swim sites in the Los Angeles River Watershed for each calendar month of the recreation season. Red-shaded cells indicate that more than the allowed 10% of samples collected per month for each site, exceeded the statistical threshold value standard.

	June	n =	July	n =	August	n =	# of Exceedances of the STV standard
Bull Creek	0	5	0	5	40%	5	1
Eaton Canyon	20%	5	20%	5	0	5	2
Switzer Falls	0	5	0	5	0	5	0
Gould Mesa	0	5	0	5	0	5	0
Sturtevant Falls	0	4	0	5	0	4	0
Hermit Falls	25%	4	20%	5	0	5	2
Tujunga Wash at Hansen Dam Rec	0	5	20%	5	40%	5	2
Hansen Dam Recreation Lake	0	5	0	5	0	5	0

Table 25 shows the percentage of samples that exceeded the Statistical Threshold Value (STV; updated water quality objective) at each site monthly. The WQO allows 10% of samples to exceed the STV in a calendar month. Samples at Eaton Canyon and Hermit Falls exceeded the STV in June and July (20% each). Tujunga Wash at Hansen Dam Recreational Area also exceeded the allowance twice, in July (20%) and August (40%). Tujunga Wash and Bull Creek in the Sepulveda Basin had the highest percentage of exceedances across all sites, both occurred in August (40%).

Table 26 shows the percentage of samples that exceed the 6-week rolling geometric mean REC-1 standard. Bull Creek at Sepulveda Basin had the highest number of exceedances (100%), followed by Eaton Canyon and Tujunga Wash at Hansen Dam (80%). Switzer Falls, Gould Mesa Campground, Sturtevant Falls, Hermit Falls, and Hansen Dam Recreation Lake did not exceed the geometric mean standard during the sampling period, indicating that elevated *E. coli* concentrations are not persistent at these five sites.

During the 2019 recreation season, a total of 226 samples were collected from kayak zones in the Sepulveda Basin Recreation Zone and the Elysian Valley Recreation Zone (Table 27). Samples are compared to single sample maximum LREC-1 standards due to limited water contact during boating. Of the samples collected, the Upper Elysian Valley had the most exceedances (18%), followed by the Lower Sepulveda Basin Zone (11%). The Upper Elysian Valley exceeded the 30-day geometric mean LREC-1 standards (126 MPN/ 100 mL) in June, July, and August (

Table 28).

Table 26. Six-week rolling geometric mean *E. coli* concentrations (MPN/100 mL) at recreational swim sites in the Los Angeles River Watershed in 2019 (REC-1 Standards).

	5/26/19 - 7/6/19	6/2/19 - 7/13/19	6/9/19 - 7/20/19	6/16/19 - 7/27/19	6/23/19- 8/3/19	6/30/19 - 8/10/19	7/7/19 - 8/17/19	7/14/19 - 8/24/19	7/21/19 - 8/31/19	7/28/19- 9/7/19	# Exceedances of 6-Week Average	n	% Exceedance REC 1 Std
Location	Week 1-6	Week 2-7	Week 3-8	Week 4-9	Week 5-10	Week 6-11	Week 7-12	Week 8-13	Week 9-14	Week 10-15			
Bull Creek Sepulveda Basin	154	162	157	142	133	165	216	201	214	228	10	10	100
Eaton Canyon Natural Area Park	123	78	88	144	110	127	153	131	131	195	8	10	80
Switzer Falls	14	15	14	21	25	21	29	24	29	36	0	10	0
Gould Mesa Campground	18	23	17	21	23	23	30	30	52	23	0	10	0
Sturtevant Falls	55	63	40	41	41	37	34	34	41	53	0	10	0
Hermit Falls	41	44	38	45	46	55	55	58	54	56	0	10	0
Tujunga Wash at Hansen Dam	91	92	131	167	207	225	280	288	302	433	8	10	80
Hansen Dam Recreation Lake	17	19	27	73	10	10	10	10	10	10	0	10	0
# Exceedances of 6-Week Average	2	1	2	3	3	3	3	3	3	3	**26**		
n	8	8	8	8	8	8	8	8	8	8		**80**	
% Exceedance REC 1 Std.	25	13	25	38	38	38	38	38	38	38			**33**

Table 27. Single sample *E. coli* concentrations (MPN/100 mL) at recreational kayak sites in the Los Angeles River Watershed from May through September 2019. NS indicates the site was not sampled on that date (576 MPN/ 100mL LREC-1 Standards).

Location	# of Exceedances	n	% Exceedance
Sepulveda Basin Recreation Zone			
Upper Kayak Zone	3	37	8
Middle Kayak Zone	2	38	5
Lower Kayak Zone	4	38	11
Elysian Valley Recreation Zone			
Upper Kayak Zone	7	38	18
Middle Kayak Zone	2	38	5
Lower Kayak Zone	1	37	3
# Exceedance LREC 1 Std.	**19**		
n		**226**	
% Exceedance LREC 1 Std.			**8**

Table 28. 30-day geometric mean of *E. coli* concentrations (MPN/100 mL) at kayak zones in the Sepulveda Basin Recreation Zone and Elysian Valley Recreation Zone (LREC-1 Standards).

Location	June (n =8)	July (n = 9)	August (n = 9)	September (n = 8)	# Exceedances of 30 day Average
Sepulveda Basin Recreation Zone					
Upper Kayak Zone	50	49	82	56	0
Middle Kayak Zone	106	82	145	148	2
Lower Kayak Zone	115	75	94	89	0
Elysian Valley Recreation Zone					
Upper Kayak Zone	541	305	145	115	3
Middle Kayak Zone	145	51	61	49	1
Lower Kayak Zone	131	77	69	105	1

Table 29. Site usage summary for recreational swim sites sampled in 2019.

Monitored Swim Site	Average Number of People on Shore	Average Number of Animals	Average Number of Bathers
Bull Creek Sepulveda Basin	0.84	2.00	0
Eaton Canyon Natural Area Park	13.45	3.90	3
Gould Mesa Campground	1.26	0	0.21
Tujunga Wash at Hansen Dam Rec Area	2.70	1.50	0.42
Hansen Dam Recreation Lake	9.45	1.00	0.00
Hermit Falls	3.05	0.37	0.53
Sturtevant Falls	26.33	1.78	2.67
Switzer Canyon	1.25	0	0.0

Based on the two-tailed t-test described in the methods, there was no significant relationship between bacteria exceedances and days with expected high use (weekends/holidays). Additionally, there was also no significant relationship between site metrics (visitor counts, animal counts) and the number of exceedances (Table 29). For example, there were weak relationships between FIB concentrations and the number of people on shore (r =0.072), the number of animals (r =0.270), and the number of bathers (r = 0.202) (Table 30), as indicated by the low Spearman's rank correlation coefficients. Despite Sturtevant Falls having the highest number of people and animals on shore during the sampling period, Sturtevant did not exceed any REC-1 standards (Table 26 and

Table 29). In contrast, Bull Creek at Sepulveda Basin had the least number of visitors on shore but 100% of samples exceeded the rolling geometric mean standards (Table 26). This may be due to homeless encampments upstream of Bull Creek or the increased amount of urban runoff at this site. Despite Sturtevant Falls and Eaton Canyon having the most people and animals on shore (

Table 29), Sturtevant had no exceedances, and both sites had fewer exceedances than Tujunga Wash at Hansen Dam Rec Area, sites where few people or animals were noted. It is important to note that many sites are sampled in the morning, prior to the arrival of large crowds and bacteria concentrations may reflect usage patterns of the previous day. The monitoring program attempts to account for this by scheduling sampling on holidays and the days after a major holiday.

Two observational variables correlated with *E. coli* concentrations across sites, including pH ($r = -0.465$) and turbidity ($r = 0.446$) (Table 30). These correlations were weak but statistically significant ($p<0.05$). Bacteria face multiple stressors once outside a host, such as 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). Sediments and vegetation can also 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). Patchy bacteria distributions can make it difficult to detect relationships between use patterns and environmental variables.

Table 30. Spearman correlation table analyzing relationship between *E. coli,* site usage, and in-situ measurements for all sites combined. Highlighted green values represent significant correlations ($r > 0.6$ or $r < -0.6$). Highlighted yellow values represent weak, but significant relationships ($r > 0.3$ or $r < -0.3$).

	Air Temperature	Water Temperature	Specific Conductivity	pH	Turbidity	Number of People On Shore	Number of Animals	Number of Bathers	Number of Fisherman	E. coli
Air Temperature										
Water Temperature	0.467									
Specific Conductivity	0.175	0.657								
pH	0.003	-0.066	-0.134							
Turbidity	-0.064	0.474	0.437	-0.313						
Number of People On Shore	0.039	0.049	-0.149	0.466	0.079					
Number of Animals	0.001	0.152	0.01	0.026	0.288	0.44				
Number of Bathers	0.172	-0.03	-0.253	0.179	0.032	0.552	0.389			
Number of Fisherman	**	**	**	**	**	**	**	**		
E. coli	-0.033	0.128	0.005	-0.465	0.446	0.072	0.27	0.202	**	

** There were not enough data points to determine the correlation coefficient for these two parameters

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 sites that are popular with the angler community. Data will provide watershed managers with the information necessary to educate the public about the safety of consuming the fish they catch.

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 the Office of Environmental Health Hazards (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 analyzed only the muscle tissue of the fish, which is common practice in regional regulatory programs. 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. The Sepulveda Basin, the site selected for sampling in 2019, is not restocked by California Department of Fish and Wildlife.

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 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 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 31 and Table 32). 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 2019 bioaccumulation survey.

Table 31. 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 32. 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 14 fish were successfully collected from Sepulveda Basin including, common carp (*Cyprinus carpio*), bluegill sunfish (*Lepomis macrochirus)*, and green sunfish (*Lepomis cyanellus*) (Figure 32). They were combined, by species, into four separate composites. On average, the largest fish captured in the lake was common carp (1400 g), while the smallest fish caught was green sunfish (37.5 g) (Table 33).

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).
- Green sunfish are opportunistic predators, feeding primarily on invertebrates and small fish. (Regents of University of California)

Table 33. Number, average standard weight, and length of the individual and composite fish samples collected in 2019.

Waterbody	Comp #	Sample Type	n	Species Name	Common Name	Avg. Weight (g)	Standard Length			Total Length		
							Avg. (mm)	Min (mm)	Max (mm)	Avg. (mm)	Min (mm)	Max (mm)
LA River, Sepulveda Basin	1	Consumption	3	*Cyprinus carpio*	common carp	1246.7	383	375	395	437	353	482
	2	Consumption	3	*Cyprinus carpio*	common carp	1400.0	347	322	375	448	415	478
	1	Consumption	4	*Lepomis macrochirus*	bluegill	60.0	100	92	105	126	112	134
	1	Consumption	4	*Lepomis cyanellus*	green sunfish	37.5	92	87	99	117	110	126

Total Fish **14**
Total Composites **4**

Of the four contaminants measured in each of the composites of fish tissue, none exceeded the OEHHA ATL thresholds. PCBs were not detected in any of the fish tissue composites (Table 34).

When compared to the OEHHA ATL thresholds for all contaminants, bluegill, common carp, and green sunfish from Sepulveda Basin were all safe to eat. Based on these thresholds, one should limit their consumption to three 8-oz servings a week.

Bluegill, green sunfish, and common carp are trophic level three fish (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 trophic position. While all fish in this study were found safe to eat three times a week (8-oz), size may explain why common carp had higher concentrations of contaminants than bluegill and green sunfish.

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.

Table 34. Sport fish consumption chemistry results: concentration of contaminants in fish tissues relative to the OEHHA ATL thresholds.

Fish Consumption
LA River, Sepulveda Basin - LALT314

Common Name	Comp. #	Mercury (ppb)	Selenium (ppb)	DDTs (ppb)	PCBs (ppb)
bluegill	1	13	740	14.8	ND
common carp	1	33	810	5.9	ND
common carp	2	29	940	12.3	ND
green sunfish	1	23	600	16.6	ND

🟩 Three 8-oz servings a week ATL
🟨 Two 8-oz servings a week ATL
🟧 One 8-oz serving a week ATL
🟪 No consumption ATL.

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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 2019 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 2019). 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, one lake, 10 randomly selected, and 4 targeted sites were sampled in 2019.

Freshwater targeted and random analysis completeness was 100% for general chemistry, nutrients, major ions, and bioassessment (Table A-1).

Percent completeness for bioaccumulation samples analyzing organochlorine pesticides was 100% in 2019. PCB's were 100% complete for 43 congeners. Due to missing standards, 24 PCB congeners were reported 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 2019, 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 2019 surveys, laboratory blanks for copper, iron, and zinc were 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 2019.

	2019					
			Number of Non-Detects (<MDL)			
Analyte	**Number of Sites**	**Completeness (%)**	**Effluent (n=3)**	**Natural (n=5)**	**Urban (n=6)**	**Total**
Genreal 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	2	0	2
Turbidity	14	100	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	1	1	2
Dissolved Organic Carbon	14	100	0	0	0	0
Nitrate as N	14	100	0	1	0	1
Nitrite as N	14	100	2	5	4	11
OrthoPhosphate as P	14	100	0	4	2	6
Phosphorus as P	14	100	0	0	0	0
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	1	4	5
Chromium	14	100	0	1	1	2
Copper	14	100	0	0	0	0
Iron	14	100	0	0	2	2
Lead	14	100	0	1	0	1
Mercury	14	100	3	5	5	13
Nickel	14	100	0	0	0	0
Selenium	14	100	0	3	0	3
Zinc	14	100	0	0	0	0
Bioassessment						
Benthic Macroinvertebrate ID	14	100	NA	NA	NA	NA
Algae ID	11	100	NA	NA	NA	NA

Table A-2 1 Percent completeness and non-detects for bioaccumulation samples collected in 2019.

Bioaccumulation	2019		
	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	3
DDE(p,p')	4	100	0
DDT(o,p')	4	100	4
DDT(p,p')	4	100	2
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 2019 (continued)

	2019		
Bioaccumulation	**Number of Samples**	**% Completeness**	**Number of Non-Detects (<MDL)**
PCBs			
PCB 003	4	0	NA
PCB 008	4	0	NA
PCB 018	4	100	4
PCB 027	4	0	NA
PCB 028	4	100	4
PCB 029	4	0	NA
PCB 031	4	0	NA
PCB 033	4	0	NA
PCB 037	4	100	4
PCB 044	4	100	4
PCB 049	4	100	4
PCB 052	4	100	4
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	4
PCB 070	4	100	4
PCB 074	4	100	4
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	4
PCB 105	4	100	4
PCB 110	4	100	4
PCB 114	4	100	4
PCB 118	4	100	4
PCB 119	4	100	4
PCB 123	4	100	4

Table A-2 3 Percent completeness and non-detects for bioaccumulation samples collected in 2019 (continued)

Bioaccumulation	2019		
	Number of Samples	% Completeness	Number of Non-Detects (<MDL)
PCB 126	4	100	4
PCB 128	4	100	4
PCB 128/167	4	100	4
PCB 137	4	0	NA
PCB 138	4	100	4
PCB 141	4	0	NA
PCB 146	4	0	NA
PCB 149	4	100	4
PCB 151	4	100	4
PCB 153	4	100	4
PCB 156	4	100	4
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	4
PCB 174	4	0	NA
PCB 177	4	100	4
PCB 180	4	100	4
PCB 183	4	100	4
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	4
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							
Arsenic	2019	LabBlank	3841	0.02	mg/L	0.02	0.02
Copper	2019	LabBlank	3896	0.11	mg/L	0.1	0.1
Iron	2019	LabBlank	3874	0.0078	mg/L	0.005	0.005
Iron	2019	LabBlank	3903	0.0061	mg/L	0.005	0.005
Zinc	2019	LabBlank	3896	2.92	mg/L	0.58	0.58

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

QAQC Table. Matrix spikes, matrix spike duplicates (MS), laboratory control samples, laboratory control sample duplicates (LCS), certified reference material (CRM), Laboratory Duplicates (Lab Dup), percent recovers (% R) and relative percent differences (RPD) that did not meet data quality objectives (DQO). Boldface 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
Metals (Samplewater)									
Total Iron	000NONPJ	6-Aug-19	3950	MS	75-125 %	**63**	113	**56**	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 2019.

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	SM 2130 B	NTU	0.3
Total Suspended Solids	SM 2540 D	mg/L	2
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
Metals (Dissolved)			
Arsenic	EAP 200.8	ug/L	1
Cadmium	EAP 200.8	ug/L	0.2
Chromium	EAP 200.8	ug/L	0.5
Copper	EAP 200.8	ug/L	0.5
Iron	EPA 200.7	ug/L	20
Lead	EAP 200.8	ug/L	0.5
Mercury	SM 3112 B or EPA 7470 A	ug/L	0.2
Nickel	EAP 200.8	ug/L	1
Selenium	EAP 200.8	ug/L	1

Zinc	EAP 200.8	ug/L	1
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	2
Total Dissolved Solids	SM 2540 C	mg/L	28
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 B	mg/L	0.5
Total Organic Carbon	SM 5310 B	mg/L	0.5
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	EPA 200.8 or 200.7	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	EPA 200.8 or 200.7	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	5
Lead	EPA 6010 B	mg/Kg dw	0.5
Mercury	EPA 7471 A	mg/Kg dw	0.02
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	20
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	0.5-20
Polychlorinated Biphenyl (PCBs)	EPA 8082	µg/Kg dw	0.2
Polynuclear Aromatic Hydrocarbons (PAHs)	EPA 8270C	ug/Kg dw	300-3300
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.	%	0.05
Metals			
Mercury	EPA 7471A	mg/kg ww	0.02
Selenium	EPA 6010B	mg/kg ww	1
Organics			
Organochlorine Pesticides (DDTs)	EPA 8081A	µg/kg ww	0.5
Polychlorinated Biphenyl (PCBs)	EPA 8082	µg/kg ww	0.5-20
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.