APPENDIX H

BIOASSESSMENT

2012 Bioassessment Monitoring Program in Los Angeles County

March 2013

Final Report

WESTON SOLUTIONS

Prepared for:
Los Angeles County Flood Control District
Watershed Management Division
900 South Fremont Avenue
Alhambra, California 91803-1331

2012
BIOASSESSMENT MONITORING PROGRAM IN LOS ANGELES COUNTY

Final Report

Prepared for:

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Watershed Management Division
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ACRONYMS AND ABBREVIATIONS

°C	degree Centigrade
°F	degree Fahrenheit
%	percent
ABL	Aquatic Bioassessment Laboratory
bioassessment	biological assessment
Bioassessment Program	biological assessments of various freshwater streams in five Los Angeles County watersheds
BMI	benthic macroinvertebrate
CDFG	California Department of Fish and Game
cm^2	square centimeter
County	Los Angeles County
CRAM	California Rapid Assessment Method
CSBP	California Stream Bioassessment Procedure
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FFG	functional feeding group
ft^2	square foot
GIS	Geographic Information System
IBI	Index of Biotic Integrity
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LARWMP	Los Angeles River Watershed-wide Monitoring Program
LASGRWC	Los Angeles and San Gabriel River Watershed Council
mg/L	milligram per liter
mh	macrophyte herbivore
mm	millimeter
MQO	minimum quality objective
MS4	Municipal Separate Storm Sewer System
mS/cm	millisiemen per centimeter
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
O/E	Observed taxa/Expected taxa
om	omnivore
pa	parasite
ph	piercer herbivore
Public Works	County of Los Angeles Department of Public Works
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
RWQCB	Los Angeles Regional Water Quality Control Board
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California Coastal Water Research Project

SGRRMP	San Gabriel River Regional Monitoring Program
SMBW	Santa Monica Bay Watershed
SMC	Stormwater Monitoring Coalition
SMC Program	Stormwater Monitoring Coalition Southern California Regional Watershed Monitoring Program
SOW	scope of work
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TV	tolerance value
USEPA	United States Environmental Protection Agency
WESTON®	Weston Solutions, Inc.
xy	xylophage/woodeater

EXECUTIVE SUMMARY

Background

Weston Solutions, Inc. (WESTON®) was contracted by the Los Angeles County Flood Control District (LACFCD) to perform biological assessments (bioassessments) of various freshwater streams in Los Angeles County (County) (Bioassessment Program). The Bioassessment Program is required for National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit compliance, (Board Order No. 01-182, NPDES Permit No. CAS004001), under the enforcement of the Los Angeles Regional Water QualityControl Board (RWQCB). The goals of this program are to assess biological integrity and to detect biological trends and responses to pollution in receiving waters throughout the County. To achieve these goals, the program focuses on the sampling and analysis of freshwater stream benthic macroinvertebrates (BMI). The program was initiated in October 2003 and monitoring surveys have been conducted annually since that time, for a total of ten surveys to date. Surveys were conducted in October 2003, October 2004, October 2005, July (San Gabriel River Watershed only) and October 2006, June (San Gabriel River Watershed only) and October 2007, November 2008, June 2009, June/July 2010, June/July 2011, and June 2012.

In the 2012 sampling year, the Bioassessment Program continued to incorporate three collaborative monitoring programs in addition to the basic NPDES Program. The three programs included the San Gabriel River Regional Monitoring Program (SGRRMP) which began in 2006, the Los Angeles River Watershed-Wide Monitoring Program (LARWMP) which began in 2008, and the Stormwater Monitoring Coalition (SMC) Southern California Regional Watershed Monitoring Program (SMC Program) which began in 2009.

Study Area and Monitoring Sites, 2012

The study area consisted of 20 stream monitoring sites within the five primary watersheds of the County. The watersheds and number of sites sampled in each were as follows:

- San Gabriel River Watershed: four sites.
- Los Angeles River Watershed: six sites.
- Dominguez Channel Watershed: one site.
- Santa Monica Bay Watershed including Malibu Creek Watershed and Ballona Creek Watershed: five sites.
- Santa Clara River Watershed: four sites.

From June 14, 2012 to June 28, 2012, 20 sites were sampled. Four of the monitoring reaches (SGUT-501–San Gabriel River, SGUT-504–San Gabriel River, 6–Arroyo Seco, and 17–Cold Creek) were considered reference sites because they were located in areas of minimal upstream urban development and runoff, and were in un-altered channels. Several of the SMC sites also were in likely reference condition, but were not sampled for that reason. Five of the other sites were located in concrete-lined channels: LALT500–Rio Hondo, LALT501–Arroyo Seco, LALT503–Tujunga Wash, 19–Dominguez Channel, and SMC18116–Lindero Canyon. The fifteen remaining sites were in unlined channels.

Methodology

Field sampling followed the standard protocols described in the Surface Water Ambient Monitoring Program (SWAMP) physical habitat assessment protocol (Ode, 2007). Organisms were identified to standard taxonomic Level II effort as specified in the *Southwest Association of Freshwater Invertebrate Taxonomists* (SAFIT) *List of Freshwater Invertebrate Taxa*. Data analysis included the calculation of standard community-based metric values and a Southern California Index of Biotic Integrity (IBI) (Ode et al., 2005). In addition to the SWAMP physical habitat assessment, the California Rapid Assessment Method (CRAM) for riverine wetlands was performed at the SMC sites. Additional analyses included a comparison of concrete-lined channels to unlined channels, comparison of IBI scores to site elevations, and Bray–Curtis-based cluster analysis of taxa and monitoring sites. These analyses were performed separately for the 2012 data and for the 2003 to 2012 data.

Findings

Taxonomic evaluation of the 2012 samples yielded 166 different taxa from 12,837 individual organisms. Ostracoda (seed shrimp) were the most abundant organism collected throughout the County, and midges in the family Chironomidae were collected at every site. The majority of organisms collected from the monitoring sites were moderately or highly tolerant to stream impairments. Seventeen of the 20 sites were dominated by organisms in the collector feeding groups (collector–gatherers and collector–filterers), which typically become more abundant in response to water quality impairment.

The IBI score of a monitoring reach is considered the strongest analytical tool for rating overall benthic community quality. The score is in points on a 0 to 70 scale, where higher scores indicate higher quality BMI communities. Sites rated Poor or Very Poor have an IBI score of 26 or lower and are considered impaired (i.e., 26 is the impairment threshold). The IBI scores for the 2012 study ranged from 0 to 56 of the possible 70 points (Table ES-1), and the ratings for quality of BMI communities ranged from Very Poor to Very Good. The monitoring reaches located in highly modified, concrete-lined channels had Very Poor or Poor IBI ratings. Analysis of individual metrics as well as total IBI scores showed that monitoring sites located in the lower-elevation, urban watershed areas had lower-quality benthic communities than sites located in the middle to upper and natural reaches of the watersheds. Prior correlation analyses of elevation and IBI scores have indicated a positive and significant correlation countywide. When individual watersheds were considered, a positive and significant correlation between elevation and IBI scores existed in the San Gabriel River Watershed and Los Angeles River Watershed, whereas a negative but insignificant correlation (i.e., IBI scores were somewhat lower at higher elevation monitoring sites) existed in the Santa Monica Bay and Santa Clara River Watersheds. This was likely due to differences in the amount of urbanization relative to the location of the monitoring sites, particularly considering the relatively pristine and isolated conditions of the sub-watersheds along the Malibu coast that are at low elevation. Analysis of the IBI scores for the 10 survey years through 2012 did not indicate any substantial trend through time toward degradation or improvement at any of the sites, with one possible exception: Site 7–Arroyo Seco was trending toward a statistically significant improvement in BMI community quality through 2011, although the 2012 results did not continue that trend.

An analysis of the benthic community quality in concrete-lined sites versus unlined sites for all watersheds combined in 2012 indicated a statistically significant difference in IBI scores based on channel type. When reference sites were added to the analysis, the difference in IBI scores was greater between concrete-lined sites and unlined sites. When considering all survey years, the difference between concrete-lined sites and unlined sites was statistically significant for most watersheds. When reference sites were included in the analysis, all watersheds had higher quality BMI communities in the unlined sites, although the difference was not significant in the Los Angeles River Watershed (where reference sites were underrepresented). Linear regression analysis between CRAM scores for physical habitat quality and IBI scores for 2009 through 2012 data combined had an R^2 of 0.553, indicating a significant relationship between the two.

For targeted sites with long-term monitoring data, an analysis of physical habitat stability was performed to assess whether any sites were degrading in physical habitat quality. None of the sites have shown any trends for improvement or degradation either through anthropogenic or natural processes. Two of the sites had major streambed and BMI community alteration due to storm and/or fire events, and biotic integrity at both sites recovered within about two years although physical habitat integrity was slower to recover.

An analysis of potential stressors to the BMI community was performed. These were divided into physical habitat attributes and water quality constituents and were compared to IBI scores. The results indicated that substrate complexity and channel alteration were the two physical conditions that were most strongly correlated to IBI scores and that dissolved ionic constituents and organic carbon were the water quality constituents most strongly correlated to IBI scores. Using a step-wise multiple regression approach, several significant relationships between IBI scores and a combination of predictors were found. However, although a significant relationship was found, the predictive ability of the model was poor. Therefore, it is not possible to accurately predict IBI scores although several analytes are useful as indicators that biotic integrity will likely be impaired (e.g., total dissolved solids, chloride, and sulfate). An analysis of the effect of organophosphorus and pyrethroid pesticides showed that all of the sites where pesticides were detected had impaired biotic integrity.

Conclusion

Stream bioassessment monitoring of the watersheds of the County has been conducted for ten consecutive years beginning in October 2003, at a total of 63 different sites. Monitoring sites located in highly urbanized areas of the watersheds have consistently had BMI communities that were considered impaired based on the Southern California IBI. Reference monitoring site BMI communities have been rated unimpaired for the duration of the study, with the exception of 6–Arroyo Seco, which was rated impaired in the 2010 survey after severe wild fire impacts and has since recovered. Sampling and analysis methodology has been altered somewhat in the standard protocols, but overall results have been relatively consistent for most of the monitoring sites. One site, 7-Arroyo Seco, had shown a general trend toward BMI community quality improvement through 2011, but the 2012 IBI score did not continue that upward trend. None of the sites that have been sampled for multiple years have shown any significant trend for decreasing biotic integrity. Correlations between IBI scores and channel type (i.e., concrete-lined versus unlined), elevation, and CRAM habitat scores indicated that all three factors are significantly related to IBI scores when all areas of a watershed are considered. These relationships were also confirmed by two-way cluster analysis of sites and their corresponding taxa.

Table ES-1. Index of Biotic Integrity Scoring Results for 2012

Receiving Waterbody	Site Code	IBI Score (0–70 scale)	IBI Rating
San Gabriel River Watershed			
San Gabriel River (unlined channel)	SGUT-501	56	Very Good
San Gabriel River (unlined channel)	SGUT-504	44	Good
San Gabriel River (unlined channel)	SGUT-505	26	Poor
Walnut Channel (unlined channel)	5, SGLT-506	9	Very Poor
Los Angeles River Watershed			
Arroyo Seco (unlined channel)	6	40	Fair
Arroyo Seco (unlined channel)	7	10	Very Poor
Rio Hondo (lined channel)	LALT500	2	Very Poor
Arroyo Seco (lined channel)	LALT501	20	Poor
Compton Creek (unlined channel)	8, LALT502	6	Very Poor
Tujunga Wash (lined channel)	LALT503	6	Very Poor
Dominguez Channel Watershed			
Dominguez Channel (lined channel)	19	0	Very Poor
Santa Monica Bay Watershed			
Arroyo Sequit (unlined channel)	SMC13076	44	Good
Lindero Canyon (lined channel)	SMC18116	13	Very Poor
Cold Creek (unlined channel)	SMC15464	43	Good
Cold Creek (unlined channel)	17	54	Good
Triunfo Creek (unlined channel)	18	18	Poor
Santa Clara River Watershed			
Bouquet Canyon (unlined channel)	SMC02888/ SMC02888 Dup	47/ 41	Good
Gleason Canyon (unlined channel)	SMC04432	45	Good
Santa Clara River (unlined channel)	SMC016892	21	Poor
Santa Clara River (unlined channel)	SMC017378	31	Fair

1.0 INTRODUCTION

Weston Solutions, Inc. (WESTON®) was contracted by the Los Angeles County Flood Control District (LACFCD) to perform biological assessments (bioassessments) of various freshwater streams in five Los Angeles County (County) watersheds (Bioassessment Program). The Bioassessment Program is required for National Pollutant Discharge Elimination System (NPDES) Permit compliance as enforced by the Los Angeles Regional Water Quality Control Board (RWQCB) (i.e., Region 4). The goals of the program are to assess biological integrity and to detect possible biological trends and responses to pollution in receiving waters throughout the County. Sampling and analysis followed the protocols described in the Surface Water Ambient Monitoring Program (SWAMP) physical habitat assessment protocol (Ode, 2007) and also incorporated the Stormwater Monitoring Coalition (SMC) technical report Regional Monitoring of Southern California's Coastal Watersheds (SCCWRP, 2007). The County program was initiated in October 2003, and monitoring surveys have been conducted annually since that time. In 2012, the Bioassessment Program incorporated three monitoring programs in addition to the NPDES Program. These included the San Gabriel River Regional Monitoring Program (SGRRMP) which began in 2006, the Los Angeles River Watershed-Wide Monitoring Program (LARWMP) which began in 2008, and the Stormwater Monitoring Coalition (SMC) Southern California Regional Watershed Monitoring Program (SMC Program) which began in 2009.

The Bioassessment Program includes the collection and identification of stream benthic macroinvertebrates (BMI) and also assesses the quality and condition of the in-stream physical habitats and adjacent riparian zones. Using species-specific tolerance values (TVs) and community composition, numerical biometric indices are calculated that determine the ecological health of streams. Over time, this information may be used to identify ecological trends and aid analyses of the appropriateness of water quality management programs (Yoder and Rankin, 1998).

Invertebrates reside in streams for periods ranging from one month to several years and have varying sensitivities to physical, biological, and chemical disturbances in the stream. By assessing the invertebrate community structure of a stream, a realistic, long-term measure of stream habitat health and ecological response is obtained. This information may complement monitoring programs that test water quality parameters, which provide a measure of habitat conditions only at the moment sampling occurs. The addition of bioassessment to chemical, bacterial, and toxicological approaches to watershed monitoring programs gives a comprehensive indication of water quality and the effects of ecological impacts.

This report presents the results of stream bioassessment surveys from 20 monitoring sites in the Los Angeles Basin conducted from June 14, 2012 to June 28, 2012, as well as analyses of historical data. No significant rain events occurred during the sampling period or during the month prior to the sampling. A taxonomic list of all identified BMIs, biological metric and Index of Biotic Integrity (IBI) calculations, physical habitat information, and a discussion and analysis of the results are included in this report. Representative photographs of the monitoring sites are presented in Appendix A, details of the results of the Countywide survey are included in data tables in Appendix B, and other relevant documentation, such as field data sheets, chain-of-custody forms, and quality assurance (QA) data, is included in Appendix C.

2.0 STUDY AREA OVERVIEW

The monitoring sites assessed in this study were located in five major watersheds throughout the County. These included the San Gabriel River Watershed, Los Angeles River Watershed, Dominguez Channel Watershed, Santa Monica Bay Watershed (including the Malibu Creek Watershed and the Ballona Creek Watershed), and Santa Clara River Watershed. The monitoring reaches are described in Table 1, along with the rationale for monitoring each site. Figure 1 is a map of the monitoring site locations.

Four of the monitoring sites were located in concrete-lined channels: LALT500–Rio Hondo, LALT501–Arroyo Seco, LALT503–Tujunga Wash, and 19–Dominguez Channel. Four of the soft bottomed (unlined) monitoring sites were considered reference sites with minimal upstream urban development: SGUT-501–San Gabriel River, SGUT-504–San Gabriel River, 6–Arroyo Seco, and 17–Cold Creek. One other site, SMC04432, was also located in a stream reach that would likely qualify as reference. All eleven remaining sites were in unlined channels with some influence from urban runoff.

Table 1. Los Angeles County Flood Control District Stream Bioassessment Monitoring Stations, 2012

Site	Targeted (T) or Random (R) SMC Site	Receiving Waterbody	Location, Date Sampled	Coordinates	Justification	Elevation (feet above sea level)
San Gabriel River Watershed: four sites						
SGUT-501	T	San Gabriel River Unlined Channel	San Gabriel River upstream of the confluence with Bear Creek, 6/19/2012	N 34.24067° W -117.88215°	Upstream reference site, targeted/fixed site for SGRRMP	1,620
SGUT-504	T	San Gabriel River Unlined Channel	Upper San Gabriel River near East Fork Road, 6/19/2012	N 34.23652° W -117.81664°	Upstream reference site, targeted/fixed site for SGRRMP	1,512
SGUT-505	T	San Gabriel River Unlined Channel	Upper San Gabriel River below Morris Reservoir, 6/18/2012	N 34.17133° W -117.88762°	Targeted/fixed site for SGRRMP	898
5, SGLT-506	T	Walnut Creek Unlined Channel	Walnut Channel upstream of San Gabriel River, 6/18/2012	N 34.06180° W -117.99314°	Targeted/fixed site for SGRRMP	298
Los Angeles River Watershed: six sites						
6	T	Arroyo Seco Unlined Channel	Upstream of Arroyo Seco Spreading Grounds, 6/20/2012	N 34.20327° W -118.16647°	Upstream reference site with minimal impact from residential land use	1,118
7	T	Arroyo Seco Unlined Channel	Arroyo Seco downstream from Interstate 134, 6/20/2012	N 34.144963° W -118.165102°	Assess impacts of residential land use	725
LALT500	T	Rio Hondo Lined Channel	Rio Hondo at Los Angeles River, 6/22/2012	N 33.93555° W -118.17200°	Offset site for the LARWMP	82
LALT501	T	Arroyo Seco Lined Channel	Arroyo Seco at Los Angeles River, 6/21/2012	N 34.08677° W -118.21076°	Offset site for the LARWMP	300

Table 1. Los Angeles County Flood Control District Stream Bioassessment Monitoring Stations, 2012

Site	Targeted (T) or Random (R) SMC Site	Receiving Waterbody	Location, Date Sampled	Coordinates	Justification	Elevation (feet above sea level)
8, LALT502	T	Compton Creek Unlined Channel	Compton Creek at Los Angeles River, 6/22/2012	N 33.84622° W -118.20922°	Offset site for the LARWMP	22
LALT503	T	Tujunga Wash Lined Channel	Tujunga Wash at Los Angeles River, 6/21/2012	N 34.14691° W -118.38932°	Offset site for the LARWMP	578
Dominguez Channel Watershed: one site						
19	T	Dominguez Channel Lined Channel	Dominguez Channel upstream of Vermont Avenue 6/15/2012	N 33.87111° W -118.29683°	Assess impacts from upper Dominguez Channel Watershed	3
Santa Monica Bay Watershed: five sites						
SMC13076	R	Arroyo Sequit Unlined Channel	Arroyo Sequit Creek along Mullholland Hwy., 6/28/2012	N 34.066349° W -118.931895°	Random site for the SMC Regional Monitoring Program	225
SMC18116	R	Lindero Canyon Lined Channel	Lindero Canyon at E. Thousand Oaks Blvd., 6/28/2012	N 34.156900° W -118.790484°	Random site for the SMC Regional Monitoring Program	975
SMC15464	R	Cold Creek Unlined Channel	Cold Creek along Mulholland Highway 6/15/2012	N 34.096529° W -118.667771°	Random site for the SMC Regional Monitoring Program	866
17	T	Cold Creek Unlined Channel	Cold Creek, downstream of Stunt Rd., 6/14/2012	N 34.094204° W -118.648148°	Upstream reference site with minimal impact from residential land use	1,240
18	T	Triunfo Creek Unlined Channel	Triunfo Creek downstream of Troutdale Dr. and nursery 6/14/2012	N 34.11418° W -118.77917°	Assess impacts of nursery	752
Santa Clara River Watershed: four sites						
SMC02888	R	Bouquet Canyon Unlined Channel	Bouquet Canyon 4.15 miles downstream of Bouquet Reservoir, 6/26/2012	N 34.544013° W -118.436264°	Random site for the SMC Regional Monitoring Program	2,187
SMC04432	R	Gleason Canyon Unlined Channel	Gleason Canyon 2.75 miles upstream of confluence with Aliso Canyon, 6/26/2012	N 34.410891° W -118.148816°	Random site for the SMC Regional Monitoring Program	3,790
SMC16892	R	Santa Clara River Unlined Channel	Santa Clara River 0.85 miles upstream of Pico Canyon Road, 6/27/2012	N 34.410433° W -118.661072°	Random site for the SMC Regional Monitoring Program	881
SMC17378	R	Santa Clara River Unlined Channel	Santa Clara River 0.60 miles downstream of Pico Canyon Road, 6/27/2012	N 34.402676° W -118.684124°	Random site for the SMC Regional Monitoring Program	841

SGUT = San Gabriel River Upper watershed Targeted site
SGLT = San Gabriel River Lower watershed Targeted site
LALT = Los Angeles River Lower watershed Tributary site
SMC = Stormwater Monitoring Coalition

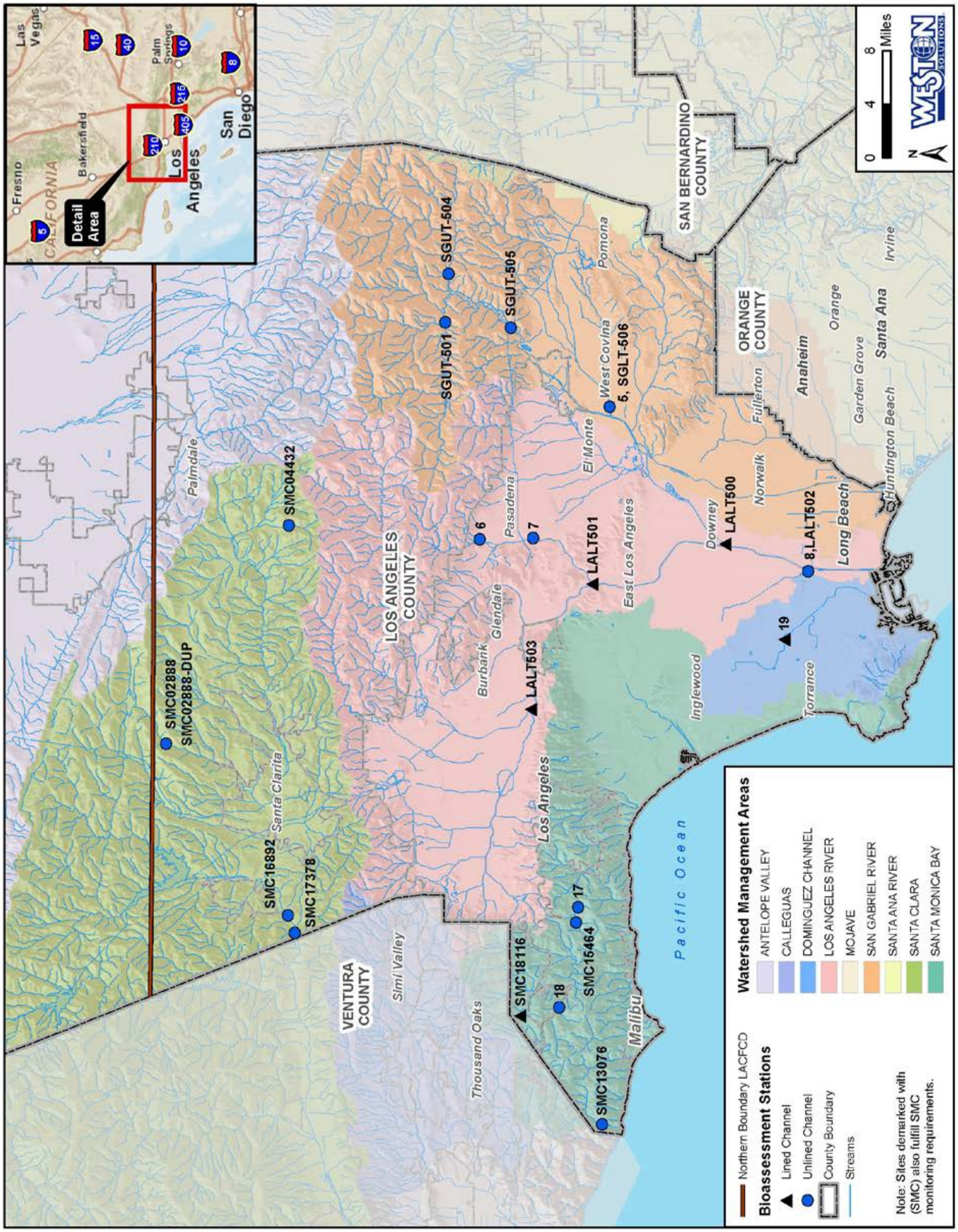

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Figure 1. Stream Bioassessment Monitoring Locations for 2012

3.0 METHODS

A general description of the methods incorporated in the sampling program is presented below. WESTON personnel followed the protocols of the SWAMP physical habitat assessment procedure (Ode, 2007), the SMC regional bioassessment workplan (SCCWRP, 2007), and Quality Assurance Project Plan (QAPP) (SCCWRP, 2009). The California Rapid Assessment Method (CRAM) for riverine wetlands (Collins et al., 2012) was also performed at the SMC sites. These documents may be referenced for more detailed procedural information.

The sampling and analysis for the 2012 survey was performed using the same protocols as in the 2009–2011 surveys. Throughout the history of the program, there have been varying levels of effort concerning the in-stream sampling area and the number of organisms processed for each site. These variances have been dictated by changes in the standard protocols and were not at the discretion of the LACFCD or its consultants. Sample area size has varied from 9 square feet (ft^2) to 18 ft^2 and has been 11 ft^2 since 2009. The sampling strategy within the sites has changed from targeted riffle sampling to a reachwide sampling technique where collections were made at evenly spaced 15-meter transects. In the laboratory, the target number of organisms identified varied from 500 to 900 organisms and has been 600 organisms since 2009.

3.1 Sampling Site Selection

Historically, the Bioassessment Program consisted of 20 targeted sites. In 2003, Los Angeles County Department of Public Works (LACDPW) staff performed a field reconnaissance of the monitoring reaches prior to program initiation to determine the suitability of the 20 original proposed sites. Over the years, various sites have been “offset” to contribute to other watershed-specific monitoring programs. For example, Sites 11, 12, and 13 in the Los Angeles River Watershed were offset in 2008 with Sites LALT500, LALT501, and LALT503 as a contribution to the LARWMP for the Council for Watershed Health, formerly known as the Los Angeles and San Gabriel River Watershed Council (LASGRWC). Other programs that have been incorporated include the San Gabriel River Regional Monitoring Program (SGRRMP), also under the Council for Watershed Health, and the SMC Program. Sites that contributed to the SGRRMP have site codes beginning with “SG,” sites that contributed to the LARWMP have site codes beginning with “LALT,” and sites that contributed to the SMC program have site codes beginning with “SMC.” More information on the SMC program is available at http://www.socalsmc.org/

In 2012, the 20 sites sampled included 13 targeted sites that have been sampled historically and seven random sites that were sampled for the first time in 2012. In 2012, data from eight of the targeted sites also contributed to the LASGRWC’s programs. The seven sites for the SMC Program were selected using a stratified random process as part of a probablilistic survey design. A list of potential sites was provided by the SMC coordinator at SCCWRP and these were assessed in the order provided until the target number of suitable sites was identified. Sites were rejected if they lacked semi-perennial flow, were non-wadeable, were deemed too dangerous, were too remote to sample in a single day, or if access permission was denied. Typically, a majority of the SMC sites provided are rejected.

3.2 Monitoring Reach Delineation

Historically, monitoring sites were established in stream reaches with ample current flow and riffle habitat, where available. The sampling points specified in the California Stream Bioassessment Procedure (CSBP) (Harrington, 2003) targeted riffle habitat, and this document may be consulted for detailed information regarding the historical sampling protocols. An ideal riffle is an area of variable flow regimes with some surface disturbance and a relatively complex and stable substrate. These areas provide increased colonization potential for benthic invertebrates. Riffles typically support the greatest diversity of invertebrates in a stream.

Beginning in 2009, all of the monitoring sites were delineated to encompass a 150-meter stream reach, regardless of site conditions. Historical targeted sites sampled in 2012 were in the same or relatively identical locations as in past surveys. Randomly placed SMC sites were established so that the downstream margin was as close to the nominal coordinates as possible and never more than 300 meters away from the nominal coordinates.

3.3 Sample Collection

Historically, once a sampling transect was established, BMI were collected using a 1-foot-wide, 0.5-millimeter (mm) mesh D-frame kick-net. Depending on the protocol, a 1-ft^2 or 2-ft^2 area upstream of the net was sampled by disrupting the substrate and scrubbing the cobble and boulders so that organisms were dislodged and swept into the net by the current or by hand sweeping. In areas with little or no current, the substrate was disturbed, and the net was swept back and forth to capture the organisms. The duration of the sampling generally ranged from 1 to 3 minutes, depending on substrate complexity. Three areas along each transect were sampled and combined into one composite sample. The three sample points on the transect were usually taken near the right and left margins and in the middle of the stream, or the three sample points were selected to best represent the diversity of habitat types present. This procedure was repeated for the next two riffles, proceeding from downstream to upstream. Sample material was transferred from the kick-net to 1-quart jars, preserved with 95 percent (%) ethanol, and returned to WESTON's benthic laboratory for processing.


Kick Net Sampling


Benthic Macroinvertebrate Sample

Beginning in 2009, BMI samples have been collected at evenly spaced 15-meter transects for a total of 11 transects in each 150-meter reach (transects are labeled alphabetically, A through K). The physical conditions at all of the 2012 sites allowed for sampling over an uninterrupted 150-

meter reach. BMI were collected using a standard 1-foot-wide kick-net, and each sample point consisted of a 1-ft^2 area. The samples were collected in a repeating alternating margin-center-margin pattern and were otherwise collected and preserved using methods similar to those previously used.

Every monitoring site was sampled from downstream to upstream and photographed, at a minimum, at Transects A, F, and K. Representative photographs of the monitoring sites are presented in Appendix A.

3.4 Physical Habitat Quality Assessment

Historically, for each monitoring reach sampled the physical habitat of the stream and its adjacent banks were assessed using the CSBP methods modified from the United States Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (Barbour et al., 1999). Habitat quality parameters were assessed to provide a record of the overall condition of the reach. Parameters (e.g., channel alteration, frequency of riffles, width of riparian zones, and vegetative cover) help to provide a more comprehensive understanding of the condition of the stream. Additionally, specific characteristics of the sampled riffles were recorded, including riffle length, depth, gradient, velocity, substrate complexity, and substrate composition.

Beginning in 2009, the SWAMP physical habitat assessment protocol was used. This protocol is more comprehensive and quantitative than the CSBP protocol. Detailed measures (e.g., substrate size, bank vegetation, human influences, and in-stream features) were taken at the same 11 transects where BMI collections were taken. A subset of the physical habitat measures were also assessed at intertransects 7.5 meters apart. Copies of the SWAMP field data sheets are presented in Appendix C (electronic version only). In 2009, the CRAM protocol for assessing riverine wetland quality was incorporated into the monitoring program and has been conducted at the SMC sites since.

CRAM assesses a number of wetland attributes (e.g., in-stream habitat complexity, riparian vegetation, buffer zone width and quality, adjacent land uses, and hydrologic connectivity). CRAM incorporates a broader landscape scope than the SWAMP physical habitat assessment, and yields a single score for a site. The range of possible scores is 25 to 100 points, with higher scores representing higher quality wetlands. The scoring system has yet to be calibrated to give ratings such as ‘Poor’ or ‘Good’ that correspond to specific score ranges.

In situ physical water quality measurements were taken at each of the monitoring sites. Measurements included water temperature, specific conductance, pH, dissolved oxygen, and turbidity. Water samples were collected and analyzed for alkalinity in the laboratory to achieve greater accuracy than the standard field methods.

3.5 Laboratory Processing and Analysis

At the laboratory, samples were relinquished under chain of custody to the laboratory sample custodian. Prior to sample processing, technicians signed out each sample in a sample tracking logbook. The sample was poured over a No. 35 standard testing sieve (i.e., 0.5-mm stainless-steel mesh), and the ethanol was retained for reuse. The sample was gently rinsed with fresh water, and large debris (e.g., wood, leaves, and rocks) was removed. The sample was transferred to a tray marked with grids approximately 25 square centimeters (cm^2) and was spread homogenously to a thickness of approximately 0.25 inch. One grid was randomly selected, and the sample material contained within the grid was removed and processed. In cases where the animals appeared abundant, only a fraction of the sample in the grid may have been removed. The material from the grid was examined under a stereomicroscope, and the invertebrates were removed, sorted into major taxonomic groups, and placed in vials containing 70% ethanol. This process was repeated until the specified number of organisms was removed from the sample (i.e., 300, 500, or 600, depending on the protocol). Organisms from a grid in excess of the specified number were placed in a separate vial labeled “extra animals,” so that a total abundance for the sample could be estimated. All sample processing information was entered onto a Stream Bioassessment Sorting Sheet (Appendix C). Processed material from the sample was placed in a separate jar and was labeled “sorted,” and the unprocessed material was returned to the original sample container, checked in to the sample tracking logbook, and archived. Sorted material was retained for QA purposes.

Historically, all organisms were identified to standard taxonomic Level I as specified in the *Southwest Association of Freshwater Invertebrate Taxonomists* (SAFIT) *List of Freshwater Invertebrate Taxa* (SAFIT, 2006), genus level for most insects, and order or class for non-insects. The taxonomic levels are fixed under this document to prevent inconsistencies in taxonomic effort between laboratories. The level of taxonomic effort was consistent from 2003 through 2008. Beginning in 2009, the taxonomic effort level was increased to SAFIT Level II, in which insects are identified to species level when possible, and Chironomidae are identified to genus level to meet SMC requirements. With the exception of some beetles, nearly all of the insects identified in the program were in larval or pupal stages of development, which metamorphose into an aerial adult form. Nearly all of the non-insect taxa are aquatic for their entire life history.

Quality Assurance/Quality Control—After sample processing was completed, a minimum of 20% of the BMI samples were checked to ensure a 95% or better organism removal efficiency. To comply with the SMC QA requirements, all SMC samples underwent the sorting QA. Results of the sorting quality assurance/quality control (QA/QC) were entered onto the Stream Bioassessment Sorting Sheet (Appendix C). To ensure accuracy of the taxonomic identifications, at least 20% of the samples (i.e., four samples) were sent to the California Department of Fish and Game (CDFG) Aquatic Bioassessment Laboratory (ABL) for taxonomic verification. Any discrepancies between ABL identifications and the original identifications were reconciled in the taxonomic database. Taxonomic QA/QC results for one sample were also sent to the SMC to determine whether minimum quality objectives (MQOs) were met. Results of the sorting and taxonomic QA/QC analyses are presented in Appendix C.

3.6 Data Analysis

Taxonomic data were entered into an electronic file using Microsoft Word and were converted into an SAS® database for QA/QC and data reduction values were calculated from the entire database. For calculation of BMI community-based metrics and the IBI (described below), the database was randomly reduced to a 500-organism count (Ode et al., 2005). A list of the standard CSBP metrics, a brief description of what they signify, and their predicted responses to impairment are presented in Table 2. A taxonomic list of the macroinvertebrates present in each sample was created in Microsoft Excel, including the designated TV and Functional Feeding Group (FFG) of each taxon. Rare feeding groups such as macrophyte herbivores (mh), piercer herbivores (ph), omnivores (om), parasites (pa), and xylophages/wood-eaters (xy) were combined into a group designated “other.” Note that for some organisms identified at the Family level or above, a single TV or FFG was not assigned because the taxa within the group have a broad range of tolerances or feeding strategies, and a single designation is not representative.

In addition to the individual metric values, a multi-metric IBI was calculated for each monitoring reach (Ode et al., 2005). The IBI is a quantitative scoring system for assessing the quality of BMI assemblages and is currently the most useful tool for reducing a complex macroinvertebrate dataset to a qualitative rating for each monitoring reach. The IBI score is derived from the cumulative value of seven biological metrics (Table 2). Percent collector–filterers and percent collecter–gatherers are combined into a single IBI metric. The total scores were categorized into ratings of the benthic community, ranging from Very Poor to Very Good. It has been noted that the Southern California IBI was developed with very few reference sites located at low elevations in the County. Future development of a refined IBI has been suggested by SWAMP.

Using data generated from the BMI samples, additional analyses included comparisons of IBI scores from concrete-lined and unlined channels, IBI scores and monitoring site elevations, and comparative analyses of mean biological metrics and IBI scores for all years of monitoring.

Table 2. Bioassessment Metrics Used to Characterize Benthic Invertebrate Communities

Metric	Description	Expected Response to Impairment
Richness Measures		
Taxa Richness	Total number of individual taxa	Decrease
Coleopteran Taxa*	Number of taxa in the insect order Coleoptera (beetles)	Decrease
EPT[1] Taxa*	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	Decrease
Dipteran Taxa	Number of taxa in the insect order Diptera (true flies)	Increase
Non-Insect Taxa	Number of non-insect taxa	Increase
Predator Taxa*	Number of taxa in the predator feeding group	Decrease
Composition Measures		
EPT Index	Percent composition of mayfly, stonefly, and caddisfly larvae	Decrease
Sensitive EPT Index	Percent composition of mayfly, stonefly, and caddisfly larvae with TVs between 0 and 3	Decrease
Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver, 1963)	Decrease
Margalef Diversity	Measure of sample diversity weighted for richness	Decrease
Tolerance/Intolerance Measures		
TV	Value between 0 and 10 of individuals designated as pollution tolerant (higher values) or intolerant (lower values)	Increase
Dominant Taxon	Percent composition of the single most abundant taxon	Increase
Percent Chironomidae	Percent composition of the tolerant dipteran family Chironomidae	Increase
Percent Intolerant Organisms*	Percent of organisms in sample that are highly intolerant to impairment as indicated by a TV of 0, 1, or 2	Decrease
Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a TV of 8, 9, or 10	Increase
Percent Tolerant Taxa*	Percent of taxa in sample that are highly tolerant to impairment as indicated by a TV of 8, 9, or 10	Increase
Percent Non-Insect Organisms	Percent of organisms in sample that are not in the Class Insecta	Increase
Percent Non-Insect Taxa*	Percent of taxa in sample that are not in the Class Insecta	Increase
FFGs		
Percent Collector–Gatherers*	Percent of macrobenthos that collect or gather fine particulate matter	Increase
Percent Collector–Filterers*	Percent of macrobenthos that filter fine particulate matter	Increase
Percent Scrapers	Percent of macrobenthos that graze upon periphyton	Increase
Percent Predators	Percent of macrobenthos that feed on other organisms	Variable
Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	Decrease
Percent Other	Percent of macrobenthos that are pa, mh, ph, om, and xy	Variable
Abundance		
Estimated Abundance	Estimated number of organisms in entire sample	Variable

*Metrics used to calculate the IBI
[1]EPT = Ephemeroptera, Plecoptera, and Trichoptera
Source: SDRWQCB, 1999

4.0 COUNTYWIDE SURVEY RESULTS FROM 2012 AND 2003 THROUGH 2012

A discussion of the 2012 survey results is presented below. A complete list of the benthic invertebrates identified at all sites and replicates is presented in Appendix B.1. Ranked total abundance for each species at all sampling sites combined is presented in Appendix B.2, and the calculated BMI metric values for each monitoring reach are presented in Appendix B.3.

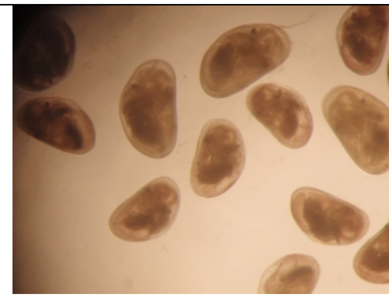
The reader may notice seeming discrepancies between the number of unique taxa listed in the metrics tables, and the apparent number of taxa in the taxa list. This was due to fact that the metrics were calculated on a randomly selected subset of 500 organisms and also to the presence of immature or damaged specimens identified at a higher systematic level than the standard effort that were not considered to be unique taxa. It should also be noted that the increased taxonomic effort since the 2009 surveys substantially increased the apparent taxa richness; thus, comparisons with past surveys need to consider this difference.

4.1 Benthic Macroinvertebrate Community – 2012 Study Area Summary

When all sites in the County study area are combined, a total of approximately 166 unique taxa were identified from 12,837 individual organisms (Appendix B.1 and Appendix B.2). The five most abundant taxa in descending order were Ostracoda (seed shrimp) with 1,164 individuals; the mayfly, *Baetis* sp., with 946 individuals; the amphipod *Hyalella* sp. with 700 individuals; the black fly *Simulium* sp. with 680 individuals; and the mayfly *Fallceon* sp. with 656 individuals (Appendix B.2) (Figure 2). All of these taxa are moderately to highly tolerant to habitat impairment and, with the exception of *Simulium*, which is a collector-filterer, are in the collector–gatherer feeding group. Collector taxa feed on organic detritus, algae, and various microorganisms (Smith, 2001; Usinger, 1956), and high abundances of these organisms are often associated with high levels of urban runoff (Lenat and Crawford, 1994).

The order Diptera (true flies) had the greatest number of unique taxa identified (69 taxa, including 45 Chironomid genera and species complexes), followed by Trichoptera (caddisflies) with 19 taxa, Coleoptera (beetles) with 18 taxa, and Ephemeroptera (mayflies) with 14 taxa (Appendix B.1). Chironomidae (midges) were the only family of BMI that was collected at every site, while Baetidae (minnow mayflies) were collected at every site except 19–Dominguez Channel.


Mayfly, *Baetis* sp


Seed Shrimp, Ostracoda


Amphipod, *Hyalella* sp.


Black Fly, *Simulium* sp.


Mayfly, *Fallceon* sp.

Figure 2. The Most Abundant Organisms Collected in Los Angeles County for the 2012 Survey

4.2 2012 Benthic Macroinvertebrate Community Metrics

Benthic invertebrate community metric values for each monitoring reach are presented in Appendix B.3. Table 2 above may be referenced for a brief definition of each metric and how its results respond to impairment. Each metric is based on a different component of the BMI community, and the combination of metric scores gives an indication of overall biotic integrity for a given site.

Taxa Richness

Taxa richness is the total number of unique taxa in a sample, and it is presumed that higher richness indicates higher biotic integrity. This number does not account for damaged or immature specimens identified at a higher taxonomic level than specified in the SAFIT list (also referred to as indiscriminate or non-distinct taxa). In 2012, taxa richness per sample ranged from 9 taxa at LALT501–Arroyo Seco to 56 taxa at SGUT-501–San Gabriel River and SMC13076–Arroyo Sequit (Appendix B.3). Taxa richness values for historical surveys prior to 2009 were based on Level I taxonomic effort, which is likely why they, for the most part, were substantially lower than for surveys since 2009. The lined sites had a mean of 19 taxa per site, while the unlined sites had a mean of 39 taxa per site, and the reference sites had a mean of 48 taxa per site in 2012.

Diversity and Dominance

Two diversity indices were calculated for each site: Shannon Diversity, which increases with diversity and weights for evenness of distribution among taxa and Margalef Diversity, which increases with raw diversity values. Shannon Diversity values per site ranged from 0.9 at 19–Dominguez Channel to 3.5 at SMC13076–Arroyo Sequit (Appendix B.3). Margalef Diversity values per site ranged from 1.6 at LALT501–Arroyo Seco to 9.5 at SGUT-501–San Gabriel River (Appendix B.3). Dominance is a metric that is presumed to decrease with increasing biotic integrity. Dominance by a single taxon ranged from 10.4% *Microtendipes* sp. at SMC13076–Arroyo Sequit to 76.2% Ostracods at 19–Dominguez Channel (Appendix B.1, Appendix B.3).

Ephemeroptera, Plecoptera, and Trichoptera Taxa

This metric represents the number of taxa in the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) that are collected at each site. These orders contain impairment-sensitive taxa, and greater diversity of these taxa indicates higher biotic integrity. Several of these taxa (e.g., mayflies in the family Baetidae and the caddisflies, *Cheumatopsyche* sp., *Hydropsyche* sp., and *Hydroptila* sp.), have moderate TVs and are tolerant to urban runoff that does not contain high levels of chemical pollutants or dissolved ionic constituents. This means that percent-sensitive EPT (TV $\leq$3) is a much stronger metric than total-percent EPT when assessing ecological health of a site. All of the stonefly taxa are sensitive to urban runoff.

The greatest number of EPT taxa (21) was collected at SGUT-501–San Gabriel River, and the second greatest number of EPT taxa (17) was collected at SGUT-504–San Gabriel River (Appendix B.3). EPT taxa were collected at every monitoring site except for 19–Dominguez Channel. EPT individuals were most abundant at the two Santa Clara River sites, SMC16892 and SMC17378, where they comprised 66.2% and 71.8% of the benthic community, respectively, although none were considered sensitive (Appendix B.3). The most abundant of the EPT taxa across the survey region included *Baetis* sp., *Fallceon* sp., and the caddisfly *Hydroptila* sp. (Appendix B.2). Sensitive EPT taxa (TV 0 to 3) were collected at ten of the sites and were collected in the greatest numbers at SGUT-501–San Gabriel River, where they comprised 38.4% of the benthic community. The high percentage of sensitive EPT at this site was primarily due to a high abundance of the mayfly, *Serratella* sp., with 119 individuals (Appendix B.2).

The Sensitive Mayfly, *Serratella* sp.

Tolerance Values

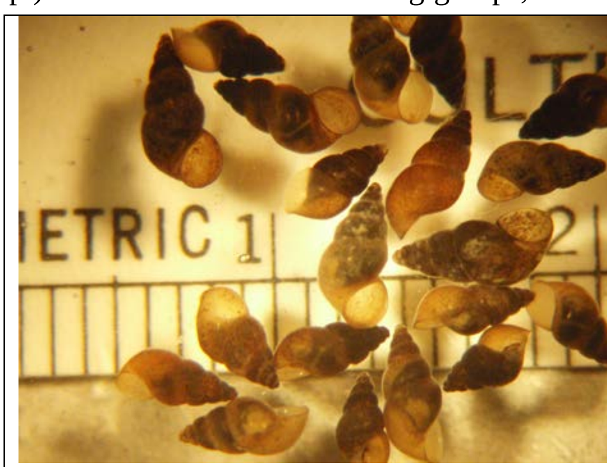
For most stream macroinvertebrates, a TV has been determined for each taxon through prior research on each type of animals' life history (Hilsenhoff, 1987). TVs range from 0, for organisms highly intolerant (i.e., sensitive) to impairments, to 10, for organisms that are highly tolerant to impairments. For some taxa, the TV is either unknown or is too diverse within a group to assign a single value and, therefore, no TV is applied. A low to moderate abundance of high TV organisms does not necessarily imply impairment (SDRWQCB, 2001), but more importantly, the presence of sensitive organisms is unlikely when a stream is impaired. The presence of highly intolerant organisms (TV 0 to 2) is likely the strongest indicator of good water quality.

Average community TVs for all sites ranged from 3.3 at 17–Cold Creek and to 7.6 at 19–Dominguez Channel (Appendix B.3). Highly tolerant organisms (TV 8 to 10) were most abundant at 19–Dominguez Channel and comprised 83.6% of the community, primarily due to the predominance of ostracods. Highly tolerant organisms were least abundant at LALT501–Arroyo Seco, where they comprised 0.6% of the community. Highly intolerant (i.e., sensitive) organisms were collected from ten sites, which were the same sites where sensitive EPT were collected. Sensitive EPT with a TV of 2 or less are also counted in the highly intolerant metric. 17–Cold Creek had the greatest number of intolerant organisms, where they comprised 51.0% of the community. Highly intolerant organisms collected in high numbers Countywide included the mayfly, *Serratella micheneri* (190 individuals), the stonefly, *Malenka* sp. (189 individuals), and the caddisflies, *Lepidostoma* sp. and *Micrasema* sp. (162 and 157 individuals, respectively).

Functional Feeding Groups

As with TVs, FFG designations have been determined through prior life-history research or observations of each taxon. In rare instances, the feeding strategy of an organism is unknown, and for some taxonomic designations at a high level (e.g., family level), the feeding strategies are too diverse to assign a single feeding group to the taxon. The percent composition of the FFGs provides useful information regarding benthic community function, and some feeding groups contain greater numbers of intolerant organisms (Table 2). In general, a more even distribution of the feeding groups indicates a higher quality benthic community. The information from feeding group composition may be particularly useful in detecting physical habitat degradation and impacts from urbanization.

Seventeen of the 20 monitoring reaches were dominated by taxa in the collector feeding groups (i.e. collector-gatherers plus collector-filterers were greater than 50% of the community) and four of the five lined channel sites had greater than 90% collector taxa (Appendix B.3). The seven most abundant taxa in the study region (i.e., Ostracods, *Baetis* sp., *Hyalella* sp., *Simulium* sp., *Fallceon* sp., *Cricotopus* sp., and *Dicrotendipes* sp.) were in the collector feeding groups, which generally increase in abundance in response to urban runoff in a watershed (SLSI, 2003). Two sites had non-collector feeding groups that were dominant: SMC15464–Cold Creek was dominated by scrapers (i.e., hydrobiid snails, including the invasive New Zealand Mud Snail, *Potamopyrgus antipodarum*) and 17–Cold Creek was dominated by shredders, the most abundant of which were the stonefly, *Malenka* sp. and the caddisfly, *Lepidostoma* sp. LALT503–Tujunga Wash had the greatest dominance by a single feeding group, where collector–gatherers comprised 97.8% of the community.



New Zealand mud snail,
Potamopyrgus antipodarum

Estimated Abundance

The estimated total abundance is the total number of BMI predicted to be in the sample if the entire sample had been processed (e.g., if 50% of the sample was processed and had 600 BMI, the estimated total abundance would be 1,200). This value is then divided by 11 to calculate the estimated number of animals living in one square foot of benthic habitat. Response to moderate habitat impairment is often indicated by an increase in total abundance by highly tolerant organisms, with a corresponding decrease in taxa richness and diversity; however, severe impairment can result in a catastrophic decrease in total abundance.

Estimated abundance ranged from 68 organisms per square foot of substrate at LALT500–Rio Hondo to 655 organisms per square foot at 19–Dominguez Channel (Appendix B.3). These values are moderate and none of the sites had extremely high abundance (e.g., in 2010, SMC03944 had an estimated 11,409 organisms per square foot (WESTON, 2011)). Abundance at the reference sites ranged from 177 to 621 organisms per square foot.

4.3 2012 Physical Habitat Quality Assessment

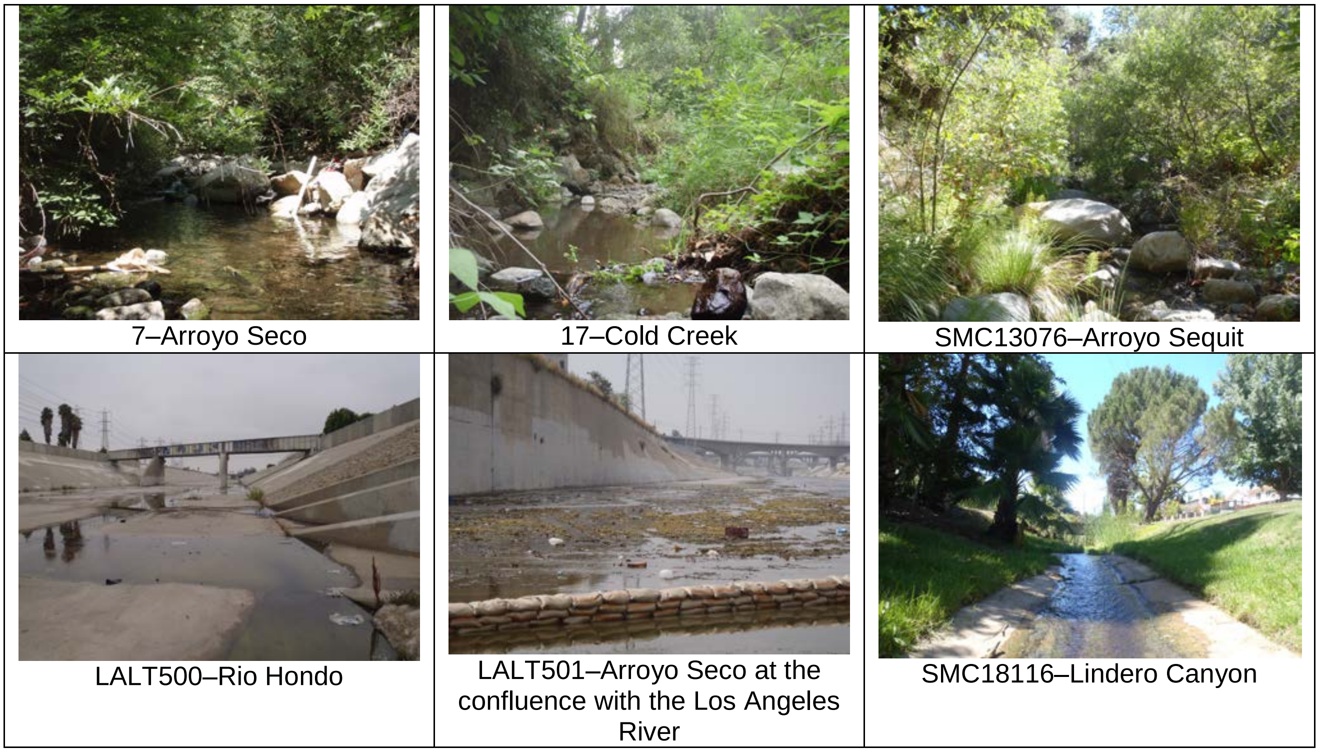
Assessment Methods

The SWAMP physical habitat procedure was performed at all sites. The procedure is much more comprehensive than the historical USEPA method in which ten parameters were assessed qualitatively on a 0 to 20 point scale to give a single habitat score. The SWAMP procedure retained three of these original USEPA parameters, including epifaunal substrate/cover, sediment deposition, and channel alteration. Additionally, many aspects of the reachwide habitat were quantitatively assessed (e.g., substrate size, algal cover, bank vegetation cover, canopy cover, in-stream habitat complexity, and human influences, flow volume, and reach gradient). Qualitative assessments were also made to characterize flow habitats and bank stability. As of the writing of this report, summary indices of the SWAMP physical habitat data have not been developed, although CRAM scores (described below) do provide a multi-attribute summary score to determine relative habitat quality. Table 3 lists the more relevant physical habitat parameters and briefly describes the conditions that are most beneficial to macroinvertebrate communities. Figure 3 presents photographs of good and poor quality physical habitats. Water quality data are presented in Appendix B.4, and physical habitat measures for each monitoring reach are presented in Appendix B.5.

Table 3. Parameters Used to Characterize the Physical Habitat of a Stream Reach

Parameter	Conditions Assessed	Optimal Conditions
Epifaunal substrate/cover*	The percentage of substrate favorable for epifaunal colonization. Most favorable is a mix of snags, submerged logs, undercut banks, cobble, and other stable habitats.	Complex mix of stable substrates occupying a high percentage of the stream bottom.
Embeddedness	The percentage of fine sediment surrounding gravel, cobble, and boulder particles.	Very little embeddedness, with layered substrate.
Flow habitats	The presence of cascades, rapids, riffles, runs, glides, and pools.	A mix of all regimes, dominated by riffles.
Sediment deposition*	The percentage of bottom affected by the deposition of new gravel, sand, or fine sediment.	Little or no new deposition, less than 5% of the bottom affected.
Channel flow	The percentage of the stream channel filled by flowing water and the amount of substrate covered.	Water reaches base of both lower banks and minimal amount of substrate is exposed.
Channel alteration*	The amount of channelization, dredging, embankments, or shoring structures present.	Channelization or dredging absent or minimal; stream with normal pattern.
Riffle frequency	The frequency of occurrence of riffle habitat.	Occurrence of riffles frequent, with variety of habitat.
Bank stability	Evidence of erosion or bank failure.	Evidence of erosion and bank failure absent or minimal.
Vegetative protection	The percent cover by undisturbed, native vegetation on the streambank surfaces and immediate riparian zones.	More than 90% of the streambank surfaces covered by native vegetation.
Riparian vegetative zone width and canopy cover	The width of native riparian vegetation along both streambanks and the amount of overhanging vegetation above the streambed providing shade and coarse organic matter.	Width of riparian zone more than 18 meters; human activities have not impacted zone. Canopy covers majority of streambed.

Source: CSBP, 1999
*Retained by SWAMP procedure



7–Arroyo Seco | 17–Cold Creek | SMC13076–Arroyo Sequit

LALT500–Rio Hondo | LALT501–Arroyo Seco at the confluence with the Los Angeles River | SMC18116–Lindero Canyon

Figure 3. Examples of Good Physical Habitat Conditions (top row) and Poor Physical Habitat Conditions (bottom row)

Water Quality

Water quality measurements at most of the monitoring sites did not indicate severe impairment. Values for pH ranged from 7.36 to 9.19 at 8, LALT502–Compton Creek and 19–Dominguez Channel, respectively. Specific conductance, a general indicator of dissolved solids, was moderate to low at all sites (e.g., < 2.0 milliSiemens per centimeter [ms/cm]) at all but three (lined) sites. Dissolved oxygen levels were suitable for BMI at all sites, with the lowest value recorded at 8, LALT502–Compton Creek (7.01 milligrams per liter [mg/L]). Water temperatures were somewhat variable throughout the County, ranging from 12.8 degrees Centigrade (°C) (55.0 degrees Fahrenheit [°F]) at SMC13076–Arroyo Sequit to 24.3 °C (75.7 °F) at 19–Dominguez Channel, although there were no very high temperatures (i.e. above 30 °C) recorded. Turbidity, a measure of water clarity (clear waters have low nephelometric turbidity unit [NTU] values and the meter range is 0-1,000 NTU), was relatively low at all sites, with the highest value recorded at SMC18116–Lindero Canyon (7.5 NTU). Elevated turbidity is most commonly caused by suspended sediments in the water column. Hardness and alkalinity were moderate to low at most sites, with the exception of SMC18116–Lindero Canyon, which had values of 1,024 and 328, respectively. Excessive salts, metallic cations (e.g., calcium, magnesium, and ferrous iron), and limestone formations can naturally elevate water hardness (Sawyer and McCarty, 1978), which may subsequently limit the BMI community to taxa that are tolerant to these constituents.

Currently, SWAMP has not developed standard metrics summarizing the overall habitat quality, but the more relevant physical habitat measures (e.g., substrate composition, channel alteration, canopy cover, and flow characteristics) are presented in Appendix B.5. For the seven SMC sites, the CRAM for riverine wetlands was applied in 2012. The final CRAM scores are presented in Appendix B.5, and a complete list of all CRAM attribute scores are presented in Appendix B.6.

CRAM Analysis

The CRAM provides a single score relating to the physical habitat quality and incorporates in-stream quality, buffer zone width and quality of vegetation, and surrounding landscape attributes. The range of scores is 25 to 100 (none of the attributes can score a “0”). Higher scores indicate a higher quality physical habitat, although the scores have yet to be calibrated regionwide to provide quality rating categories (e.g., “Good” or “Poor”). In 2012, the highest quality physical habitat was at SMC04432–Gleason Canyon, with a CRAM score of 82. The poorest quality physical habitat was at SMC18116–Lindero Canyon (a lined channel site) with a CRAM score of 28.

Long Term Habitat Trends

For the thirteen targeted sites assessed in 2012, an analysis of the long term habitat conditions at the sites was performed. With one exception, none of the sites have had intentional physical alteration of the streambed or banks (e.g., habitat restoration or removal). For the four sites located in concrete-lined channels, virtually no changes have occurred to the physical habitat since the initiation of sampling, and while LALT501–Arroyo Seco had some channel re-construction in 2011 that established a low flow channel mid-stream, the site is still fully lined. Some sites however, have had streambed alteration due to natural processes related to large storm events and hydromodified flows. The two notable occurances have been Site 6–Arroyo Seco in 2009/2010 and Site 1–Santa Clara River in 2005, both of which are discussed in this report in sections 5.2 and 5.5, respectively. For these two sites, the alteration of the streambed and resultant IBI scores were significant but temporary, and recovery occurred within about two years.

The one site that field personnel have noticed substantial year to year variability has been SGLT-506–Walnut Channel. This site has a soft bottom streambed approximately 100-m wide within concrete/rip-rap lined banks. It is located just downstream of a nearly 10 mile reach of fully lined streambed and therefore receives hydromodified stormwater flows. The streambed of the monitoring site is a mix of unconsolidated, easily eroded sediment, course gravel and cobble which has been frequently altered by wet season flows. For the last four years that the SWAMP protocol has been performed at this site, there has been considerable variability in IBI scores (0 to 17), percent riffle habitat (3% to 36%), and percent cobble (9% to 41%). None of the other physical habitat attributes varied substantially over time. Figure 4 charts the relative values for these attributes and shows that the surveys with the lowest percent cobble and riffle habitat (presumably the worst physical habitat conditions) had both the highest and lowest IBI scores, while the surveys with the best streambed conditions had mid-range IBI scores of 5 and 9. This lack of a consistent response may indicate that the variability of the physical habitat quality is likely overridden by natural BMI variability as expressed by the IBI scores. The conclusion from this analysis is that most sites have not had physical habitat quality changes through time and for the sites that have had alterations, the impacts to biotic integrity have either been temporary or insubstantial.

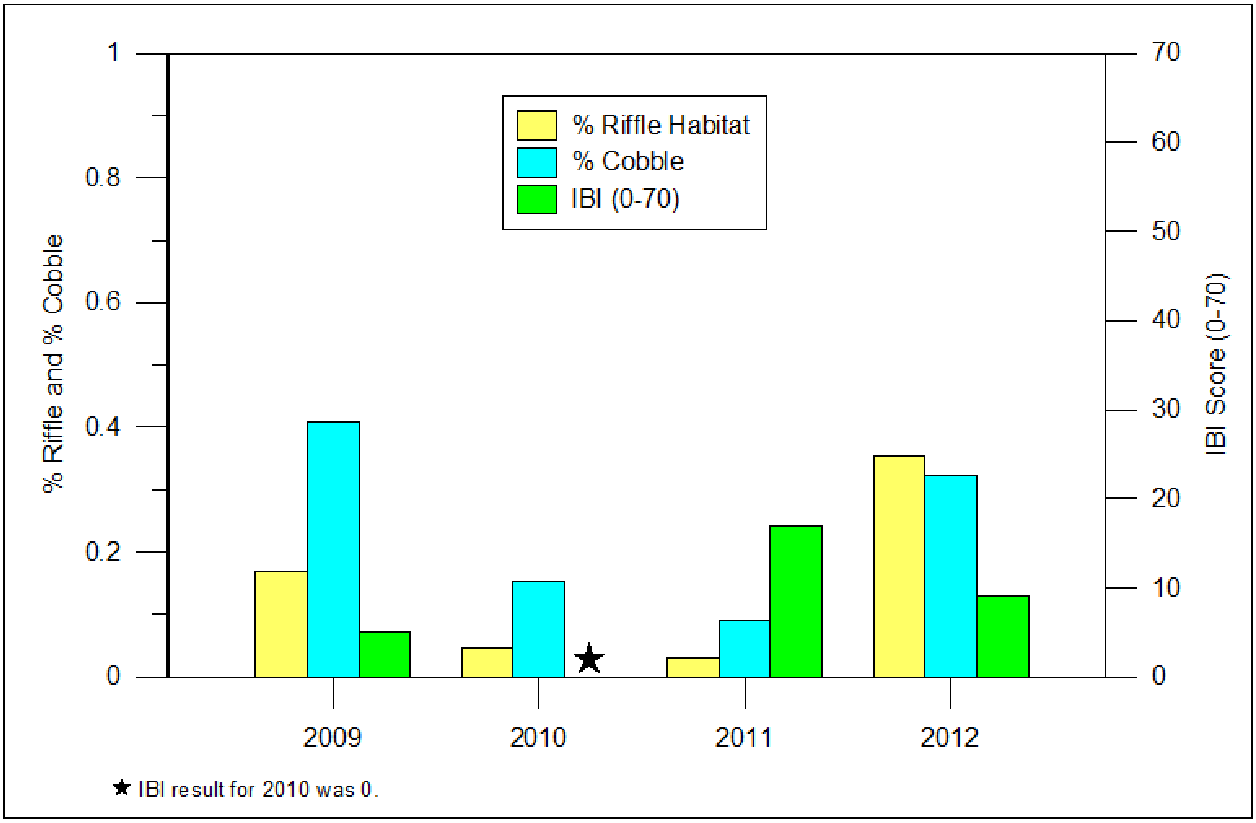


Figure 4. IBI Scores and Physical Habitat Variability at SGLT-506–Walnut Channel, 2009-2012

4.4 2012 Index of Biotic Integrity

In 2004, a Southern California IBI was developed to cover the region extending from southern Monterey County to the Mexican border (Ode et al., 2005). The IBI gives a single quantified score to a site based on a multi-metric evaluation technique, and the scores may be compared across seasons and years of a monitoring program to give an indication of trends over time. The CDFG developed the IBI based on a multi-year, comprehensive assessment of reference and non-reference conditions in Southern California to establish an expected range of benthic invertebrate community structure in the region. This IBI may be replaced in the near future; it has been noted that this IBI may lack strength when assessing low-gradient or low-elevation sites (due to the rarity of reference streams sampled in Southern California with these characteristics). Research is currently being conducted by SWAMP to create a California Stream Condition Index that will combine the IBI with a new predicitive model that compares observed BMI with expected BMI for a given location in a watershed.

Ode et al. (2005) selected seven metrics that showed a strong and predictable response to ecological impacts and stressors to calculate the IBI (Table 4). The seven metrics include number Coleoptera taxa, number EPT taxa, number predator taxa, percent collector–filterers plus collector–gatherers, percent intolerant individuals, percent non-insect taxa, and percent tolerant taxa. Each metric value was assigned a score from 0 to 10 (e.g., if there were four Coleoptera taxa in a sample, the metric score would be 7). These scores were added to provide a final IBI score; the highest possible total score was 70. This score is often normalized to a scale ranging from 0 to 100; the raw IBI scores are presented in this report. Each final score was then classified into rating categories ranging from Very Poor to Very Good. Table 4 shows the metric scoring ranges and rating categories for the Southern California IBI.

Table 4. Index of Biotic Integrity Scoring Ranges

Metric Score	Number Coleoptera Taxa	Number EPT Taxa	Number Predator Taxa	Percent CF and CG Individuals	Percent Intolerant Individuals	Percent Non-Insect Taxa	Percent Tolerant Taxa
10	>5	>17	>12	0–59	25–100	0–8	0–4
9		16–17	12	60–63	23–24	9–12	5–8
8	5	15	11	64–67	21–22	13–17	9–12
7	4	13–14	10	68–71	19–20	18–21	13–16
6		11–12	9	72–75	16–18	22–25	17–19
5	3	9–10	8	76–80	13–15	26–29	20–22
4	2	7–8	7	81–84	10–12	30–34	23–25
3		5–6	6	85–88	7–9	35–38	26–29
2	1	4	5	89–92	4–6	39–42	30–33
1		2–3	4	93–96	1–3	43–46	34–37
0	0	0–1	0–3	97–100	0	47–100	38–100
Cumulative Ratings: Very Poor: 0–13 Poor: 14–26 Fair: 27–40 Good: 41–55 Very Good: 56–70							

Source: Ode et al., 2005

The IBI is effective for broadly identifying impairment. Sites rated Poor or Very Poor have an IBI score of 26 or lower and are considered impaired (i.e., the impairment threshold is 26, or 39 on the 0 to 100 scale). It must be noted that small differences in IBI scores are not significant and may be due to natural biological variability within a stream reach. Ode et al. (2005) determined that the minimum detectable difference between IBI scores is approximately 9 points (on the 0 to 70 point scale). This implies that at least a 9-point difference between two site scores is necessary to determine if one is of significantly higher quality than the other.

The total IBI scores for each monitoring reach are shown on Figure 5 and are mapped in Figure 6. The IBI metric values, individual metric scores, and total IBI scores on the 0 to 70 and 0 to 100 scales are presented in Appendix B.7.

The 20 monitoring sites in the County had IBI ratings ranging from Very Poor to Very Good with IBI scores ranging from 0 to 56. Nine of the sites were rated above the level of impairment (i.e., Fair, Good, or Very Good). SGUT-501–San Gabriel River was the highest-rated site and was the only site rated Very Good. Four sites were rated Poor, and included sites at low to mid elevation that had substantial urban influence. The exception to this was SGUT-505–San Gabriel River, which had little upstream development but was influenced by nearby Morris Reservoir. It has been well documented that BMI community quality is often degraded downstream of reservoirs due to hydrologic modification (i.e. reduced, constant flow vs natural seasonal fluctuations) (see Rehn 2009). The seven remaining sites were rated Very Poor and included all five of the concrete-lined channel sites.

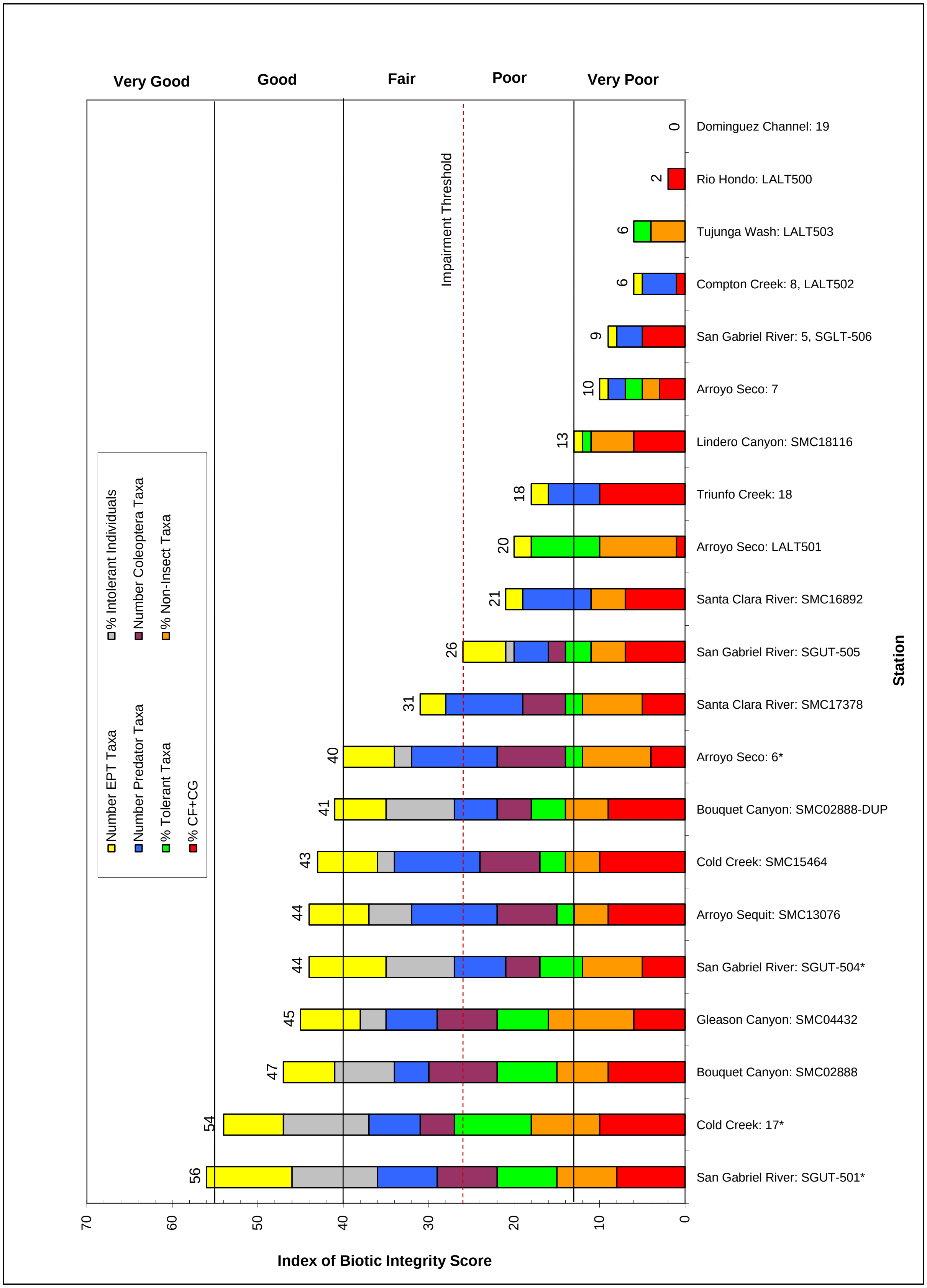


Figure 5. Index Biotic Integrity Scores for Los Angeles County Bioassessment Sites for 2012 (0–70 scale)

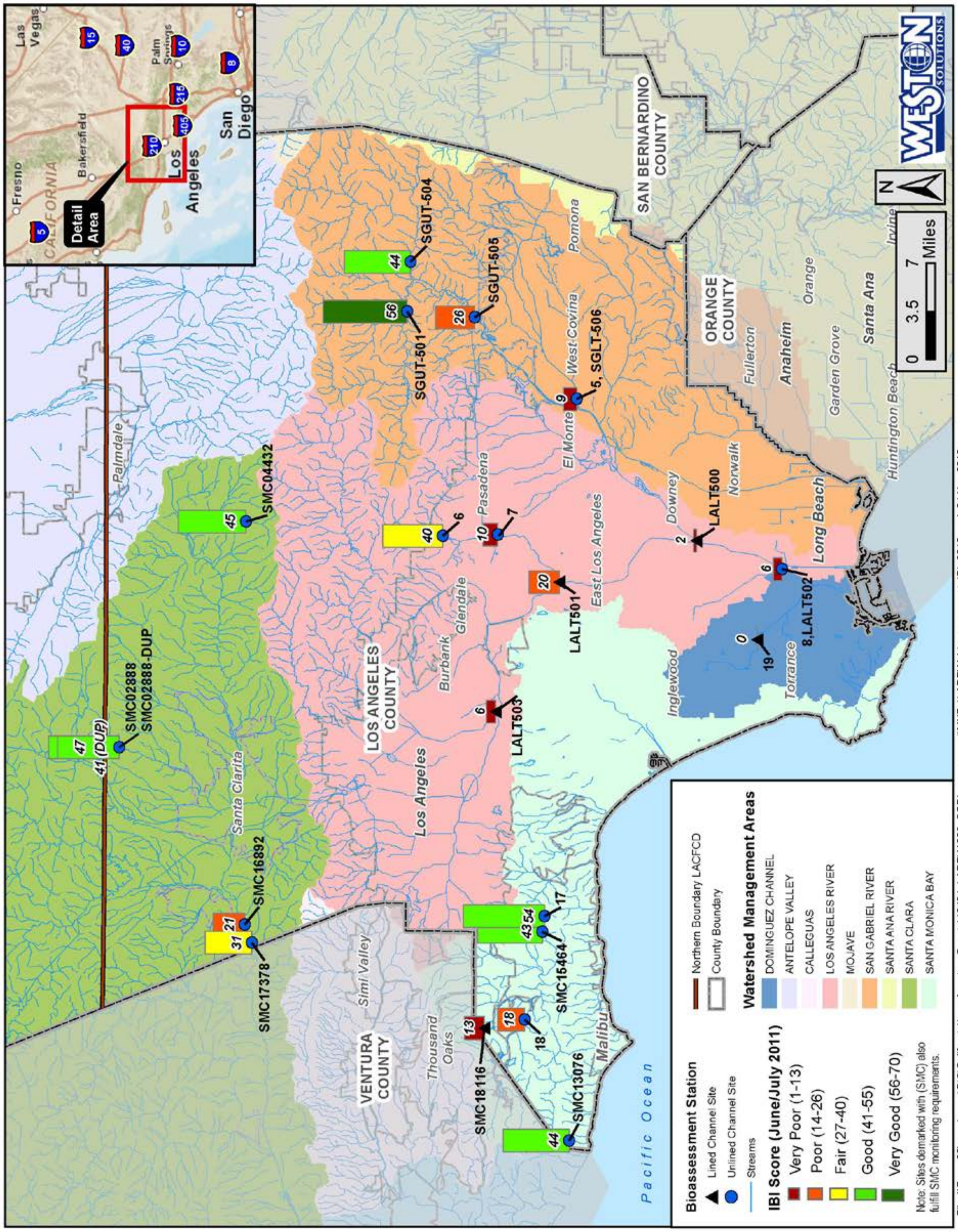


Figure 6. Stream Bioassessment Monitoring Locations with Index of Biotic Integrity Scores per Site for 2012

Comparison of Concrete-Lined Channels and Unlined Channels

In the 2012 survey, five sites were located in concrete-lined channels, including three sites in the Los Angeles River Watershed, LALT500, LALT501, and LALT503; one site in the Dominguez Channel Watershed, 19; and one site in the Santa Monica Bay Watershed, SMC18116–Lindero Canyon. A concrete substrate is considered inferior for macroinvertebrate colonization compared to a more complex natural substrate (e.g., substrates with layered cobble, plant stems, and wood). The concrete-lined channels generally had minimal coarse organic food sources, lacked riparian canopy, and had uniform water flow characteristics consisting of flat runs rather than true riffles. Concrete-lined channel sites typically have a relatively thick microalgae layer containing detritus and microorganisms, which provide the primary food resources for macroinvertebrates in this habitat type. More research is necessary at this point in time to understand what the BMI colonization potential of concrete-lined channels would be if the water quality were equivalent to reference conditions.

In 2012, the concrete-lined channel sites had IBI scores of 20 or less and benthic quality ratings of Very Poor and Poor (Figure 7). It is reasonable to infer that the poorer quality physical habitats of the concrete-lined channel sites had a deleterious effect on benthic community quality and the resultant IBI scores, but because these sites were dominated by urban runoff, water quality likely had an additional impact. All of the lined sites had low taxa richness, were heavily dominated by collector taxa (68% to 98% of the community), lacked sensitive taxa, and had three or less EPT taxa.

To determine whether the IBI scores for unlined sites were statistically different from IBI scores at concrete-lined sites, the Wilcoxon Ranked Sum test was used and is presented graphically on Figure 8. This test is a non-parametric alternative to the two-sample t-test. Instead of using the actual values of the dataset, ranks of the data are used. More detailed methods are presented in *Biostatistical Analysis* (Zar, 1999). The results for the two groups were compared. The hypothesis was tested at an alpha of 0.05, as follows:

> H_0 (null hypothesis): Unlined Channel IBI Scores = Concrete-Lined Channel IBI Scores
> H_a (alternate hypothesis): Unlined Channel IBI Scores ≠ Concrete-Lined Channel IBI Scores

The test was run using all 2012 sites, both with and without the reference sites, and no exclusions were made based on location (i.e., upper or lower) in the watershed.

The null hypothesis is that IBI scores in unlined channels are equivelant to IBI scores in concrete-lined channels. The results of the analysis indicated that in both scenarios the null hypothesis was rejected, and the alternate was accepted. This means that the IBI scores at unlined sites were statistically different, overall, from IBI scores at concrete-lined sites, with a p-value of 0.021. When the p-value is less than 0.05, the difference is significant with a 95% confidence; in other words, the chance of having this result is less than 5%, and the null hypothesis can safely (or significantly) be rejected. A visual comparison of the two groups is presented in Figure 8. The minimum and maximum IBI scores are indicated by the upper and lower horizontal lines (whiskers), the 25^{th} percentile is represented by the bottom of the shaded box, the median is the line near the middle of the box, and the 75^{th} percentile is the top side of the shaded box. The two datasets are significantly different from one another if the mean of one set is higher or lower than the 25^{th} or 75^{th} percentile line of the other set. One version of the analysis does not include reference sites in the unlined group, whereas the other includes reference sites in the unlined group.

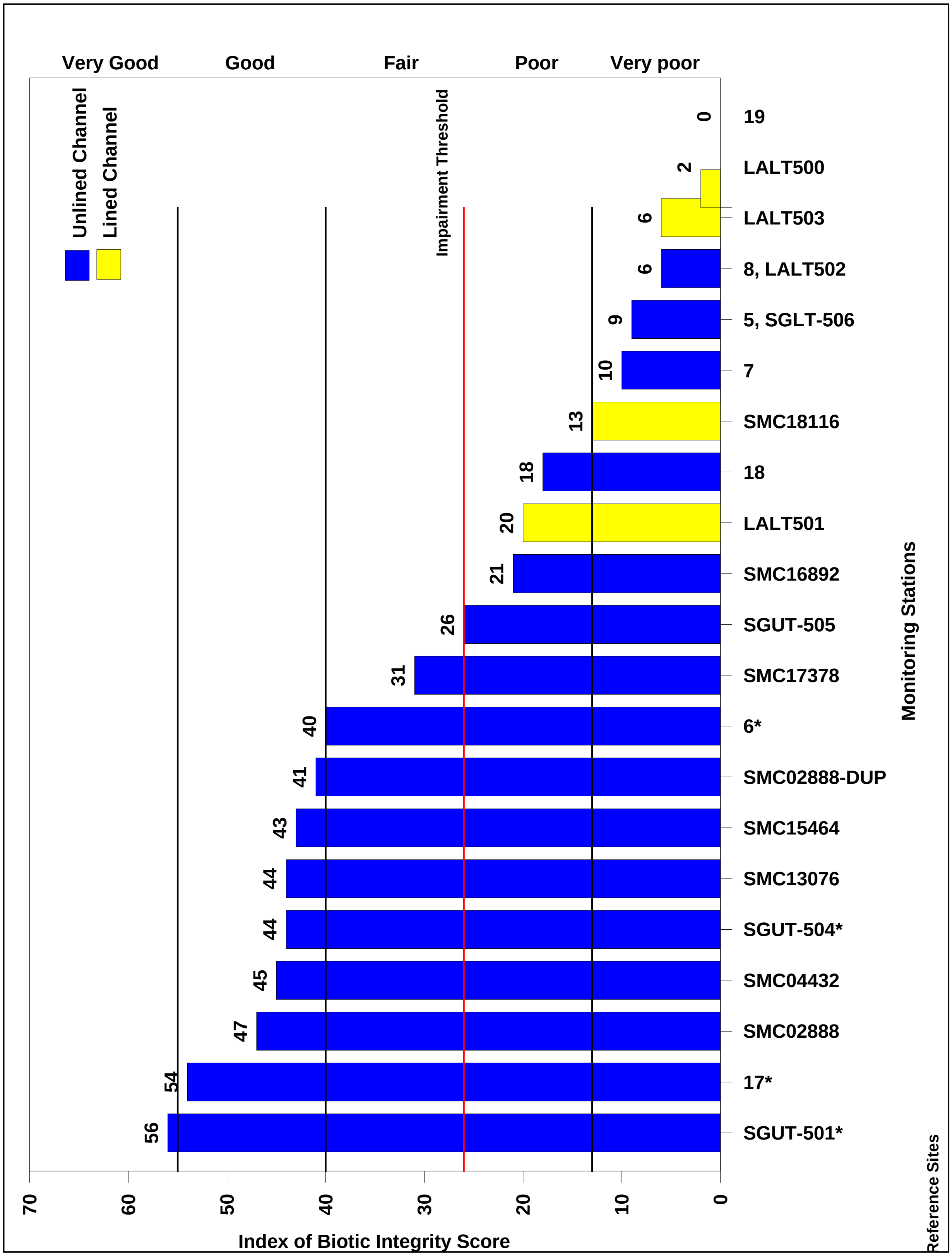


Figure 7. Index Biotic Integrity Scores for Concrete-Lined versus Unlined Channels for 2012 Survey

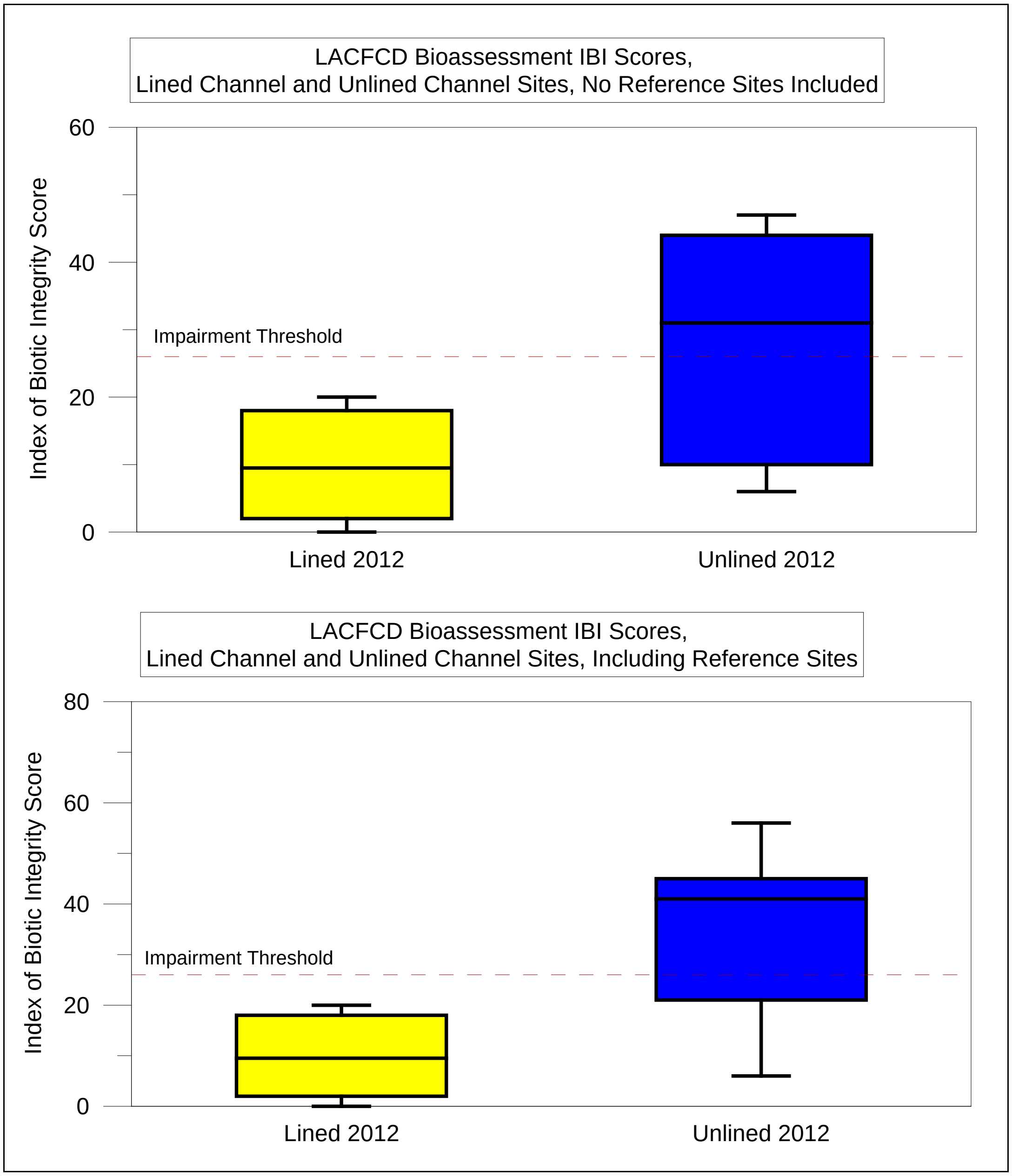


Figure 8. Comparison of Concrete-Lined and Unlined Channel Sites for 2012 Survey

Without considering reference sites, the mean IBI scores of the urban unlined sites were well above the 75th percentile (top of the shaded box) of the concrete-lined sites and, therefore, were rated superior to the lined sites. The mean of the unlined sites was also above the impairment threshold. This difference was greater than was seen in historical analyses (e.g., WESTON, 2011) due to the random placement of several SMC sites in undeveloped watershed areas. When reference sites were considered, this difference was even more apparent: the p-value decreased to 0.006, the unlined sites were clearly statistically superior to the concrete-lined sites, and the mean IBI score of the unlined sites was well above the impairment threshold.

Cluster Analysis
A cluster analysis was performed to test for similarities between site location and BMI community structure. The analysis is based on a two-way Bray–Curtis similarity matrix calculated on relative abundances of taxa by site. Sites with similar communities of taxa will cluster together; likewise, taxa that occur at the same sites will cluster together. The analysis only considers the taxa and sites and is independent of other factors such as channel type or organism tolerance, although this information was added to the cluster diagram to facilitate intertpretation (Appendix B.8). The analysis only considered organisms that occur at more than one site and with abundances of greater than three individuals.

The 2012 results are portrayed in a two-way table that shows the relative abundance of each taxon by site (Appendix B.7). Results of the cluster analysis showed four major taxa clusters and three site clusters, labeled 1 through 4 and A through C, respectively, and bounded by bold red lines. The graphic also indicates concrete-lined sites (highlighted yellow), unlined sites (highlighted blue), reference sites (with asterisked site names), and the organisms' TVs.

Overall site clustering showed that site cluster A had the greatest degree of separation from clusters B and C. Cluster A contained two of the reference sites plus all of the SMC sites that scored above the IBI threshold. Site cluster B was comprised primarily of lined and partially lined urban sites with low IBI scores. Site cluster C was a mix of site types, with two reference sites, two Santa Clara River sites, and two lined sites; the IBI scores of cluster C were quite variable.

The taxa clusters were characterized by cluster 1, and to a lesser extent, cluster 2, which contained the highly ubiquitous taxa that are tolerant to urban runoff and clusters 3 and 4, which included all of the Coleoptera (beetle) taxa and the sensitive EPT taxa (clusters 3 and 4).

The sites in cluster A were best characterized by having high numbers of taxa in taxa clusters 3 and 4. Many of the taxa in clusters 3 and 4 were sensitive organisms best represented by the caddisflies *Lepidostoma* sp. and *Micrasema* sp., and the stonefly *Malenka* sp.

Site cluster B was associated with taxa clusters 1 and 2, with no taxa in cluster 3 and the only representatives of cluster 4 were organisms with moderate to high tolerance values. Organisms most indicative of these site clusters included *Hyalella*, Ostracoda, and Oligochaeta.

Site cluster C contained a variety of site habitat types and IBI scores. The primary driver of the clustering was high abundances of moderately tolerant, ubiquitous organisms in cluster 1 (e.g., the baetid mayflies Baetis sp. and Fallceon sp., and hydroptild caddisflies). It is notable that sites 6–Arroyo Seco and SGUT-504–San Gabriel River also had sensitive taxa in clusters 3 and 4 that were more associated with site cluster A, but there were not enough of these to override the prevalence of taxa in clusters 1 and 2.

4.5 All Watersheds' Survey Results for 2003 through 2012

Study information from 2003 through 2012 (BonTerra, 2004; WESTON, 2005; WESTON, 2006; WESTON, 2007; WESTON, 2008; WESTON, 2009; WESTON, 2010; WESTON, 2011; WESTON, 2012) was compared to the 2012 data to assess year-to-year variance and trends in biotic integrity of the streams. Regional macroinvertebrate community structure was relatively similar in the ten survey years and the 10 most abundant taxa remained fairly consistent. Additionally, in nearly all of the survey years, the targeted sites with unique, high-quality communities showed year-to-year taxonomic consistency. Historically, two sites in the county have had severe alterations of the physical habitats as a result of high stormwater flows. These include 1–Santa Clara River which was scoured by high storm flows in 2005 and 6–Arroyo Seco, which was impacted in 2009 by sand and gravel deposition resulting from wildfires that occurred above the site. In both of these cases, the subsequent surveys had IBI scores that were significantly lower than suverys conducted in the years before and after the impacts.

Historically, the 2008 survey collected the greatest number of unique taxa studywide (i.e., 99) compared with 94 in 2007, 96 in 2006, 81 in 2005, 73 in 2004, and 88 in 2003. Countywide taxa richness was 146 in 2009, 130 in 2010, 136 in 2011 and 166 in 2012 but because the taxonomic effort was increased to SAFIT Level II, these values are not comparable to the historical surveys. Consequently, the 2009 to 2012 taxa richness values were converted to taxonomic Level I effort in order to calculate the mean richness values for all years. These re-calculated values are presented below in the mean metric tables for each watershed.

Comparison of Concrete-Lined Channels and Unlined Channels – 2003-2012

Since 2003, 63 sites have been monitored in the Bioassessment Program; 20 of these sites have been in concrete-lined channels.

The Wilcoxon Ranked Sum test was run with no exclusions based on location (i.e., upper or lower) in the watershed. The associated p-value was less than 0.001, indicating that the mean IBI scores of the concrete-lined sites were statistically lower than the unlined sites (p-value less than 0.05 is significant).

Comparison of Index of Biotic Integrity Scores and the California Rapid Assessment Method Scores for all Watersheds for 2009 through 2012

To test the relationship between IBI scores and physical habitat, a linear regression analysis was used to evaluate the relationship between CRAM scores and IBI scores. As noted in Section 4.3, the CRAM scores were not re-assessed since 2010 for the targeted sites, with the exception of 6–Arroyo Seco, and CRAM was performed only at the SMC sites since then.

The results of the analysis were a coefficient of determination (R^2) of 0.553 (Figure 9). This results in a correlation of 0.739. This result shows that a positive relationship exists between CRAM and IBI scores. Figure 9 shows what appear to be two groupings of sites: those with the lowest CRAM and IBI scores (i.e. CRAM <40, IBI <26) which includes most of the lined channel sites, and those with moderate to high CRAM scores (CRAM <60), but with a wide range of IBI scores. This indicates that sites with good habitat may have low IBI scores, while none of the sites with high IBI scores had low CRAM scores. CRAM generally correlates better with IBI scores than with individual physical habitat parameters because it incorporates water source and a wider stream buffer (i.e., CRAM is more likely to incorporate urban aspects of the watershed beyond the streambed and banks).

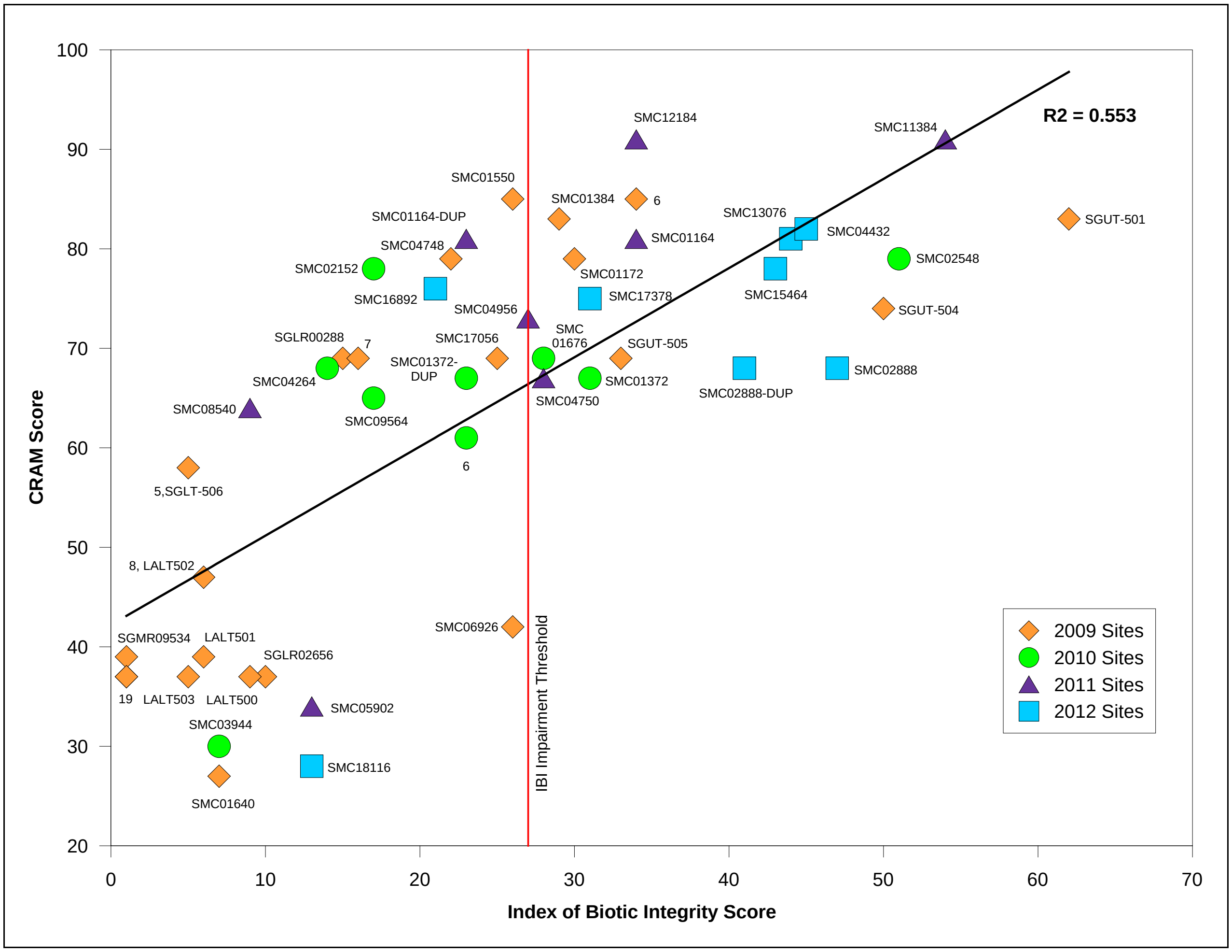


Figure 9. Correlation of California Rapid Assessment Method and Index of Biotic Integrity Scores for 2009 through 2012

Cluster Analysis for 2003–2012

A cluster analysis was performed to test for similarities between site location and BMI community structure. The analysis was performed as described in Subsection 4.4 above. The similarity matrix is shown in Appendix B.9.

Overall results of the analysis indicated there were four major taxa clusters and five site clusters, labeled 1 through 4 and A through E, respectively. This analysis confirmed that the BMI communities are different based on their location in the watershed and also by channel type.

The site clusters fell into two general groups, with clusters B and D containing low to mid-elevation urban sites including all of the concrete-lined channel sites. Clusters A, C and E contained the reference sites and less developed, mid to higher elevation sites. The BMI assemblages and IBI scores of the sites also confirmed that the higher elevation and/or less urbanized portions of the watersheds were of superior quality to the low elevation sites with greater urbanization.

The taxa clusters were in three general groups, with clusters 1 and 3 containing the ubiquitous and moderately to highly tolerant taxa, cluster 2 was entirely limited to chironomid genera, and cluster 4 contained all of the Coleoptera (beetle) taxa and intolerant (sensitive) taxa. Taxa cluster 2 was likely not a significant cluster, since the Chironomidae in this cluster are habitat generalists with moderate tolerance values.

Site cluster A was most associated with taxa cluster 4, which contained the sensitive taxa. Site cluster C had a large distance from all other clusters due to a relatively unique BMI assemblage (with replicate samples collected); if only one sample had been collected there, the site would likely have fallen into cluster A, since cluster C also had sensitive taxa in cluster 4.

Site clusters B and D were relatively similar based on taxa present, and were dominated by taxa clusters 1 and 3, with very few taxa in cluster 4. All of the lined and partially lined sites were in these two clusters and none had IBI scores above the impairment threshold.

Site cluster E contained SMC sites that were in the mainstem of the Santa Clara River. The primary driver of this cluster was relatively high abundances of the beetle *Tropisternus* sp., the mayfly *Tricorythodes* sp., and the damselfly *Hetaerina Americana*.

Stressor Analysis

An analysis of the water quality constituents detected during monitoring with the potential to degrade biotic integrity was undertaken. This endeavor has been historically difficult since there are still many unknown factors in the interactions between habitat, chemical pollutants, and individual BMI tolerance to individual stressors. For this program, additional confounding factors included the change in physical habitat assessment methods in 2009, chemistry data that was collected only at the Los Angeles and San Gabriel River sites for the Council for Watershed Health, and a limited number of targeted sites with multi-year results. The analysis below was performed on targeted sites that had four to ten years of survey data, and includes a total of 12 sites: four in the San Gabriel River Watershed, six in the Los Angeles River Watershed, and two in the Santa Monica Bay Watershed.

An initial screen was performed on candidate stressors, which were divided into two catergories: water quality constituents and physical habitat attributes. Scatter plots of physical habitat attributes with IBI scores were created to assess broad relationships and the results of this are presented in Figure 10. Sediment deposition appeared to have the weakest relationship to IBI scores, even though this parameter is widely considered to negatively impact biotic integrity. The lack of sediment deposition in concrete-lined channels that had low IBI scores likely drove this apparent lack of a relationship, so a separate plot was performed for sites that summed the % concrete and the % fine sediments. Substrate complexity and channel alteration had the highest correlation to IBI scores, with higher IBI scores associated with greater substrate complexity and lower IBI scores associated with greater channel alteration. The % gradient (or slope), % canopy, % riffle habitat, and % fines plus % concrete were moderately to weakly related to IBI scores.

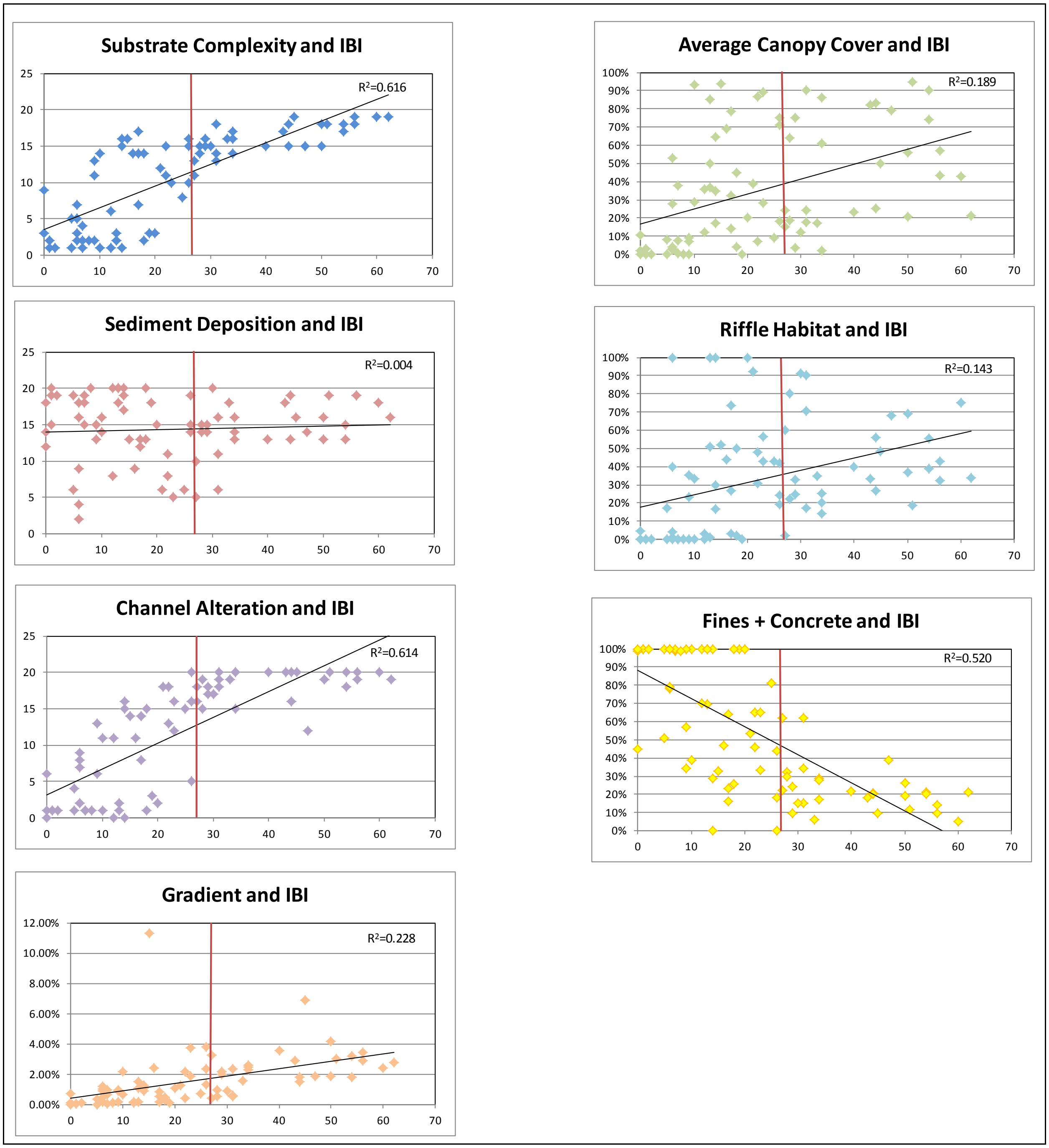


Figure 10. Scatter Plots of IBI Scores with Physical Habitat Attributes. Vertical Red Lines Indicate the IBI Impairment Threshold

A Spearman rank correlation of IBI scores and chemical analytes indicated a significant, and in each case negative, relationship for ten constituents (Table 5). Pesticides were considered; however, since a large majority of the analyses had "non-detect" results, the data were incompatible with this statistical analysis. A separate method was used for pesticides and is presented below.

Four of the top six analytes with the strongest negative correlation with IBI scores were related to dissolved solids and ionic constituents. Toxicity tests have shown that BMI are sensitive to elevated concentrations of dissolved ions (e.g., Mount et al, 1997). Total Kjeldahl nitrogen and total and dissolved organic carbon also showed strong correlations with IBI scores, although the affect of organic carbon is usually as a co-factor that affects susceptibility to other more toxic constituents.

Table 5. Spearman Rank Correlation of IBI Scores and Potential Biological Stressors. Yellow Highlights Indicate Significant Correlations

Analyte	Critical Value	Number of Samples	Correlation Coefficient
Total Dissolved Solids	0.56	13	-0.953
Chloride	0.415	23	-0.732
Sulfate	0.398	25	-0.689
Total Kjeldahl Nitrogen	0.325	31	-0.672
Total Organic Carbon	0.325	37	-0.639
Specific Conductance	0.216	83	-0.631
Dissolved Organic Carbon	0.325	37	-0.615
Hardness as CaCO3	0.317	39	-0.595
Phosphorus as P	0.317	39	-0.514
Suspended Solids	0.345	33	-0.423
OrthoPhosphate as P	0.317	39	-0.315
Total Nitrogen	0.46	19	-0.242
Alkalinity as CaCO3	0.335	35	-0.026
Nitrate as N	0.321	38	0.034
Silica	0.46	19	0.037
Sediment Deposition	0.216	83	0.181

Scatter plots relating the chemical analytes with IBI scores were created (Figure 11). This also shows that dissolved ions generally had the strongest negative relationships to IBI scores. What is also evident is that while many of the constituents had low values with low IBI scores, the reverse situation was never the case; none of the constituents had high values where there was a high (i.e., unimpaired) IBI score.

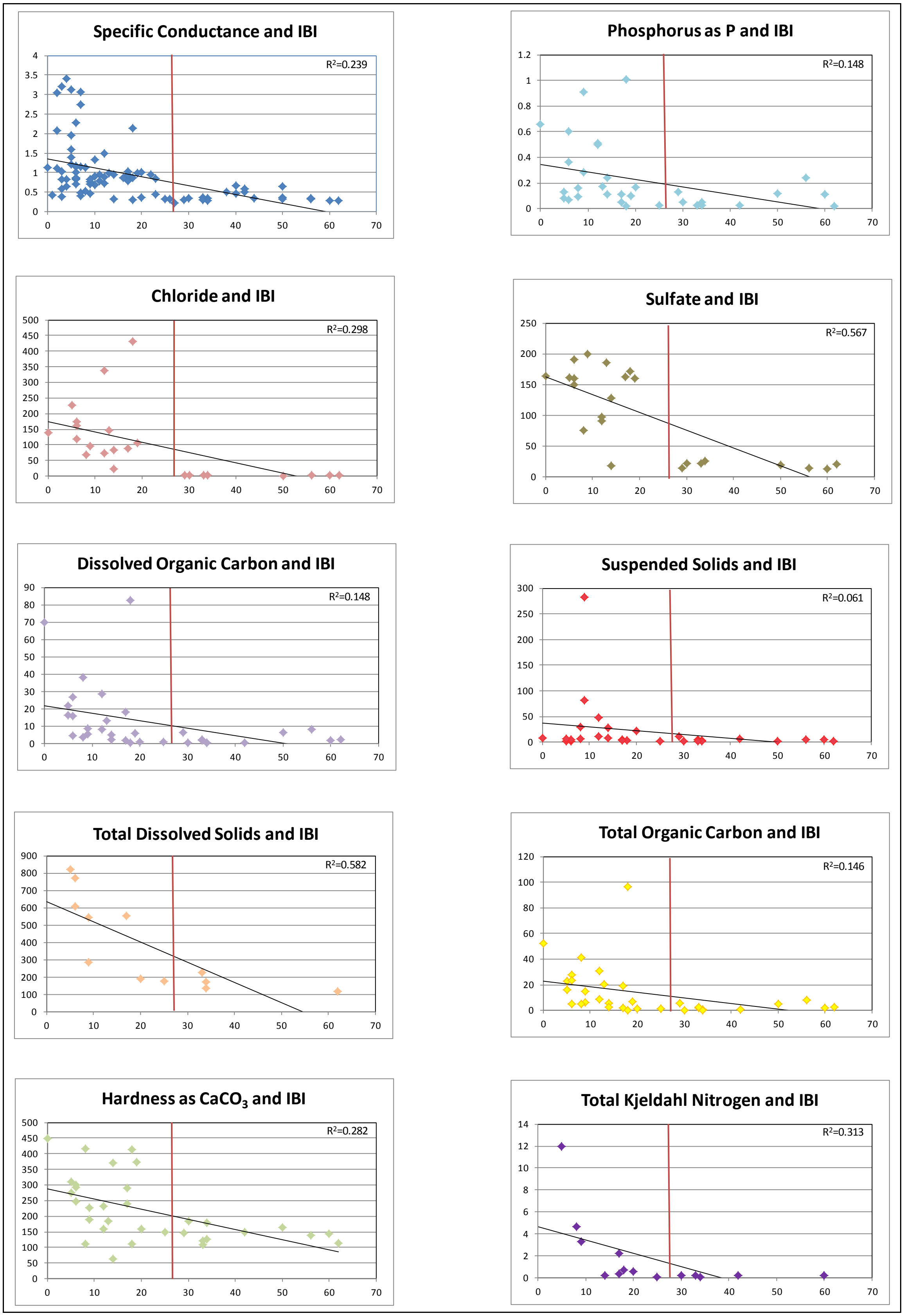


Figure 11. Scatter Plots of IBI Scores with Chemical Analytes. Vertical Red Lines Indicate the IBI Impairment Threshold

A stepwise multiple regression was then performed on the top ten candidate stressors to determine if a constituent or combination of constituents could be used to predict IBI scores based on existing data. Initially, all constituents were used in the analysis, but because of the limited number of samples for some constituents, the regression was re-run using the constituents with the greatest number of samples (sediment deposition, specific conductance, alkalinity, dissolved organic carbon, hardness, nitrate, orthophosphate, phosphorus, and total organic carbon). It should be noted that sediment deposition, which did not appear to be related to IBI scores by itself, when assessed in conjunction with other variables, was shown to be a strong co-factor. A stepwise model was applied that was optimized to include the following parameters: sediment deposition, dissolved organic carbon, and chloride. While this model was "significant", it did a poor job of accurately predicting IBI scores (R^2=0.376). Therefore, although sediment deposition, dissolved organic carbon, and chloride may be good indicators of poor IBI scores, they are not useful for the prediction of IBI scores.

Organophosphorus and pyrethroid pesticide data were available from the Council for Watershed Health sites in the San Gabriel and Los Angeles Rivers. Since most analytes were rarely detected, standard statistical analyses were not appropriate for the data. Instead, a whisker box plot was created comparing IBI scores to sites where any pesticide analyte was detected versus sites that had none detected (Figure 12). The results show that the IBI scores were lower at sites that had pesticides detected and that the difference was significant with a P value of <0.001. Additionally, for sites that had pesticides detected, none had IBI scores above the impairment threshold, and the highest IBI score was 12.

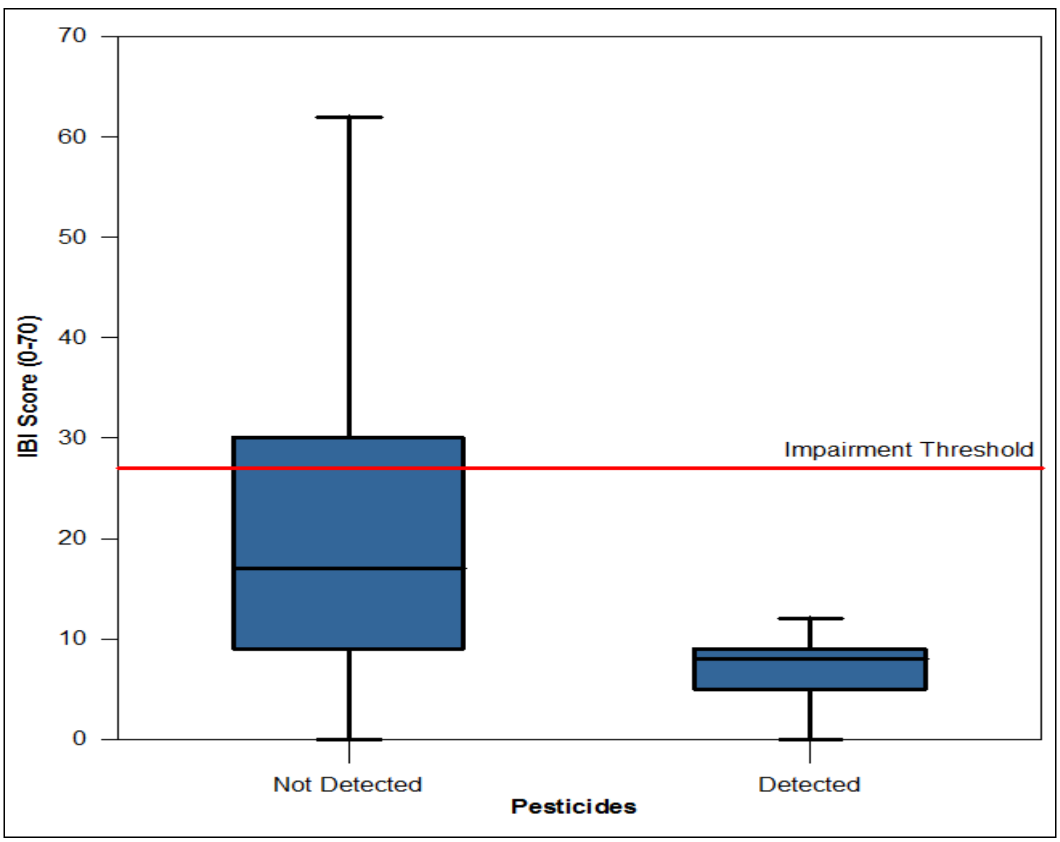


Figure 12. Comparison of IBI Scores for Sites with Pesticides Detected and Sites without Pesticides Detected

5.0 2003–2012 SURVEY RESULTS BY WATERSHED

Study information from 2003 through 2012 (BonTerra, 2004; WESTON, 2005; WESTON, 2006; WESTON, 2007; WESTON, 2008; WESTON, 2009; WESTON, 2010; WESTON, 2011; WESTON 2012) was compared to assess the year-to-year variance and trends in biotic integrity of the streams. For these multi-year historical analyses, each watershed is considered separately. Targeted monitoring sites were sampled in the same locations and at the same time of year (mid-fall) from 2003 through 2008, except for the four San Gabriel River Watershed sites, sampled in June 2008. Since 2009, the sampling index period has been June to July. Analyses for each watershed are presented in Subsections 5.1 through 5.5.

One site, 19–Dominguez Channel, was permanently moved approximately 0.5 miles upstream in 2006 because high salinity (tidal influence) was detected at the original site. In 2010, LALT501–Arroyo Seco was temporarily moved approximately 0.8 miles upstream to avoid impacts from channel maintenance activities and was moved back to the original location in subsequent years. Since the Bioassessment Program's inception in 2003, many of the original fixed monitoring sites have also been relocated to accommodate other watershed-specific monitoring programs, including the SMC Regional Bioassessment Program. Some of these sites have switched from a fixed or targeted location to a randomly (or stratified randomly) selected site. Random sites have been sampled for a single year and were then relocated the following year. Therefore, multi-year assessments may not be made for a number of sites in some watersheds, although these may be used to give an overall picture of biotic integrity watershed-wide.

5.1 San Gabriel River Watershed Survey Results for 2003–2012

The San Gabriel River Watershed has been sampled 47 times in 18 different locations from 2003 through 2012 (Figure 13). One site, 5, SGLT-506–Walnut Channel, has been sampled in all ten surveys, but the remaining sites have been sampled a maximum of seven times. Many sites have been sampled only once. Sites with "SG" in the site code prefix were offset sites for the SGRRMP study, and two of these sites, SGLR01278 and SGLR02656, were also designated SMC sites in 2009.

The watershed lacks full hydrologic connectivity between the upper and lower watershed areas, and these two areas are very different in terms of geography and land use. The upper watershed, largely in the Angeles National Forest, is sparsely populated and has many high-gradient natural streams. The lower watershed is highly urbanized with low-gradient streams, many of which have been modified through channelization for flood control. Separating the upper and lower watershed areas are a number of retention basins and spreading grounds that retain water for groundwater recharge. The bioassessment monitoring sites have signaled this difference with higher IBI scores (Table 6) and better physical habitat rankings for the upper watershed sites 4, SGUT-501, SGUT-504, and SGUT-505.

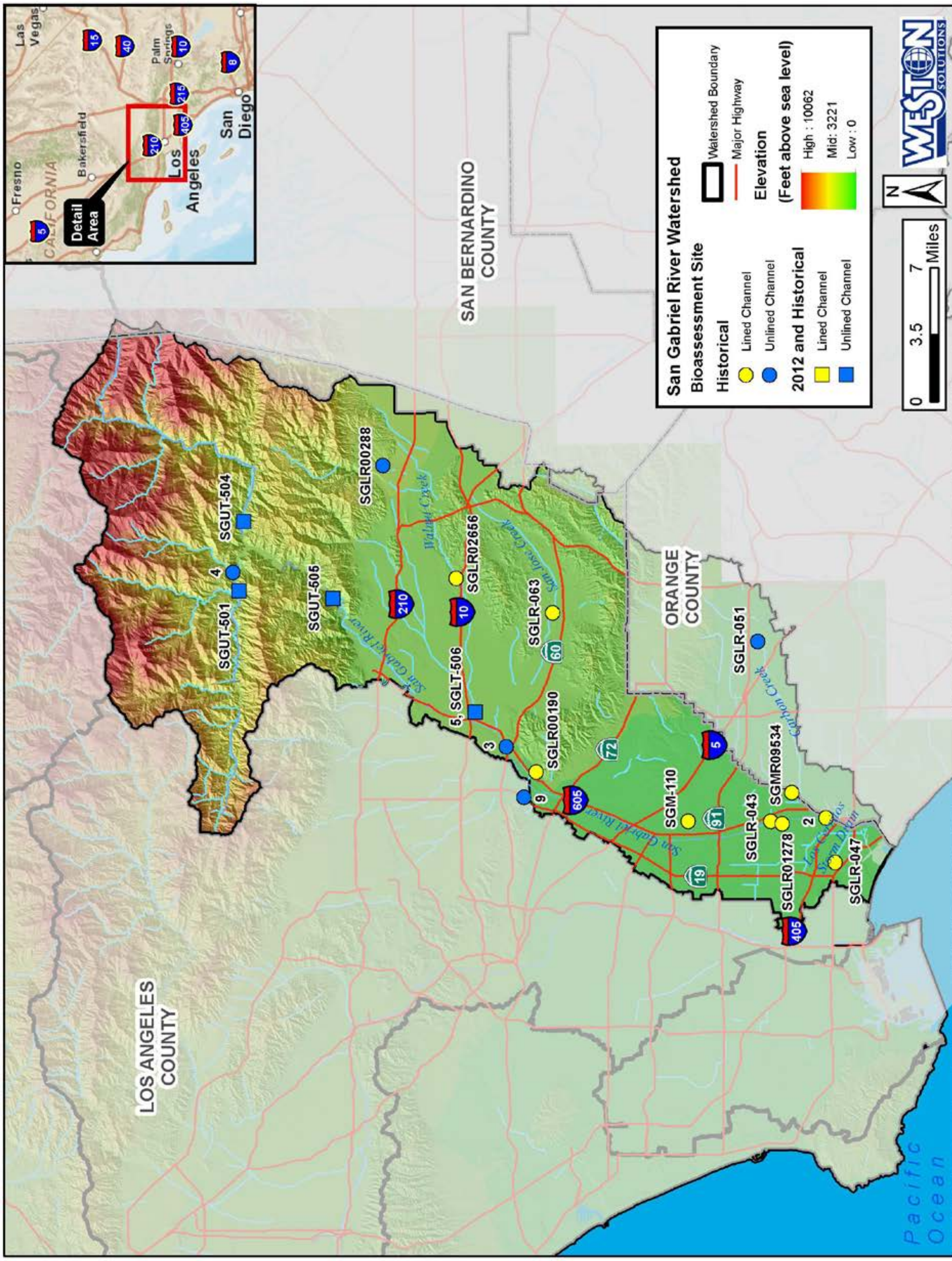


Figure 13. Bioassessment Monitoring Sites in the San Gabriel River Watershed for 2003–2012

Mean Metric Analysis for 2003–2012

Table 6 shows the mean biological metric values of four individual metrics that are considered strong indicators of ecological health. The concrete-lined channel sites are highlighted in yellow and unlined channel sites are highlighted in blue. Reference sites are signified with an asterisk following their site names. For consistency with historical surveys, the 2009 to 2012 taxa richness values were adjusted to taxonomic Level I from Level II.

Table 6. San Gabriel River Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2012

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
San Gabriel River	4*	2	24.0	12.0	3.1%	85.0%
San Gabriel River	SGUT-501*	4	43.3	21.0	37.5%	56.7%
San Gabriel River	SGUT-504*	7	27.0	12.5	11.7%	77.5%
San Gabriel River	SGUT-505	7	24.4	8.9	4.5%	72.5%
San Gabriel River	SGL00190	1	7.0	0.0	0.0%	73.5%
San Gabriel River	SGLR-043	1	13.0	0.0	0.0%	74.0%
San Gabriel River	SGLR-047	1	11.0	0.0	0.0%	90.0%
San Gabriel River	SGLR-063	1	14.0	3.0	0.0%	79.4%
San Gabriel River	SGM-110	1	4.0	1.0	0.0%	100.0%
San Gabriel River	SGLR01278	1	9.0	1.0	0.0%	97.2%
San Gabriel River	SGLR02656	1	11.0	3.0	0.0%	81.6%
San Gabriel River	SGLR00288	1	14.0	2.0	0.0%	50.6%
San Gabriel River	SGMR09534	1	10.0	1.0	0.0%	95.8%
Walnut Channel	5, SGLT-506	10	14.2	2.0	0.0%	84.6%
Zone 1 Ditch	9	1	21.0	5.0	0.0%	74.0%
Coyote Creek	2	2	11.0	2.3	0.0%	92.7%
San Jose Creek	3	2	10.5	2.0	0.0%	84.0%
Carbon Creek	SGLR-051	1	15.0	3.0	0.0%	72.0%

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
* = reference site
**2009-2012 taxa richness values adjusted from Level II to Level I taxonomy values

SGUT-501–San Gabriel River biological metric values indicated the presence of a substantially higher quality benthic community than at any other site. Values for mean taxa richness and EPT taxa were approximately 60% higher than the next highest values at SGUT-504–San Gabriel River, and the percent intolerant taxa was nearly four times greater. A clear difference also existed between the lower and upper watershed sites (Site 4 and the SGUT sites are considered upper watershed sites). The lower watershed sites had a maximum mean taxa richness of 21.0, whereas taxa richness in the upper watershed sites ranged from 24.0 to 43.3. The maximum mean number of EPT taxa in the lower watershed was 5.0 (and all other sites had three or less), whereas in the upper watershed, the mean number of EPT taxa ranged from 8.9 to 21.0. Intolerant taxa were absent from all lower watershed sites and comprised from 3.1% to 37.5% of the benthic community in the upper watershed. The percent collector–filterers plus collector–gatherers (i.e., collector taxa) ranged from 50.6% at SGLR-00288 to 100.0% at SGM-110. The ubiquity of these organisms means that, independently, the metric is not always an accurate indicator of impairment, and based on the IBI scoring ranges, a percentage of less than 80% collector taxa is indicative of Good biotic conditions. The reference sites in the watershed ranged from 56.7 to 85.0% collector taxa.

Comparison of Index of Biotic Integrity Scores for 2003–2012

SGUT-501–San Gabriel River was the highest ranking site by IBI scores in the watershed (Table 7) and was also at the highest elevation (Table 1). Of all the sites monitored, the three designated reference sites (i.e., SGUT-501, SGUT-504, and 4) were always rated unimpaired, whereas most other sites were rated impaired in all surveys. SGUT-505 was the only site that had IBI scores on both sides of the impairment threshold of 26 points. This site scored above the impairment threshold twice, with IBI scores of 33 and 29 in 2009 and 2010, respectively, and the 2012 IBI score was close to the seven year mean. None of the sites have shown any significant upward or downward trends for the sites sampled five or more times (i.e., SGUT-504, SGUT-505, and 5, SGLT-506). The total scoring ranges for these sites were up to 20 points, with no consistency among sites for better or worse years (e.g., the highest IBI scores were in 2010, 2009, and 2007, respectively, for SGUT-504, SGUT-505, and 5, SGLT-506). The cause for the relatively wide range of scores for SGUT-504, SGUT 505 and 5, SGLT-506 is unclear, but is likely due to natural biological variability. In 2007, when 5, SGLT-506 had its highest IBI score, there were few Ostracoda compared to 2010, 69 versus 759 individuals, respectively. The 2007 assemblage also had a much greater taxa richness of predators (most notably, large dragonfly nymphs), which likely reduced the ostracod abundance through predation. These fluctuations in population dynamics may occur naturally and are not necessarily due to any water quality stressor.

Table 7. San Gabriel River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2012

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	Mean IBI Score	IBI Range
San Gabriel River	4*	30	38									34.0	8
San Gabriel River	SGUT-501*							62	56	60	56	58.5	6
San Gabriel River	SGUT-504*				42	34	33	34	50	30	44	38.1	20
San Gabriel River	SGUT-505				20	25	18	33	29	14	26	23.6	19
San Gabriel River	SGLR00288							15				15.0	
San Gabriel River	SGLR02656							10				10.0	
San Gabriel River	SGL00190						6					6.0	
San Gabriel River	SGLR-043			21								21.0	
San Gabriel River	SGLR-047			14								14.0	
San Gabriel River	SGLR-063				17							17.0	
San Gabriel River	SGM-110					19						19.0	
San Gabriel River	SGLR01278							1				1.0	
San Gabriel River	SGMR9534							1				1.0	
San Gabriel River	SGLR-051			10								10.0	
Walnut Channel	5, SGLT-506	7	7	8	9	17	5	5	0	17	9	8.4	17

Table 7. San Gabriel River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2012

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	Mean IBI Score	IBI Range
Zone 1 Ditch	9	20										20.0	
Coyote Creek	2	3	9									6.0	6
San Jose Creek	3	8	10									9.0	2

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
no highlight = not sampled
* = reference site

Comparison of Concrete-Lined Channels and Unlined Channels for 2003–2012

All concrete-lined channel sites monitored in the San Gabriel River Watershed were in the lower watershed. A majority of these were sampled one year only and all had IBI scores under 26, indicating impaired biotic integrity (Table 7). The Wilcoxon Ranked Sum test was run with and without the reference sites, without making any exclusions based on location (i.e., upper or lower) in the watershed. When reference sites were excluded, a p-value of 0.097 resulted, and the mean IBI scores of the concrete-lined sites were not statistically lower than the unlined sites in the lower watershed (p-value less than 0.05 is significant; i.e., the chance of having this result is less than 5%), and the null hypothesis can safely (or significantly) be rejected. When reference sites from the upper watershed were also considered, the p-value decreased to 0.002, which signifies that the unlined sites were statistically superior to the concrete-lined sites.

Using a whisker–box plot to compare the two channel types, the mean IBI scores of the concrete-lined sites were similar to the unlined sites in the lower watershed (Figure 14). When the reference sites were added to the analysis, a statistically significant difference between site types resulted (i.e., the median line of unlined sites was above the 75th percentile line of the concrete-lined sites), which signified that the unlined sites had superior biotic integrity than the concrete-lined sites. This was likely due to the more natural water source and better physical habitat quality of the reference sites relative to the concrete-lined sites.

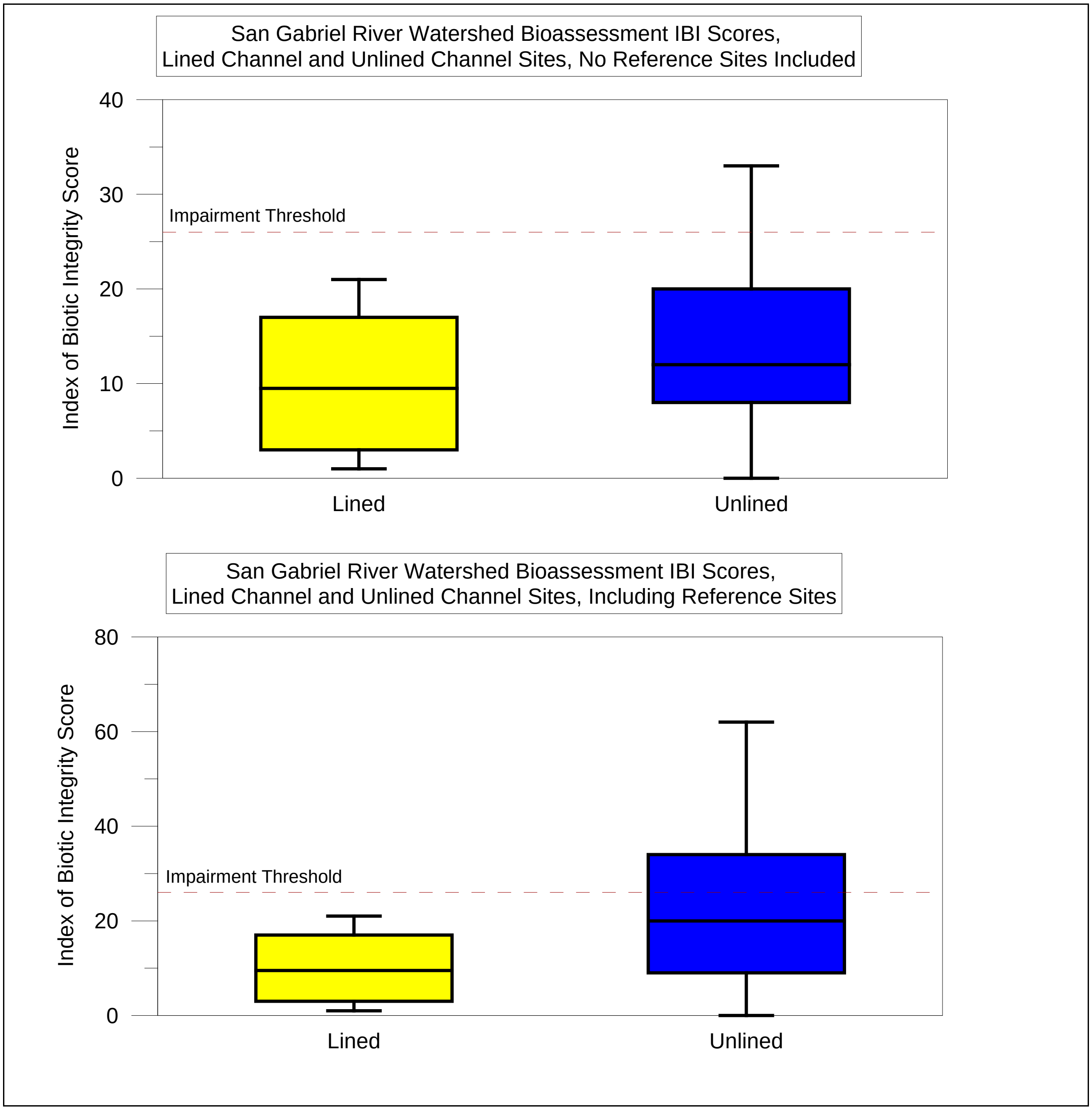


Figure 14. Comparison of Concrete-Lined and Unlined Channel Sites, San Gabriel River Watershed for 2003–2012

Comparison of Index of Biotic Integrity Scores and Elevation for 2003–2012

To examine the relationship of IBI scores and elevation, a Spearman rank correlation was conducted for IBI score versus elevation. The correlation coefficient for IBI versus elevation was 0.856. The correlation was significant, based on a critical value of 0.288 (47 samples and an alpha of 0.05). These results indicate that site IBI scores were significantly correlated to elevation and that IBI scores increased with elevation in this watershed. Additionally, a linear correlation of IBI scores and elevation indicated a significant relationship (R^2=0.733) between the two.

5.2 Los Angeles River Watershed Survey Results for 2003–2012

The Los Angeles River Watershed is similar to the San Gabriel River Watershed in that much of the upper watershed is in the Angeles National Forest, whereas the lower watershed is highly urbanized and has been modified with flood control channels, reservoirs, and spreading grounds. The Los Angeles River Watershed bioassessment monitoring sites have mainly been in the lower watershed, with the exception of 6–Arroyo Seco (Figure 15). Site 6–Arroyo Seco is located near the base of Millard Canyon just above the Arroyo Seco Spreading Grounds and received little or no urban runoff. The spreading grounds disrupt the hydrologic connectivity to such an extent that 7–Arroyo Seco, located approximately 4 miles downstream of 6–Arroyo Seco, was dominated by urban runoff. All other monitoring sites were in highly modified waterways in the lower watershed with either fully or partially concrete-lined channels. Because large areas of wilderness in the upper watershed have not been monitored as part of the Bioassessment Program, the full range of reference conditions has not been documented for this watershed.

The watershed has been sampled 57 times in nine locations from 2003 through 2012. Sites 8, LALT-502–Compton Creek and 7–Arroyo Seco have been sampled in all ten surveys, and all other sites have been sampled at least five times. Sites with "LALT" in the site code prefix were offset sites for the LARWMP study beginning in 2008 and have been sampled in tributaries to the Los Angeles River immediately above their confluence with the Los Angeles River.

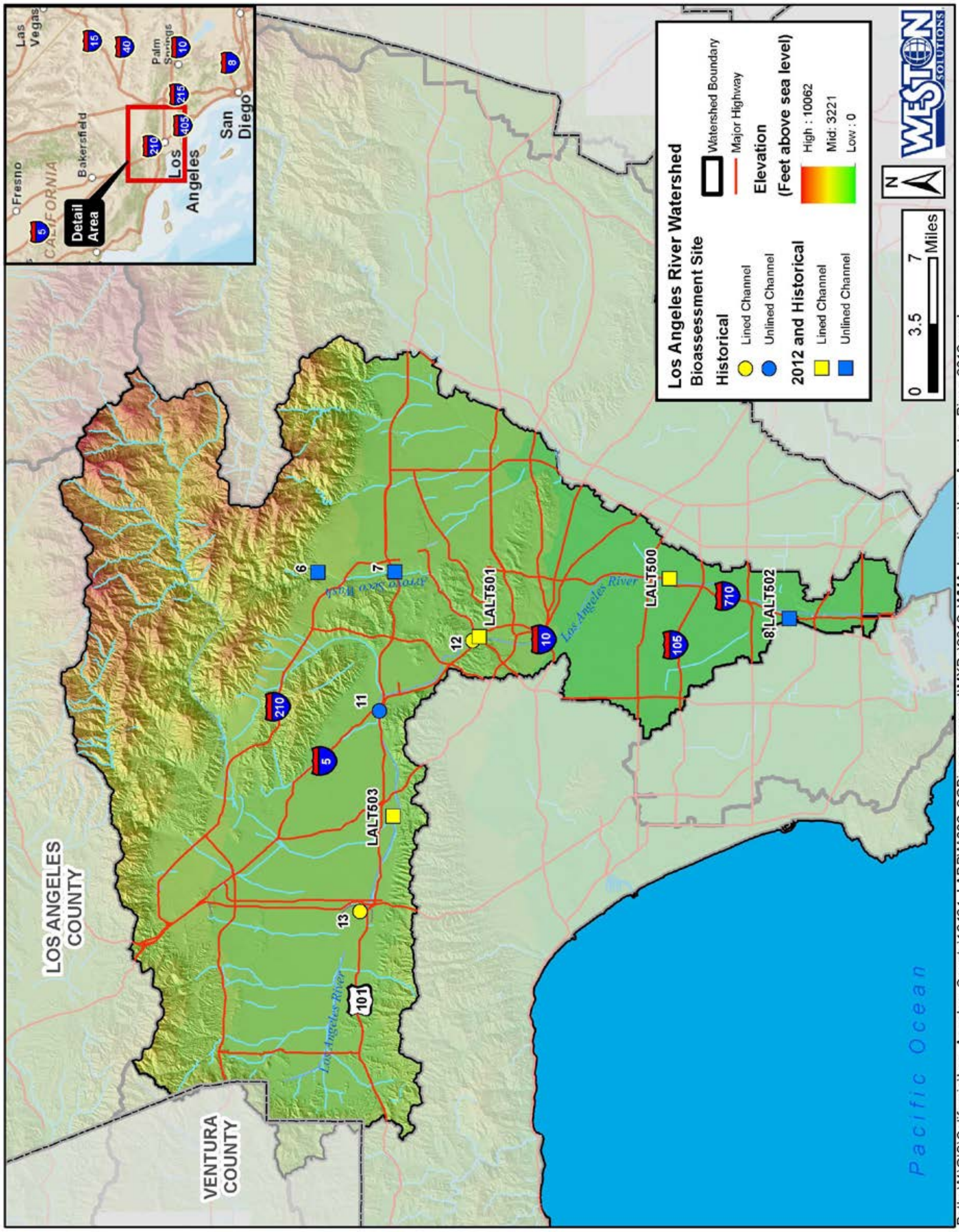


Figure 15. Bioassessment Monitoring Sites in the Los Angeles River Watershed for 2003–2012

Mean Metric Analysis for 2003–2012

Table 8 shows the mean biological metric values of four individual metrics that are considered strong indicators of ecological health. The concrete-lined channel sites are highlighted in yellow and unlined channel sites are highlighted in blue. Reference sites are identified by asterisks following their site names. The biological metric values at 6–Arroyo Seco indicated a higher quality benthic community than at any other site in the watershed. Values for taxa richnes and EPT taxa were substantially higher at 6–Arroyo Seco (30.4 and 9.6, respectively), and it was the only site where intolerant (sensitive) taxa were collected. The lower watershed sites had a maximum mean taxa richness of 16.4 and a maximum mean number of 2.9 EPT taxa, both of which were at 7–Arroyo Seco. The mean percent collector–filterers plus collector–gatherers ranged from 80.6% to 98.2% in the lower watershed and was 61.3% at 6–Arroyo Seco. These metrics indicate Poor biotic conditions in the lower watershed and Good biotic conditions at 6–Arroyo Seco.

Table 8. Los Angeles River Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2012

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Arroyo Seco	6*	8	30.4	9.6	2.3%	61.3%
Arroyo Seco	7	10	16.4	2.9	0.0%	80.6%
Los Angeles River	11	5	10.0	1.0	0.0%	98.2%
Los Angeles River	12	5	9.6	2.2	0.0%	90.3%
Los Angeles River	13	5	11.4	2.0	0.0%	94.7%
Rio Hondo	LALT500	5	13.0	1.6	0.0%	90.8%
Arroyo Seco	LALT501	5	12.2	2.6	0.0%	96.0%
Compton Creek	8, LALT502	10	12.4	1.4	0.0%	93.0%
Tujunga Wash	LALT503	5	12.6	1.6	0.0%	91.0%

yellow highlight = concrete-lined channel site

blue highlight = unlined channel site

*= reference site

**2009-2012 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Index Scores for 2003–2012

Site 6–Arroyo Seco has been the highest rated site in every survey since the beginning of the Bioassessment Program, with a mean IBI score of 38.8 of 70 and a quality rating of Fair (Table 9). This site also had the greatest range of IBI scores (27 points) with an IBI score of 23 in 2010 that was significantly lower than for any other survey. This was likely due to impacts of the Station Fire and subsequent erosion in the upper watershed that deposited substantial alluvial material in the sampling reach (see photographs below). In 2011, the IBI score was marginally above the impairment threshold, but in 2012 the site had recovered and the IBI score was greater than the eight year mean. All other sites had IBI scores ranging from Poor to Very Poor. Site 7–Arroyo Seco was the second highest rated site with a mean IBI score of 14.9 and a quality rating of Poor, although its 2010 and 2011 IBI scores increased 4 and 5 points, respectively, from any previous sample year. The site appeared to have been trending upward over the first nine years of sampling, but the IBI score was 10 in 2012, which was the second lowest score since 2003. One site, LALT501–Arroyo Seco, had its highest IBI score to date in 2012 (with an IBI of 20) while LALT500–Rio Hondo had its lowest IBI score to date (with an IBI of 2). The IBI score for site 8, LALT502 in 2010 was substantially (although not significantly) higher than for all previous years.

6–Arroyo Seco pre-fire, October 2008 (left) and post-fire, July 2010 (right)

Post-fire, July 2012

Table 9. Los Angeles River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2012

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	Mean IBI Score	IBI Range
Arroyo Seco	6*			38	50	40	42	50	23	27	40	38.8	27
Arroyo Seco	7	11	9	12	17	11	18	16	22	23	10	14.9	14
Los Angeles River	11	1	3	7	0	0						2.2	7
Los Angeles River	12	11	9	9	7	17						10.6	10
Los Angeles River	13	2	7	6	1	4						4.0	6
Rio Hondo	LALT500						3	9	13	8	2	7.0	11
Arroyo Seco	LALT501						2	6	19	14	20	12.2	18
Compton Creek	8, LALT502	1	3	4	6	6	3	6	6	12	6	5.3	11
Tujunga Wash	LALT503						3	5	18	12	6	8.8	15

yellow highlight = concrete- lined channel site
blue highlight = unlined channel site
no highlight = not sampled
* = reference site

Comparison of Concrete-Lined Channels and Unlined Channels for 2003–2012

All of the concrete-lined channel sites monitored in the lower watershed had IBI scores indicating impaired biotic integrity (Table 9). The Wilcoxon Ranked Sum test was run with and without the reference site. No exclusions were made based on location in the watershed. When reference sites were excluded, the p-value was 0.936, and the mean IBI scores of the concrete-lined sites were not statistically lower than the unlined sites in the lower watershed (p-value less than 0.05 is significant; i.e., the chance of having this result was greater than 5%). Therefore, the null hypothesis that concrete-lined and unlined sites in the lower watershed have similar IBI scores can safely (or significantly) be accepted. When the reference site from the upper watershed was considered, the p-value decreased to 0.140, and the unlined sites were still not statistically different from the concrete-lined sites. However, if more high-quality, unlined upper watershed sites had been sampled, there likely would have been a significant difference in IBI scores between the two site types.

Using a whisker–box plot to compare the two channel types, the mean IBI scores of the concrete-lined sites were similar to those of the unlined sites in the lower watershed (Figure 16). When the reference site was added to the analysis, a slight difference between site types resulted but not to a level of statistical significance. As with the Wilcoxon Ranked Sum test, this result is skewed by an under-representation of unlined sites in the upper watershed, as the IBI scores of 6–Arroyo Seco are clearly superior to all other sites in the watershed (Table 9).

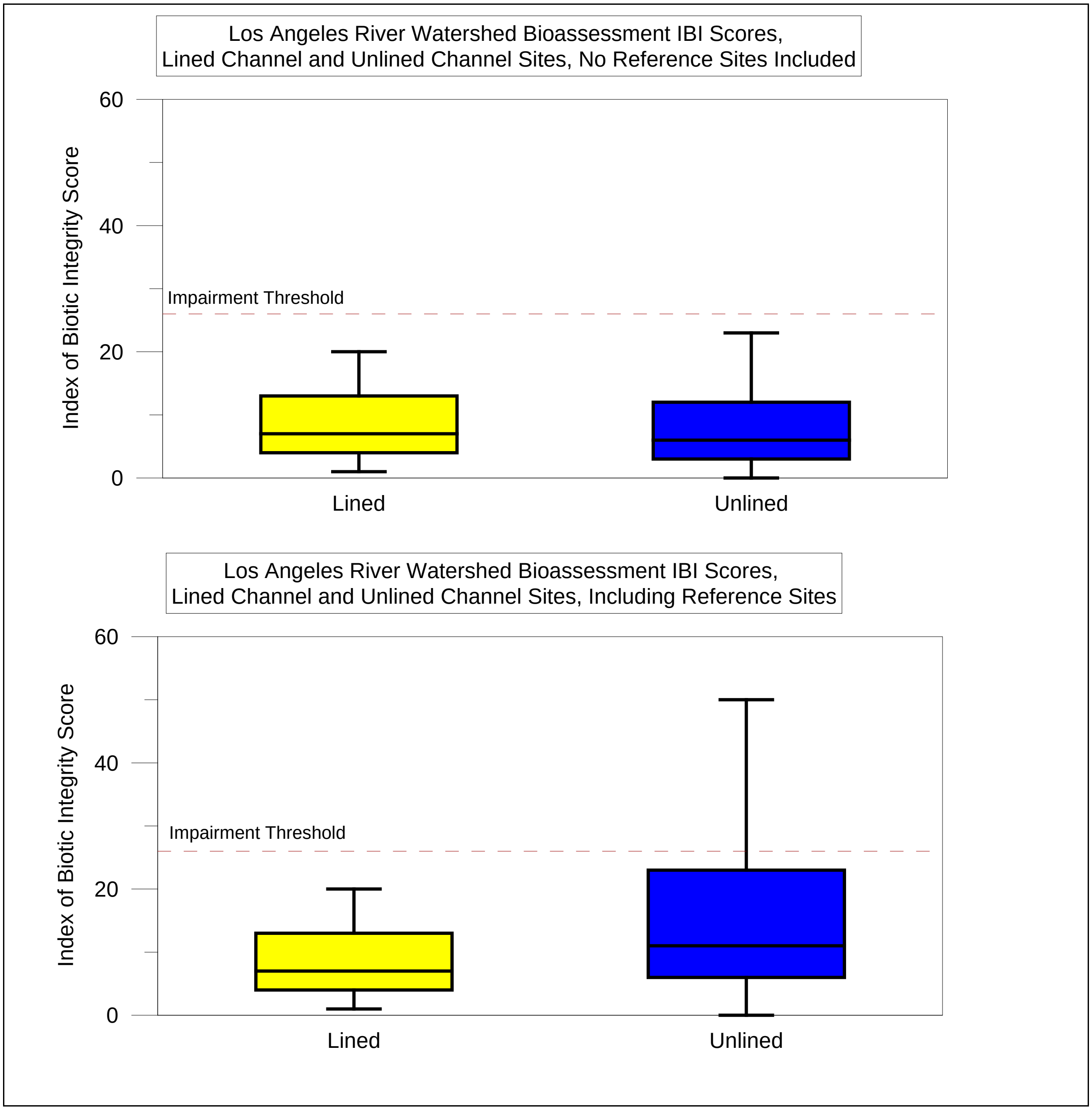


Figure 16. Comparison of Concrete-Lined and Unlined Channel Sites, Los Angeles River Watershed for 2003–2012

Comparison of Index of Biotic Integrity Scores and Elevation for 2003–2012

To examine the relationship of IBI scores and elevation, a Spearman rank correlation was conducted for IBI score versus elevation. The correlation coefficient for IBI versus elevation was 0.699. The correlation was significant based on a critical value of 0.261 (57 samples and an alpha of 0.05). This result indicates that site IBI scores were significantly and positively correlated with elevation. Additionally, a linear correlation of IBI scores and elevation indicated a significant relationship (R^2=0.489) between the two.

5.3 Dominguez Channel Watershed Survey Results for 2003–2012

The Dominguez Channel Watershed is located in the central portion of the Los Angeles Basin and is almost completely urbanized. The watershed boundary is defined not so much by topography but by a system of storm drains and flood control channels. The largest waterway is the Dominguez Channel, which discharges into the Los Angeles Harbor. The bioassessment monitoring site, 19–Dominguez Channel, has been been sampled every year since 2003 (Figure 17). Although the site was relocated approximately 0.5 miles upstream in 2006, the elevation change was approximately five feet and all other physical conditions were similar; therefore, the long-term analyses consider both locations as a single site. The site is within a fully concrete-lined channel and is upstream of any tidal influence. Because only one site was monitored in this watershed, the comparative analyses with unlined sites and elevation performed for the other watersheds were not possible.

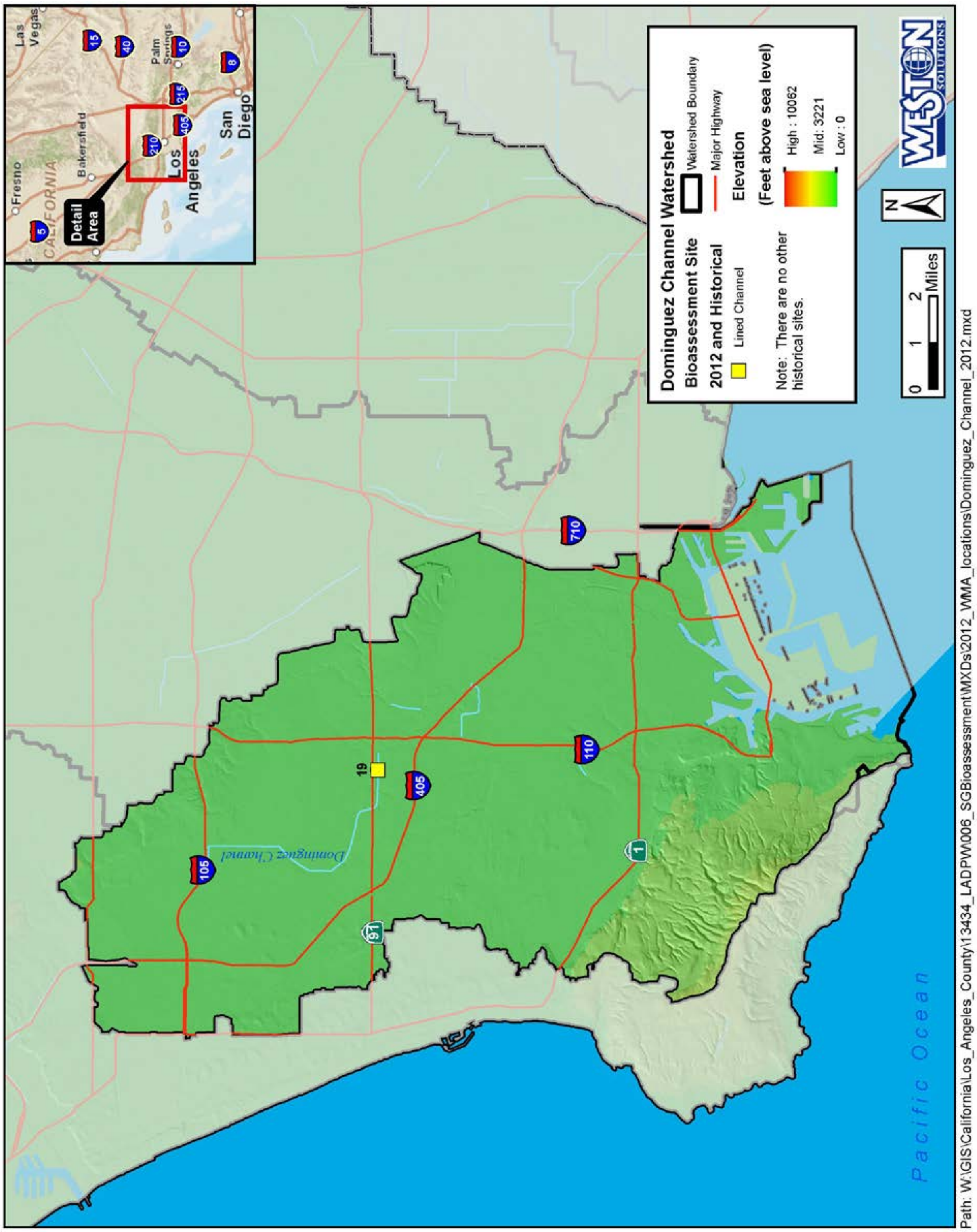


Figure 17. Bioassessment Monitoring Site in the Dominguez Channel Watershed for 2003–2012

Mean Metric Analysis for 2003–2012

Table 10 shows the mean biological metric values for 19–Dominguez Channel, which was sampled in a concrete-lined channel. All of the metrics indicated a low-quality benthic community at the site (i.e., taxa richness and EPT taxa were low, intolerant taxa were absent, and the percent collector taxa was high).

Table 10. Dominguez Channel Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2012

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Dominguez Channel	19	10	9.3	0.2	0.0%	95.1%
yellow highlight = concrete-lined channel site						
**2009-2012 taxa richness values adjusted from Level II to Level I taxonomy values						

The IBI scores for 19–Dominguez Channel have been consistently in the Very Poor range, with a mean IBI score of 1.9 (Table 11). The scores were consistently 0 or 1 for the survey years of 2005 to 2009. The 2010 IBI score of 7 was the highest to date, but was still statistically similar to all previous surveys, and in 2011 and 2012, the IBI score was 0. Figure 18 shows the IBI score ranges in a box plot.

Table 11. Dominguez Channel Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2012

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	Mean IBI Score	Range
Dominguez Channel	19	3	6	0	1	0	1	1	7	0	0	1.9	7
yellow highlight = concrete-lined channel site													

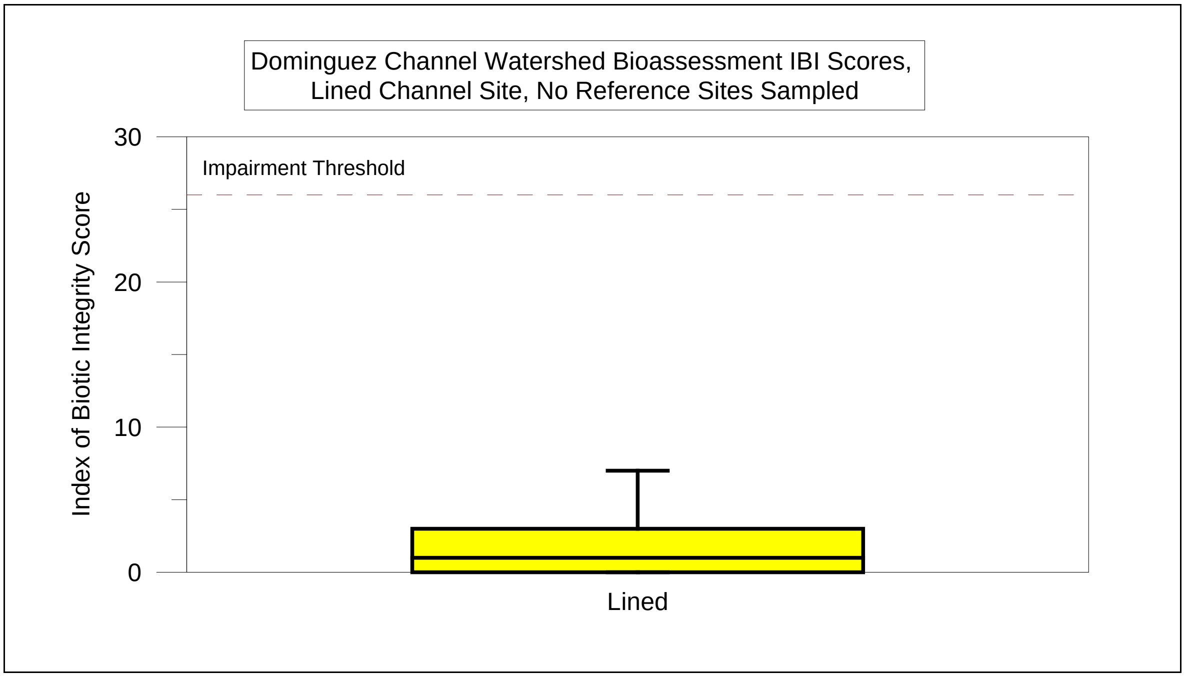


Figure 18. Index of Biotic Integrity Scores, Dominguez Channel Watershed for 2003–2012

5.4 Santa Monica Bay Watershed Survey Results for 2003–2012

The Santa Monica Bay Watershed shown in Figure 19 encompasses the Ballona Creek Watershed, the Malibu Creek Watershed, and several other small coastal drainages (e.g., Topanga Canyon, Trancas Canyon, and Arroyo Sequit). The Malibu Watershed and the adjacent watersheds contain large undisturbed areas of park land and natural preserves in the Santa Monica Mountains. In contrast to the other Los Angeles County watersheds, the majority of the urban runoff and related impacts occur in the upper reaches of the watersheds from urban centers along the Highway 101 corridor, most of which drain to Malibu Creek. The Ballona Creek Watershed is in a highly urbanized portion of the County.

The watershed has been sampled 46 times in 21 different locations from 2003 through 2012. Historically, four targeted monitoring sites were located in the upper Malibu Creek Watershed area, including one reference site, 17–Cold Creek. All of these were in unlined channels. A historical Ballona Creek monitoring site, 14–Ballona Creek, was within a fully concrete-lined channel. In 2009, all five historical sites were replaced with randomly placed SMC sites. These were then replaced by four new randomly placed SMC sites in 2010 and 2011, and then three sites in 2012. The invasive New Zealand mud snail (*Potamopyrgus antipodarum*) has been collected from several streams in the watershed. These include Malibu Creek, Trancas Canyon Creek, and in 2012, they were collected at SMC15464–Cold Creek.

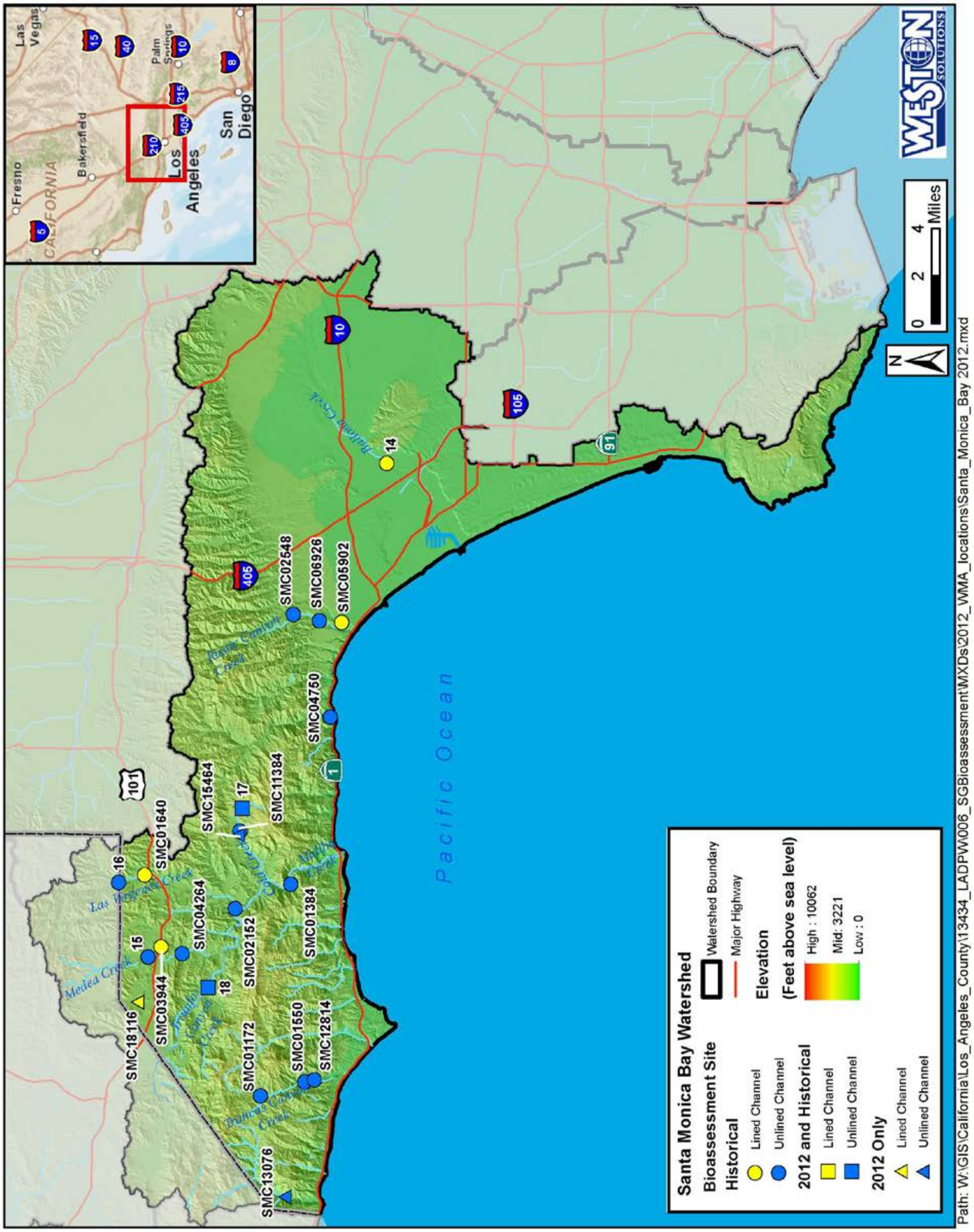


Figure 19. Bioassessment Monitoring Sites in the Santa Monica Bay Watershed for 2003–2012

Mean Metric Analysis for 2003–2012

Table 12 shows the mean biological metric values of four individual metrics that are considered strong indicators of ecological health. The concrete-lined channel sites are highlighted in yellow, and unlined channel sites are highlighted in blue. Reference sites are signified by an asterisk following their site names. Mean metric values for sites in Rustic Canyon (SMC02548), Trancas Canyon (SMC01172 and SMC12814), Cold Creek (17, SMC11384, and SMC15464), and Arroyo Sequit (SMC13076) indicated higher quality benthic communities than at other sites in this watershed. These seven sites had relatively high percentages of intolerant (sensitive) taxa and moderately high diversity of EPT taxa. Streams that were of substantially poorer quality included 14–Ballona Creek, Medea Creek (15 and SMC04264), Las Virgenes Creek (16 and SMC01640), SMC03944–Cheseboro Channel, SMC05902–Santa Monica Channel, and SMC18116–Lindero Canyon. These sites had mean taxa richness of 13 or less, two EPT taxa or less, no intolerant taxa, and 73% or more collector taxa. All other sites had moderate taxa richness, low to moderate EPT taxa, and intolerant taxa were present in most sites in low abundance.

Table 12. Santa Monica Bay Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2012

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Ballona Creek	14	6	10.5	1.8	0.0%	94.8%
Santa Monica Channel	SMC05902	1	6.0	2.0	0.0%	76.6%
Rustic Canyon Creek	SMC06926	1	21.0	5.0	1.0%	40.2%
Rustic Canyon Creek	SMC02548	1	22.0	11.0	70.0%	16.6%
Topanga Canyon Creek	SMC04750	1	24.0	8.0	1.2%	74.0%
Trancas Canyon Creek	SMC01172	2	24.5	4.0	3.5%	64.7%
Trancas Canyon Creek	SMC01550	1	21.0	4.0	13.8%	68.0%
Trancas Canyon Creek	SMC12814	1	26.0	9.0	7.0%	22.4%
Las Virgenes Creek	16	4	16.8	1.9	1.3%	89.8%
Las Virgenes Creek	SMC01640	1	4.0	0.0	0.0%	96.0%
Cold Creek	17*	7	31.7	11.3	36.9%	23.0%
Cold Creek	SMC11384	1	43.0	13.0	23.2%	32.0%
Cold Creek	SMC15464	1	44.0	13.0	4.2%	37.0%
Triunfo Creek	18	6	26.3	3.0	0.3%	63.0%
Malibu Creek	SMC01384	1	22.0	7.0	3.0%	33.8%
Malibu Creek	SMC02152	1	20.0	3.0	0.0%	24.2%
Arroyo Sequit	SMC13076	1	44.0	14.0	13.6%	60.0%
Cheseboro Canyon Channel	SMC03944	1	6.0	1.0	0.0%	95.8%
Lindero Canyon	SMC18116	1	13.0	2.0	0.0%	73.0%
Medea Creek	15	6	11.7	1.0	0.0%	82.4%
Medea Creek	SMC04264	1	13.0	2.0	0.0%	51.0%

yellow highlight = concrete-lined channel site

blue highlight = unlined channel site

* = reference site

**2009-2012 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Integrity Scores for 2003–2012

With the exception of 17–Cold Creek, the IBI scores in the Santa Monica Bay Watershed have indicated impaired biotic conditions in the middle to upper watershed areas in surveys conducted from 2003 to 2008 (Table 13). Site 17–Cold Creek was consistently the highest-rated site in the Bioassessment Program for those years and two SMC sites further downstream in Cold Creek (SMC11384 and SMC15464) also had relatively high IBI scores in 2011 and 2012. Since 2009, the results from SMC sites sampled in the Santa Monica Bay Watershed have revealed several low elevation streams with unimpaired biotic conditions, including Rustic Canyon Creek, Topanga Canyon Creek, Trancas Canyon Creek, and Arroyo Sequit. Topanga Canyon Creek was notable in that it was located at an elevation of 12 feet, approximately 300 meters from the discharge point into the Pacific Ocean.

The case of the two Rustic Canyon sites is a good example of the impacts of urban runoff on BMI communities. Two sites were sampled, one in 2009 and one in 2010. The sites were approximately one mile apart with a 200-foot elevation difference, yet the quality of the BMI communities was significantly higher at the upstream site (WESTON, 2012). This was likely due to the fact that the higher quality site, SMC02548, was above the influence of urban runoff while the lower site, SMC06926, was within the urban landscape

Table 13. Santa Monica Bay Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2012

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	Mean IBI Score	Range
Ballona Creek	14	6	10	7	5	10	4					7.0	6
Santa Monica Channel	SMC04750									13		13.0	
Rustic Canyon Creek	SMC02548								51			51.0	
Rustic Canyon Creek	SMC06926							26				26.0	
Topanga Canyon Creek	SCM04750									28		28.0	
Trancas Canyon Creek	SMC01172/ SMC01172 DUP							31/29				30.0	2
Trancas Canyon Creek	SMC01550							26				26.0	
Trancas Canyon Creek	SMC12814									34		34.0	
Las Virgenes	16			27	17	20	16					20.0	11
Las Virgenes	SMC01640							7				7.0	
Cold Creek	17*	42	52	49	53	52	55				54	51.0	13
Cold Creek	SMC11384									54		54.0	
Triunfo Creek	18	22		20	18	19	15				18	18.7	7
Malibu Creek	SMC01384							29				29.0	
Malibu Creek	SMC02152								17			17.0	
Cheseboro Channel	SMC03944								7			7.0	
Medea Creek	15	3	5	7	4	2	7					4.7	
Medea Creek	SMC04264								14			14.0	
Arroyo Sequit	SMC13076										44	44.0	
Lindero Canyon	SMC18116										13	13.0	
Cold Creek	SMC15464										43	43.0	

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
no highlight = not sampled
* = reference site
NA = Not Applicable

Comparison of Concrete-Lined Channels and Unlined Channels for 2003–2012

Five of the 21 sites monitored in the Santa Monica Bay Watershed were in fully concrete-lined channels (Table 13). All of these concrete-lined sites had mean IBI scores rated Very Poor in all surveys, while seven of the unlined sites were rated unimpaired (i.e. Fair and Good). The Wilcoxon Ranked Sum test was run with and without the reference site. No exclusions were made based on location in the watershed. When the reference site was excluded, a p-value of 0.004 resulted, and the mean IBI scores of the concrete-lined sites were statistically lower than the unlined sites in the lower watershed (p-value less than 0.05 is significant; i.e., the chance of having this result is less than 5%), and the null hypothesis that concrete-lined channels are equal to unlined channel sites can safely (or significantly) be rejected. When the reference site from the upper watershed was considered, the p-value decreased to 0.0007, and the statistical difference between the concrete-lined and unlined sites was greater.

Using a whisker–box plot to compare the two channel types, the mean IBI scores of the unlined sites were clearly statistically superior to the concrete-lined sites (i.e., the mean line of the unlined sites is above the 75th percentile of the concrete-lined sites) regardless of whether the reference sites were included (Figure 20). This contrasts slightly with the San Gabriel River Watershed and substantially with the Los Angeles River Watershed because there were a number of sites in the relatively pristine coastal watershed areas that were in reference condition but were not designated reference sites. The results of this analysis in 2011 and 2012 indicated a greater difference between the channel types compared to the 2009 and 2010 analyses (WESTON, 2010 and 2011) which resulted from the addition of several high scoring sites in the last two years.

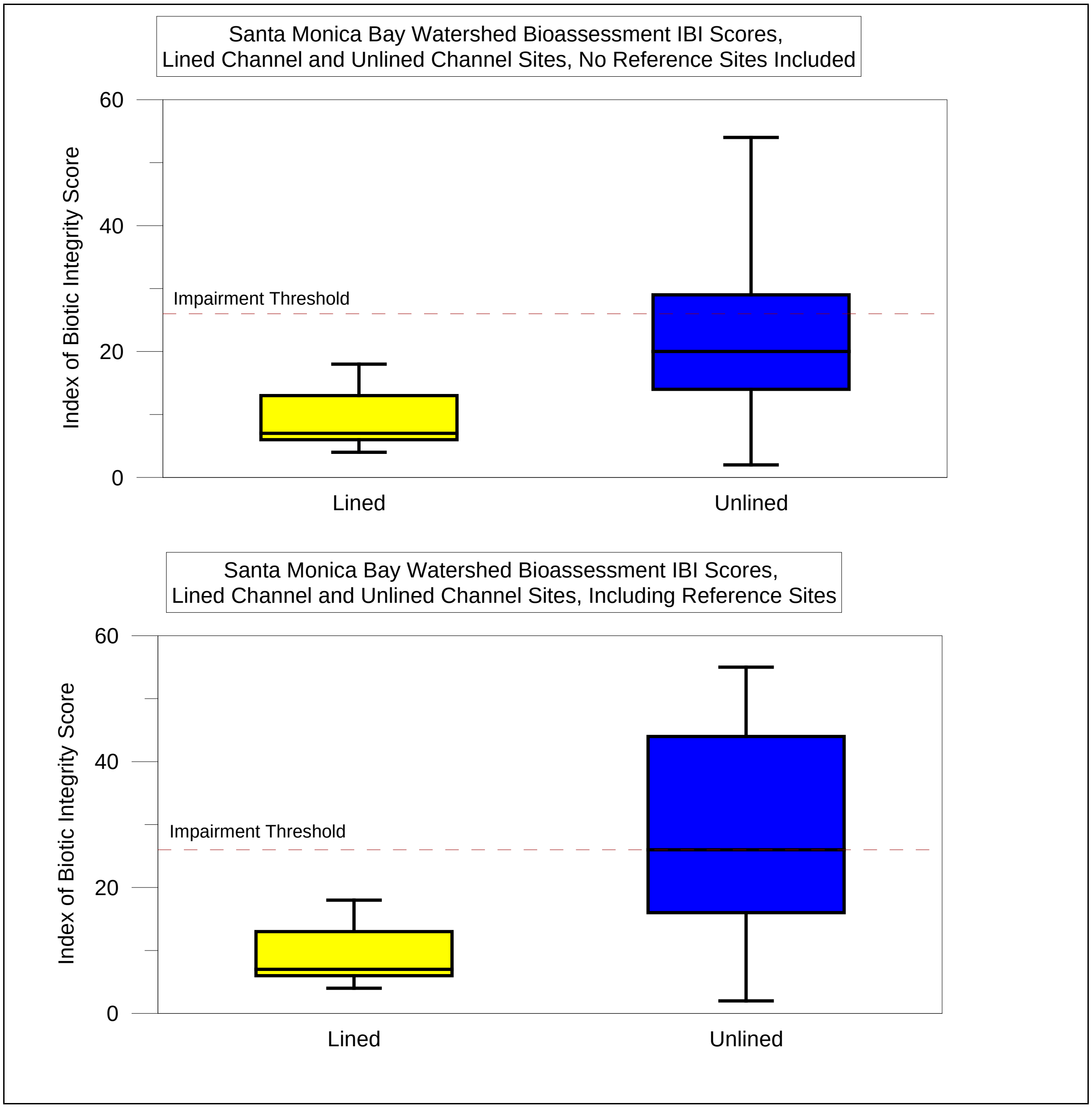


Figure 20. Comparison of Concrete-Lined and Unlined Channel Sites, Santa Monica Bay Watershed for 2003–2012

Comparison of Index of Biotic Integrity Scores and Elevation for 2003–2012

To examine the relationship of IBI scores and elevation, a Spearman rank correlation was conducted for IBI scores versus elevation. The correlation coefficient for IBI versus elevation was 0.412. The correlation was significant based on a critical value of 0.291 (46 samples and an alpha of 0.05). This result indicates that site IBI scores were weakly, yet significantly, related to elevation in this watershed. In many areas IBI scores decreased somewhat with increasing elevation and this was due to a greater amount of urban development in the upper watershed (which drains to Malibu Creek) and extensive forest land in the coastal sub-watersheds along the Malibu coast. A linear correlation of IBI scores and elevation indicated a somewhat weaker relationship (R^2=0.175) between the two than the Spearman rank correlation.

5.5 Santa Clara River Watershed Survey Results for 2003–2012

The upper portion of the Santa Clara River Watershed is in the County, with headwaters on the north slope of the San Gabriel Mountains (Figure 21). The lower watershed and outlet to the Pacific Ocean are in Ventura County. The mainstem of the Santa Clara River is unchannelized for its entire length, and a majority of the upper tributaries are non-perennial. Most of the urbanization in the upper watershed is associated with the City of Santa Clarita.

The watershed has been sampled 21 times at 13 different sites, including duplicate BMI sampling at three sites. Historically, one targeted site in the Santa Clara River mainstem, 1–Santa Clara River, was monitored every year from 2003 to 2008. An additional targeted site, 20–Bouquet Canyon, never had flowing water during the sampling period from 2003 through 2008. In 2009, these two targeted historical sites were replaced with two randomly placed SMC sites. In 2010 and 2011, there were three randomly placed SMC sites, and in 2012 there were four SMC sites in the watershed. Through 2010, all of the sites were in unlined channels of the Santa Clara River mainstem, which have been perennialized by urban runoff. Since 2010, there have been sites located in Castaic Creek (SMC8540), Towsley Creek (SMC01164), Bouquet Canyon (SMC02888), and Gleason Canyon (SMC04432).

Mean Metric Analysis for 2003–2012

Table 14 shows the mean values of four individual metrics that are considered strong indicators of ecological health. Nine of the 13 sites monitored were in the Santa Clara River mainstem. These sites were all located within eight miles of one another and had relatively similar habitat conditions with a willow-lined streambed dominated by sand. The majority of the results from these sites show similar biotic integrity, with moderate taxa richness, 4-6 EPT taxa, and no intolerant organisms. Of the four sites sampled outside of the Santa Clara River, three were of higher quality and one (SMC08540–Castaic Creek) was of lower quality. Sites in Towsley Creek, Bouquet Canyon and Gleason Canyon likely qualified as reference sites with little or no direct urban runoff. These three sites had greater taxa richness, had intolerant organisms that ranged from 0.2% to 19.0% of the community, and had substantially higher EPT taxa richness than in other areas of the watershed.

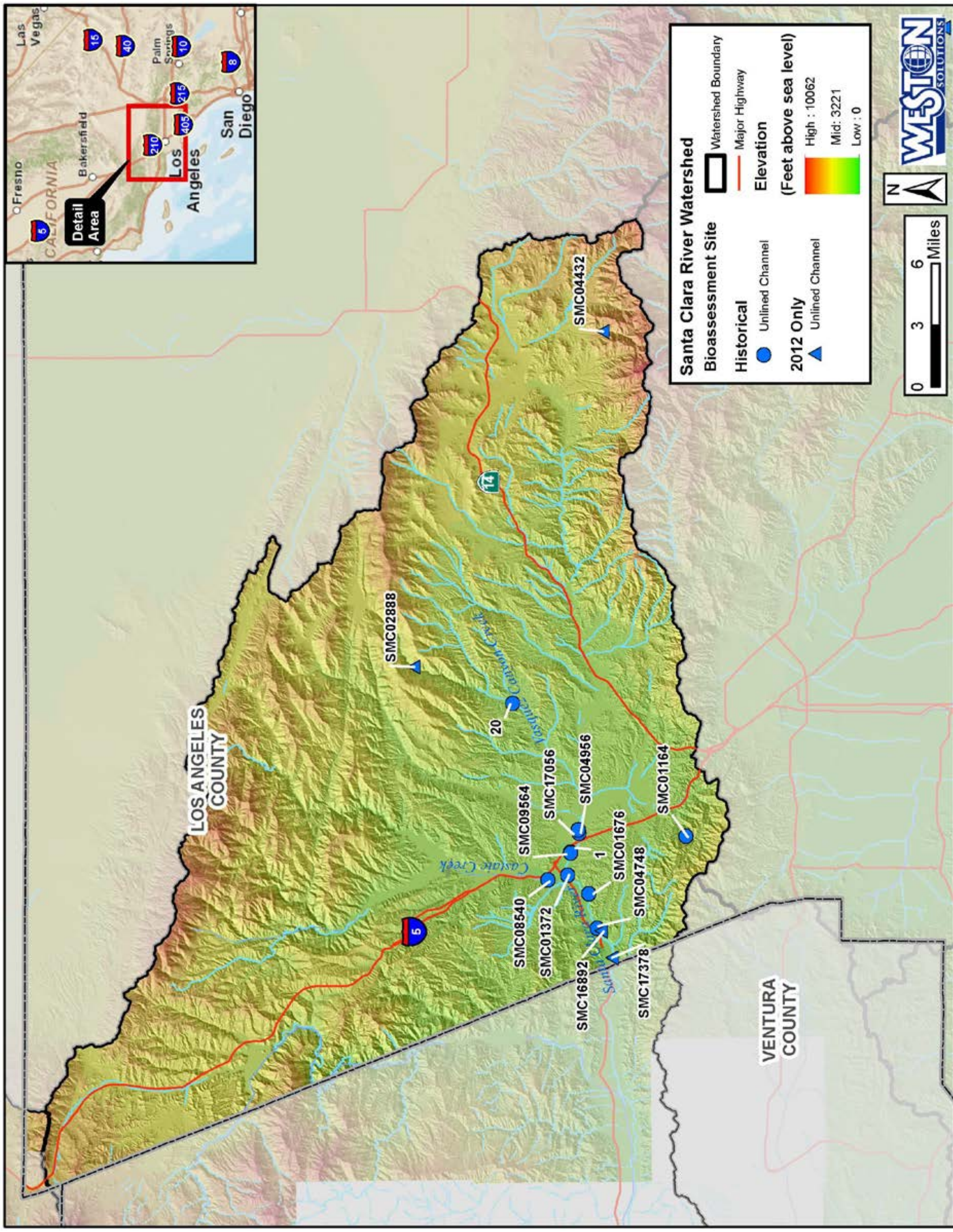


Figure 21. Bioassessment Monitoring Sites in the Santa Clara River Watershed for 2003–2012

Table 14. Santa Clara River Watershed Selected Metric Values, Annual Surveys for 2003–2012

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Santa Clara River	1	6	20.0	4.0	0.0%	69.4%
Santa Clara River	SMC04748	1	19.0	4.0	0.0%	81.4%
Santa Clara River	SMC17056	1	21.0	4.0	0.0%	69.6%
Santa Clara River	SMC01676	1	25.0	6.0	0.0%	73.6%
Santa Clara River	SMC01372/ SMC01372 Dup	2	21.0	5.0	0.0%	85.8%
Santa Clara River	SMC09564	1	14.0	5.0	0.0%	90.6%
Santa Clara River	SMC04956	1	23.0	4.0	0.0%	92.6%
Santa Clara River	SMC16892	1	24.0	4.0	0.0%	69.6%
Santa Clara River	SMC17378	1	27.0	6.0	0.0%	76.4%
Towsley Creek	SMC01164/ SMC01164 Dup	2	32.5	5.0	0.2%	74.4%
Castaic Creek	SMC08540	1	18.0	3.0	0.0%	85.0%
Bouquet Canyon	SMC02888/ SMC02888 Dup	2	28.0	10.5	19.0%	62.5%
Gleason Canyon	SMC04432	1	33.0	14.0	8.2%	75.0%

blue highlight = unlined channel site

**2009-2012 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Integrity Scores for 2003–2012

The nine sites in the Santa Clara River mainstem had IBI scores in the Poor to Fair range (Table 15 and Figure 22). Site 1–Santa Clara River has shown significant variability, with a total range of 17 points, and was the only site in the watershed to vary across three of the IBI rating categories. This was likely due to the heavy rains of 2005 that substantially eroded the streambed and flushed out most of the emergent vegetation, resulting in a low IBI score for that year. Since 2010, four sites in the Santa Clara River mainstem (SMC01372, SMC01676, SMC04956, and SMC17378) have scored above the impairment threshold. Generally, the further downstream a site was from Santa Clarita, the higher the IBI score. Three additional sites were rated unimpaired, including SMC1164–Towsley Creek, SMC02888–Bouquet Canyon, and SMC04432–Gleason Canyon. The Bouquet Canyon site had the highest IBI score in the watershed, with a score of 47 and a rating of Good.

Table 15. Santa Clara River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2012

Monitoring Reach	Station Number	IBI Score 2003	IBI Score 2004	IBI Score 2005	IBI Score 2006	IBI Score 2007	IBI Score 2008	IBI Score 2009	IBI Score 2010	IBI Score 2011	IBI Score 2012	Mean IBI Score	Range
Santa Clara River	1	21	19	10	24	27	24					20.8	17
Santa Clara River	SMC04748							22				22.0	
Santa Clara River	SMC17056							25				25.0	
Santa Clara River	SMC01676								28			28.0	
Santa Clara River	SMC01372/ SMC01372 Dup								31/23			27.0	8
Santa Clara River	SMC09564								17			17.0	
Santa Clara River	SMC04956									27		27.0	
Santa Clara River	SMC16892										21	21.0	
Santa Clara River	SMC17378										31	31.0	
Towsley Creek	SMC01164/ SMC01164 Dup									34/23		28.5	11
Castaic Creek	SMC08540									9		9.0	
Bouquet Canyon	SMC02888/ SMC02888 Dup										47/ 41	44.0	6
Gleason Canyon	SMC04432										45	45.0	

blue highlight = unlined channel site

no highlight = not sampled

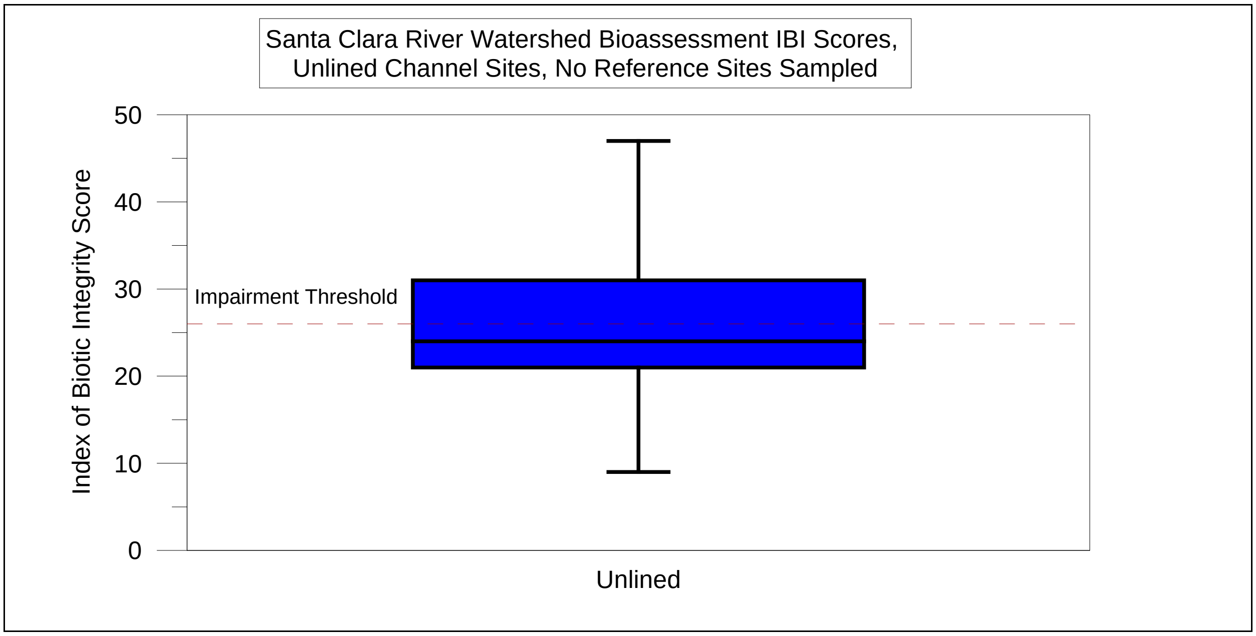


Figure 22. Index of Biotic Integrigy Scores, Santa Clara River Watershed for 2003–2012

Comparison of Index of Biotic Integrity Scores and Elevation for 2003–2012

To examine the relationship of IBI scores and elevation, a Spearman rank correlation was conducted for IBI scores versus elevation. The correlation coefficient for IBI versus elevation was 0.714. The correlation was significant based on a critical value of 0.435 (21 samples and an alpha of 0.05). These results indicate that site IBI scores were significantly correlated to elevation and that they increased with increasing elevation. This result is in contrast to previous year's results, which showed an insignificant and sometimes negative relationship. This was due to sampling that was limited to Santa Clara River mainstem sites that were within approximately 200 feet elevation of one another, with IBI scores that increased with increasing downstream distance from the City of Santa Clarita. The positive and significant correlation in 2012 was driven by the addition of several higher elevation sites with higher quality BMI communities. Additionally, a linear correlation of IBI scores and elevation also indicated a significant relationship (R^2=0.511) between the two.

6.0 SUMMARY

Twenty receiving water monitoring reaches representing five watersheds in the County were sampled for BMI and were assessed for physical habitat quality in June 2012. The monitoring reaches were located to provide an assessment of possible impacts associated with urban runoff and to evaluate the biological conditions for trend analysis of the BMI communities of the County. Since program inception in 2003, a total of 63 different sites have been sampled in ten annual surveys, and four of the sites have been sampled in all ten surveys.

Taxonomic evaluation of the 2012 samples yielded approximately 166 different taxa from 12,837 individual organisms by SAFIT Level II taxonomic effort, which was a higher level of effort than had been implemented in the sampling years 2003 to 2008, but the same level that has been implemented since 2009. In 2012, the most abundant organism collected throughout the County was Ostracoda (seed shrimp). Midges in the family Chironomidae were collected at all of the monitoring sites. The majority of organisms collected from the urban monitoring reaches were moderately or highly tolerant to stream impairments, and most of the sites were dominated by organisms in the two collector feeding groups. In 2012, all but two sites, SMC15464–Cold Creek and 17–Cold Creek, were dominated by organisms in this FFG. Site 17 was dominated by shredders, which feed on coarse organic material and the SMC site was dominated by scrapers in the family Hydrobiidae. The sexually mature hydrobiid specimens were identified as the invasive New Zealand mud snail, *Potamopyrgus antipodarum*.

The 2012 IBI scores of the monitoring reaches ranged from 0 (Very Poor) to 56 (Very Good) of a maximum of 70 points. SGUT-501–San Gabriel River was the highest rated site, and 17–Cold Creek, SMC02888–Bouquet Canyon, and SMC04432–Gleason Canyon were the second, third, and fourth highest rated sites, with IBI scores of 54, 47, and 45, respectively. Nine of the 20 sites monitoring were rated unimpaired by the IBI. Five of the monitoring reaches were located in highly modified, concrete-lined urban water courses. All of these sites had IBI ratings of Poor and Very Poor. The site with the lowest IBI score, 0, was 19–Dominguez Channel.

Comparison of the IBI scores for the ten survey years did not indicate any substantial trend toward degradation or improvement at any of the sites, and there were very few cases where a site varied between an impaired rating and an unimpaired rating. Trend analysis was not possible for sites that have been sampled for less than 4 years, which included 47 of the 63 monitoring sites. In 2011, 7–Arroyo Seco appeared be trending toward a statistically significant improvement in biotic integrity, but the 2012 results did not continue this trend

Correlation analysis between CRAM physical habitat scores and IBI scores indicated a significant relationship between physical habitat and biotic integrity. The analysis also indicated two general groups of sites that corresponded with (1) the concrete-lined and altered channel sites and (2) the natural channel sites and indicated that sites with relatively high CRAM scores could have low IBI scores while all sites with high IBI scores also had high CRAM scores. An additional analysis of physical habitat quality attributes at targeted sites did not indicate degradation through time at any of the sites. Two sites have had temporary alterations of physical habitat and biotic integrity due to high storm flows, and both of these have since recovered.

Analysis of individual metrics as well as total IBI scores showed that in the San Gabriel, Los Angeles, and Santa Clara River watersheds, monitoring sites located in the lower watershed had lower-quality benthic communities than sites located in the middle to upper reaches of the watersheds. In these two watersheds, a positive and significant difference existed between site elevation and IBI scores. In the Santa Monica Bay Watershed this correlation was very weak, and IBI scores tended to decrease with elevation, although the correlation was not statistically significant. This result was likely due to the fact that many of the lower elevation sites along the Malibu Coast were in relatively pristine sub-watersheds while the higher elevation sites along the Highway 101 corridor were much more developed.

An analysis of the difference between concrete-lined sites and unlined sites often indicated no statistically significant difference in IBI scores when the analysis was limited to sites located in the heavily urbanized lower watershed areas. When reference and mid- to upper-watershed sites were added to the analysis, the difference in IBI scores between concrete-lined sites and unlined sites was of much greater significance. The magnitude of difference in IBI scores between concrete-lined and unlined sites was variable from year to year. In 2011 and 2012, a greater difference existed between the lined and unlined sites than in the past, due to the random selection of high quality SMC sites. When this analysis was performed by watershed, the lower Los Angeles River and San Gabriel River Watershed site results did not show a difference between concrete-lined and unlined sites, whereas in the Santa Monica Bay Watershed, the difference between concrete-lined and unlined site results was much greater. This analysis was not performed in the Santa Clara River Watershed because no lined sites were sampled.

The two-way cluster analysis of 2012 taxa and sites indicated some clustering by taxa, with all of the sensitive taxa contained within a single cluster. Overall, the sites appeared to cluster more readily according to site physical conditions and location in the watershed relative to urban development, and generally confirmed the correlation between BMI assemblages and these factors. The open space watershed sites with natural channels and complex substrates had the strongest clustering, many of the Santa Clara River Watershed sites with unconsolidated sandy substrates clustered together, and the fully concrete-lined sites were contained within two of the five clusters. The lower watershed and concrete-lined sites were populated primarily with abundant, ubiquitous, and opportunistic organisms common to most sites, whereas the open space sites often had distinctive benthic communities, with a number of unique and/or sensitive taxa present at each site. Cluster analysis of all taxonomic data from 2003 to 2012 had results similar to the 2012 data, but with overall stronger associations between BMI assemblages, site IBI scores, and site physical characteristics than was observed in the analysis that considered only the 2012 sites.

An analysis of potential stressors to the BMI community was performed. These were divided into physical habitat attributes and water quality constituents and were compared to IBI scores. The two physical conditions that were most strongly related to IBI scores were substrate complexity (positive relationship) and channel alteration (negative relationship) and the water quality constituents most strongly related to IBI scores were dissolved ionic constituents and total and dissolved organic carbon. Using a step-wise multiple regression approach, several significant relationships between IBI scores and a combination of predictors were found. However, although a significant relationship was found, the predictive ability of the model was poor. Therefore, it is not possible to accurately predict IBI scores although several analytes are useful as "indicators" that biotic integrity will likely be impaired (e.g., total dissolved solids, chloride, and sulfate). An analysis of the effect of organophosphorus and pyrethroid pesticides showed that all of the sites where pesticides were detected had impaired biotic integrity and the difference in IBI scores was statistically significant.

7.0 FUTURE PROJECTIONS FOR BIOASSESSMENT

As the science of bioassessment monitoring continues to evolve, further modifications in monitoring protocols and methods are likely. Regulatory issues are likely to emerge as well, including the implementation of biological objectives or "biocriteria." This may require NPDES MS4 Permit holders to evaluate and implement ways to increase the biotic integrity of receiving waters (e.g., elevate a stream site's IBI score or another prescribed metric). Preliminary meetings regarding these potential requirements indicate that not all waterbodies will be considered equally and that biological objectives will consider existing (and potentially unmitigable) limitations on BMI colonization. These limitations may include attributes such as physical habitat constraints, natural perturbations, and cost-prohibitive mitigations, although these have yet to be defined. The development of a scientifically defensible set of biotic conditions throughout California is expected to be completed by the end of 2013, and this will set the baseline for the biocriteria regulatory framework. The regulatory requirements will be determined independently of the scientific analysis, and has the potential to become contentious.

There is a new assessment tool nearing completion that will likely replace the multi-metric IBI currently in use. Draft versions of this tool refere to it as the "California Stream Condition Index", and it will combine the IBI with a new predictive model that is expressed as a ratio of the observed (O) taxa at a site to the expected (E) taxa at a site. This O/E ratio also considers other mitigating factors that could affect BMI colonization independent of water source. These factors may include location in the watershed, rainfall, geology, or other natural ecological conditions. The O/E currently used in California seems to work better for low-gradient, depositional stream reaches where the physical habitat naturally suppresses BMI colonization than the IBI. The combination of a multi-metric index and a predictive index should improve the accuracy of using the two individually, since past experience has shown that both have limitations when assessing unusual BMI assemblages. Specifically, the IBI may underscore a site with a small number of sensitive organisms that is otherwise unimpaired, and the O/E may overscore a site with a high diversity of impairment tolerant organisms.

The development of a single physical habitat metric is being considered by SWAMP, although it has yet to be initiated at this time. Currently, the methodology for stream physical habitat assessment utilizes two separate protocols (i.e., SWAMP and CRAM). Both protocols assess unique attributes of the physical habitat, but there is also some redundancy between them. Streamlining of protocols by a state agency (e.g., SWAMP and/or CDFG) would increase efficiency of the assessment but may require approval by the State Water Resources Control Boards (SWRCBs) and RWQCBs and subsequent incorporation into the NPDES MS4 Permit.

Research to develop algal biological metrics and an algae-specific IBI for southern California is complete and under independent review. The research was conducted by SCCWRP through grant funding from the United States Environmental Protection Agency and incorporated data generated from a variety of NPDES monitoring programs. Algae respond more quickly and to different ecological stressors than BMI (particularly nutrients and sedimentation), and there is a general consensus that this monitoring tool is complementary to BMI assessment and that the addition of algal assessments will provide a more comprehensive understanding of anthropogenic impacts to the stream biota. Algal sampling and analysis is currently part of the SMC program SOW, and has the potential to become a requirement for NPDES permit compliance monitoring.

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