2011
BIOASSESSMENT MONITORING PROGRAM IN LOS ANGELES COUNTY

MARCH 2012

FINAL REPORT

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

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Prepared for:

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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
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, under the enforcement of the Los Angeles Regional Water Quality Control 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, a total of nine 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, and June/July 2011.

In 2011, the Bioassessment Program incorporated three collaborative monitoring programs in addition to the basic NPDES Program. The three programs included the San Gabriel River Regional Monitoring Program (SGRRMP), the Los Angeles River Watershed-Wide Monitoring Program (LARWMP), and the Stormwater Monitoring Coalition (SMC) Southern California Regional Watershed Monitoring Program (SMC Program).

Study Area and Monitoring Sites

The study area consisted of 18 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 (SMBW), including Malibu Creek Watershed and Ballona Creek Watershed: four sites.
- Santa Clara River Watershed: three sites.

From June 22, 2011 to July 22, 2011, 18 sites were sampled. Three of the sites originally identified in the Scope of Work (SOW) were unacceptable for sampling. These were randomly selected sites that were subsequently rejected as unsuitable for bioassessment monitoring, most frequently for non-perennial flow conditions or lack of wadeability. Three of the monitoring reaches (SGUT-501–San Gabriel River, SGUT-504–San Gabriel River, and 6–Arroyo Seco) were considered reference sites because they were located in areas of minimal upstream urban development and runoff in un-altered channels. Five of the other sites were located in concrete-lined channels: LALT500–Rio Hondo, LALT501–Arroyo Seco, LALT503–Tujunga Wash, 19–Dominguez Channel, and SMC05902–Santa Monica Channel. All ten 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 2011 data and the 2003 to 2011 data.

Findings

Taxonomic evaluation of the 2011 samples yielded 138 different taxa from 10,398 individual organisms. The mayfly *Baetis* sp. was the most abundant organism collected throughout the County, and mayflies in the family Baetidae 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. Sixteen of the 18 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 2011 study ranged from 0 to 60 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 Poor and Very 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 9 survey years through 2011 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 appears to be trending toward a statistically significant improvement in BMI community quality.

An analysis of the benthic community quality in concrete-lined sites versus unlined sites for all watersheds combined in 2011 indicated a statistically significant difference in IBI scores between sites located in the lower watershed areas 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. In the Los Angeles River Watershed, lower elevation concrete-lined sites had slightly superior BMI communities than the

unlined sites. 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 2011 data combined had an R^2 of 0.564, indicating a significant relationship between the two.

Conclusion

Stream bioassessment monitoring of the watersheds of the County has been conducted for 9 consecutive years beginning in October 2003, at a total of 56 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. 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. Only one site, 7-Arroyo Seco, has shown a general trend toward BMI community quality improvement, and no results 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 for 2011

Receiving Waterbody	Site Code	IBI Score (0–70 scale)	IBI Rating
San Gabriel River Watershed			
San Gabriel River (unlined channel)	SGUT-501	60	Very Good
San Gabriel River (unlined channel)	SGUT-504	30	Fair
San Gabriel River (unlined channel)	SGUT-505	14	Poor
Walnut Channel (unlined channel)	5, SGLT-506	17	Poor
Los Angeles River Watershed			
Arroyo Seco (unlined channel)	6	27	Fair
Arroyo Seco (unlined channel)	7	23	Poor
Rio Hondo (lined channel)	LALT500	8	Very Poor
Arroyo Seco (lined channel)	LALT501	14	Poor
Compton Creek (unlined channel)	8, LALT502	12	Very Poor
Tujunga Wash (lined channel)	LALT503	12	Very Poor
Dominguez Channel Watershed			
Dominguez Channel (lined channel)	19	0	Very Poor
Santa Monica Bay Watershed			
Topanga Canyon Creek (unlined channel)	SMC04750	28	Fair
Santa Monica Channel (lined channel)	SMC05902	13	Very Poor
Cold Creek (unlined channel)	SMC11384	54	Good
Trancas Canyon Creek (unlined channel)	SMC12814	34	Fair
Santa Clara River Watershed			
Towsley Creek (unlined channel)	SMC01164/ SMC01164 Dup	34/ 23	Fair/ Poor
Santa Clara River (unlined channel)	SMC04956	27	Fair
Castaic Creek (unlined channel)	SMC08540	9	Very Poor

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 (random site)

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 2011, the Bioassessment Program incorporated three monitoring programs in addition to the NPDES Program. These included the San Gabriel River Regional Monitoring Program (SGRRMP), Los Angeles River Watershed-Wide Monitoring Program (LARWMP), and the SMC Southern California Regional Watershed Monitoring Program (SMC Program).

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 18 monitoring sites in the Los Angeles Basin conducted from June 22, 2011 to July 22, 2011, 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 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.

Five of the monitoring sites were located in concrete-lined channels: LALT500–Rio Hondo, LALT501–Arroyo Seco, LALT503–Tujunga Wash, 19–Dominguez Channel, and SMC05902–Santa Monica Channel. Three 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, and 6–Arroyo Seco. All ten remaining sites were in unlined channels.

Table 1. Los Angeles County Flood Control District Stream Bioassessment Monitoring Stations, 2011

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, 6/29/2011	N 34.24067º W -117.88215º	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, 6/30/2011	N 34.23652º W -117.81664º	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, 6/29/2011	N 34.17133º W -117.88762º	Targeted/fixed site for SGRRMP	898
5, SGLT-506	T	Walnut Creek Unlined Channel	Walnut Channel upstream of San Gabriel River, 6/30/2011	N 34.06180º W -117.99314º	Targeted/fixed site for SGRRMP	298
Los Angeles River Watershed: six sites						
6	T	Arroyo Seco Unlined Channel	Upstream of Arroyo Seco Spreading Grounds, 6/22/2011	N 34.20327º W -118.16647º	Upstream reference site with minimal impact from residential land use	1,118
7	T	Arroyo Seco Unlined Channel	Arroyo Seco downstream from Interstate 134, 6/22/2011	N 34.144963º W -118.165102º	Assess impacts of residential land use	725
LALT500	T	Rio Hondo Lined Channel	Rio Hondo at Los Angeles River, 6/27/2011	N 33.93555º W -118.17200º	Offset site for the LARWMP	82
LALT501	T	Arroyo Seco Lined Channel	Arroyo Seco at Los Angeles River, 6/27/2011	N 34.08677º W -118.21076º	Offset site for the LARWMP	300
8, LALT502	T	Compton Creek Unlined Channel	Compton Creek at Los Angeles River, 6/27/2011	N 33.84622º W -118.20922º	Offset site for the LARWMP	22

Table 1. Los Angeles County Flood Control District Stream Bioassessment Monitoring Stations, 2011

Site	Targeted (T) or Random (R) SMC Site	Receiving Waterbody	Location, Date Sampled	Coordinates	Justification	Elevation (feet above sea level)
LALT503	T	Tujunga Wash Lined Channel	Tujunga Wash at Los Angeles River, 6/27/2011	N 34.14691º W -118.38932º	Offset site for the LARWMP	578
Dominguez Channel Watershed: one site						
19	T	Dominguez Channel Lined Channel	Dominguez Channel upstream of Vermont Avenue, 7/5/2011	N 33.87111º W -118.29683º	Assess impacts from upper Dominguez Channel Watershed	3
Santa Monica Bay Watershed: four sites						
SMC04750	R	Topanga Canyon Creek Unlined Channel	Topanga Canyon Creek along South Topanga Canyon Boulevard 7/5/2011	N 34.04100º W -118.58147º	Random site for the SMC Regional Monitoring Program	12
SMC05902	R	Santa Monica Channel Lined Channel	Santa Monica Channel along East Channel Road 6/28/2011	N 34.03432º W -118.51219º	Random site for the SMC Regional Monitoring Program	90
SMC11384	R	Cold Creek Unlined Channel	Cold Creek along Mulholland Highway 6/28/2011	N 34.09553º W -118.66522º	Random site for the SMC Regional Monitoring Program	890
SMC12814	R	Trancas Canyon Creek Unlined Channel	Trancas Canyon Creek above Paseo Canyon Drive 7/22/2011	N 34.04892º W -118.84641º	Random site for the SMC Regional Monitoring Program	160
Santa Clara River Watershed: three sites						
SMC01164	R	Towsley Creek Unlined Channel	Towsley Creek above Towsley Canyon Road 6/24/2011, 7/22/2011	N 34.35079º W -118.57968º	Random site for the SMC Regional Monitoring Program	1,630
SMC04956	R	Santa Clara River Unlined Channel	Santa Clara River mainstem upstream of Interstate 5 6/23/2011	N 34.42709º W -118.57490º	Random site for the SMC Regional Monitoring Program	1,066
SMC08540	R	Castaic Creek Unlined Channel	Castaic Creek along Live Oak Road 6/23/2011, 7/6/2011	N 34.44829º W -118.61770º	Random site for the SMC Regional Monitoring Program	1,012

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

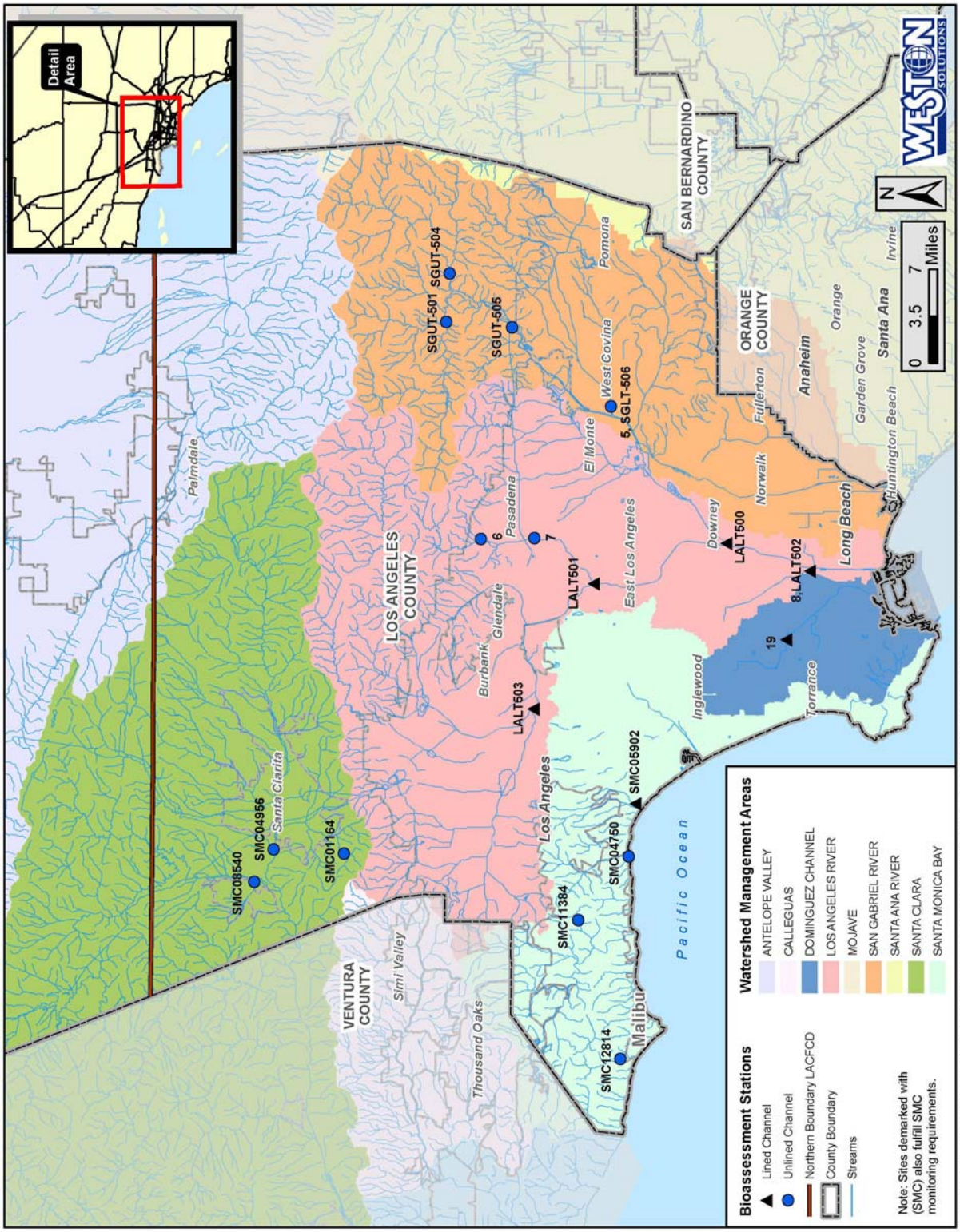


Figure 1. Stream Bioassessment Monitoring Locations for 2011

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., 2008) was also performed at the SMC sites. These documents may be referenced for more detailed procedural information.

The sampling and analysis for the 2011 survey was performed using the same protocols as in the 2009 and 2010 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 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 LASGRWC, 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 2011, the 18 sites sampled included 11 targeted sites that have been sampled historically and seven random sites that were sampled for the first time in 2011. In 2011, 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. Three of the sites originally identified in the SOW were unacceptable for sampling. These were randomly selected sites that were subsequently rejected for conditions that made them unsuitable for bioassessment monitoring. Additionally, one site that was accepted during site reconnaissance was subsequently rejected after the BMI samples were processed because the site had intermittent flow and none of the

BMI were alive at the time of sample collection. A site in Trancas Canyon, SMC12814, was added to replace the rejected site.

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 were established 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.

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 2011 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. Every monitoring site was 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 USEPA 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 also performed at all locations, although it was only required at SMC sites. In 2010 and 2011, CRAM was only performed at the SMC random sites.

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 method is relatively new, and the scoring system has yet to be calibrated to give ratings such as ‘Poor’ or ‘Good.’

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. BMI community-based metric values were calculated from the entire database. For calculation of 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

Table 2. Bioassessment Metrics Used to Characterize Benthic Invertebrate Communities

Metric	Description	Expected Response to Impairment
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 2011 AND 2003 THROUGH 2011

The 2011 Survey was conducted in June and July. A discussion of the 2011 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.

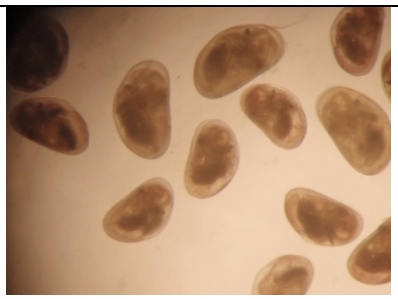
The reader may notice seeming discrepancies between the number of unique taxa listed in the metrics tables and the apparent number of taxa in the taxa list. This was due to fact that the metrics were calculated on a randomly selected subset of 500 organisms and also to the presence of immature or damaged 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 – 2011 Study Area Summary

When all sites in the County study area are combined, a total of approximately 138 unique taxa were identified from 10,398 individual organisms (Appendix B.1 and Appendix B.2). The five most abundant taxa in descending order were the mayfly, *Baetis* sp., with 1,873 individuals; Ostracods (seed shrimp) with 1,018 individuals; the Chironomid midges *Cricotopus* and *Dicrotendipes* with 869 and 652 individuals, respectively; and the black fly *Simulium* with 559 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–gatherers 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 (55 taxa, including 33 Chironomid genera and species complexes), followed by Coleoptera (beetles) with 17 taxa, Trichoptera (caddisflies) with 15 taxa, and Ephemeroptera (mayflies) with 14 taxa (Appendix B.1). Two families of BMI, Chironomidae (midges) and Baetidae (minnow mayflies), were collected at every one of the monitoring sites.

Mayfly, *Baetis* sp


Seed Shrimp, Ostracoda

Various Chironomidae

Black Fly, *Simulium*

Figure 2. The Most Abundant Organisms Collected in Los Angeles County for the 2011 Survey

4.2 2011 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 2011, taxa richness per sample ranged from 11 taxa at LALT503–Tujunga Wash to 50 taxa at SMC11384–Cold Creek (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. On average, the unlined sites had approximately 47% greater taxa richness than the concrete-lined sites.

***Diversity and Dominance*—**Two diversity indices were calculated for each site: Shannon Diversity, which increases with diversity and weights for evenness of distribution among present taxa and Margalef Diversity, which increases with raw diversity values. Shannon Diversity values per site ranged from 1.1 at LALT503–Tujunga Wash to 3.2 at SMC11384–Cold Creek (Appendix B.3). Margalef Diversity values per site ranged from 1.6 at LALT503–Tujunga Wash to 8.7 at SMC11384–Cold Creek (Appendix B.3). Dominance is a metric that is presumed to decrease with increasing biotic integrity. Dominance by a single taxon ranged from 16.2%

Micrasema at SMC11384–Cold Creek to 67.4% Ostracods at SMC01164–Towsley Creek Dup (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 ≤3) is a much stronger metric than total-percent EPT when assessing ecological health at a site. All of the stonefly taxa are sensitive to urban runoff.

The greatest number of EPT taxa (22) was collected at SGUT-501–San Gabriel River, and the second greatest number of EPT taxa (13) was collected at SMC11384–Cold Creek (Appendix B.3). EPT taxa were collected at every monitoring site with a single taxon collected at LALT500–Rio Hondo and 19–Rio Hondo (the Baetid mayfly *Callibaetis*, a high-tolerance taxon able to live in low levels of dissolved oxygen). EPT individuals were most abundant at SGUT-505–San Gabriel River, where they comprised 87.4% of the benthic community (Appendix B.3). The most abundant of the EPT taxa across the survey region included *Baetis* and the caddisfly *Hydropsyche* (Appendix B.2). Sensitive EPT taxa (TV 0 to 3) were collected at eight of the sites and were collected in the greatest numbers at SGUT-501–San Gabriel River, where they comprised 33.0% 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 78 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 impairment-tolerant 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 4.1 at SGUT-501–San Gabriel River and to 7.8 at both LALT500–Rio Hondo and SMC01164–Towsley Creek Dup (Appendix B.3). Highly tolerant organisms (TV 8 to 10) were most abundant at SMC01164–Towsley Creek Dup, where high numbers of Ostracods dominated the tolerant organisms, which comprised 85.0% of the total. Highly tolerant organisms were least abundant at SGUT501–San Gabriel River, where

they comprised 2.6% of the community. Highly intolerant (i.e., sensitive) organisms were collected from nine sites, which were the same sites where sensitive EPT were collected plus 8, LALT–502 Compton Creek. Sensitive EPT with a TV of 2 or less are also counted in the highly intolerant metric. SGUT-501 had the greatest number of intolerant organisms, where they comprised 24.8% of the community. Highly intolerant organisms collected in high numbers Countywide included the caddisfly, *Micrasema* sp. (110 individuals), the mayfly *Serratella* sp. (109 individuals), and the caddisfly, *Tinodes* sp. (39 individuals).

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.

Sixteen of the 18 monitoring reaches were dominated by taxa in the collector feeding groups (collector-gatherers plus collector-filterers) (Appendix B.1 and Appendix B.3). The eight most abundant taxa in the study region (i.e., *Baetis* sp., Ostracods, *Crictopus*, Dicrotendipes, *Simulium*, Oligochaetes, *Hyalella*, and *Hydropsyche*) were in the collector feeding groups, which generally increase in abundance in response to urban runoff in a watershed (SLSI, 2003). SMC11384–Cold Creek was dominated by "others" (predominately by *Micrasema* sp., a macrophyte herbivore) and SMC12814–Trancas Canyon Creek was dominated by scrapers (i.e., hydrobiid snails, including the invasive New Zealand Mud Snail *Potamopyrgus antipodarum*). LALT503–Tujunga Wash had the greatest dominance by a single feeding group, where collector–gatherers comprised 95.2% of the community.

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 50 organisms per square foot of substrate at 7–Arroyo Seco to 842 organisms per square foot at SMC04750–Topanga Canyon Creek (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 137 to 257 organisms per square foot.

4.3 2011 Physical Habitat Quality Assessment

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 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.

Water quality measurements at most of the monitoring sites did not indicate severe impairment. Values for pH were between 7.72 and 9.74 at 8, LALT502–Compton Creek and LALT503–Tujunga Wash, respectively. Specific conductance, a general indicator of dissolved solids, was moderate to low at all sites (e.g. < 1.8 milliSiemens per centimeter [ms/cm]) except SMC01164–Towsley Creek, which had a value of 2.754. The Towsley Creek site had no apparent upstream urban runoff sources, and it was likely that the elevated conductance was due to naturally occurring constituents. 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. Dissolved oxygen levels were suitable for BMI at most sites, with the exception of LALT–Rio Hondo, which had a value of 0.53 milligrams per liter [mg/L]. The water at this site was less than one inch deep with little flow. The remaining sites ranged from 3.93 mg/L at 8, LALT502–Compton Creek to 12.31 mg/L at SMC012184–Trancas Canyon Creek. Water temperatures were quite variable throughout the County, ranging from 16.7 degrees Centigrade (°C) (62.1 degrees Fahrenheit [°F]) at SGUT-504–San Gabriel River to 34.2 °C (93.6 °F) at SGLT500–Walnut Channel. 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 most sites, although turbidity was somewhat elevated at 7–Arroyo Seco with a value of 42.7 NTU. Elevated turbidity is most commonly caused by suspended sediments in the water column.

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 2011 (Appendix B.6).

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. 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 2011, the highest quality physical habitats were at SMC11384–Towsley Creek and SMC12814–Trancas Canyon Creek with CRAM scores of 91. The poorest quality physical habitat was at SMC05902–Santa Monica Channel (a lined channel site) with a CRAM score of 34.

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

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

4.4 2011 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 refined in the 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).

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 4 and Figure 5. The IBI metric values, individual IBI scores, and total IBI scores on the 0 to 70 and 0 to 100 scales are presented in Appendix B.7.

The 18 monitoring sites in the County had IBI ratings ranging from Very Poor to Very Good with IBI scores ranging from 0 to 60. Eight 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 one rated Very Good. Five sites were rated Poor, and included sites at low to mid elevation that had substantial urban influence, with the exception of the duplicate sample at SMC01164–Towsley Creek. The six remaining sites were rated Very Poor and included four of the five concrete-lined channel sites.

The difference in IBI scores between SMC01164–Towsley Creek and the SMC01164 duplicate sample was significant (i.e., the difference was greater than the 'minimum detectable difference' of nine points) and the two scores were on either side of the impairment threshold. The duplicate sample was collected approximately one month after the initial sample and the field biologists noted that flow was substantially reduced. The BMI assemblage had undergone substantial alteration, most notably the abundance of Ostracods increased from 40 to 433 individuals and taxonomic richness decreased from 41 taxa to 24 taxa. Because the site is presumably in reference condition, this was likely a natural seasonal variation.

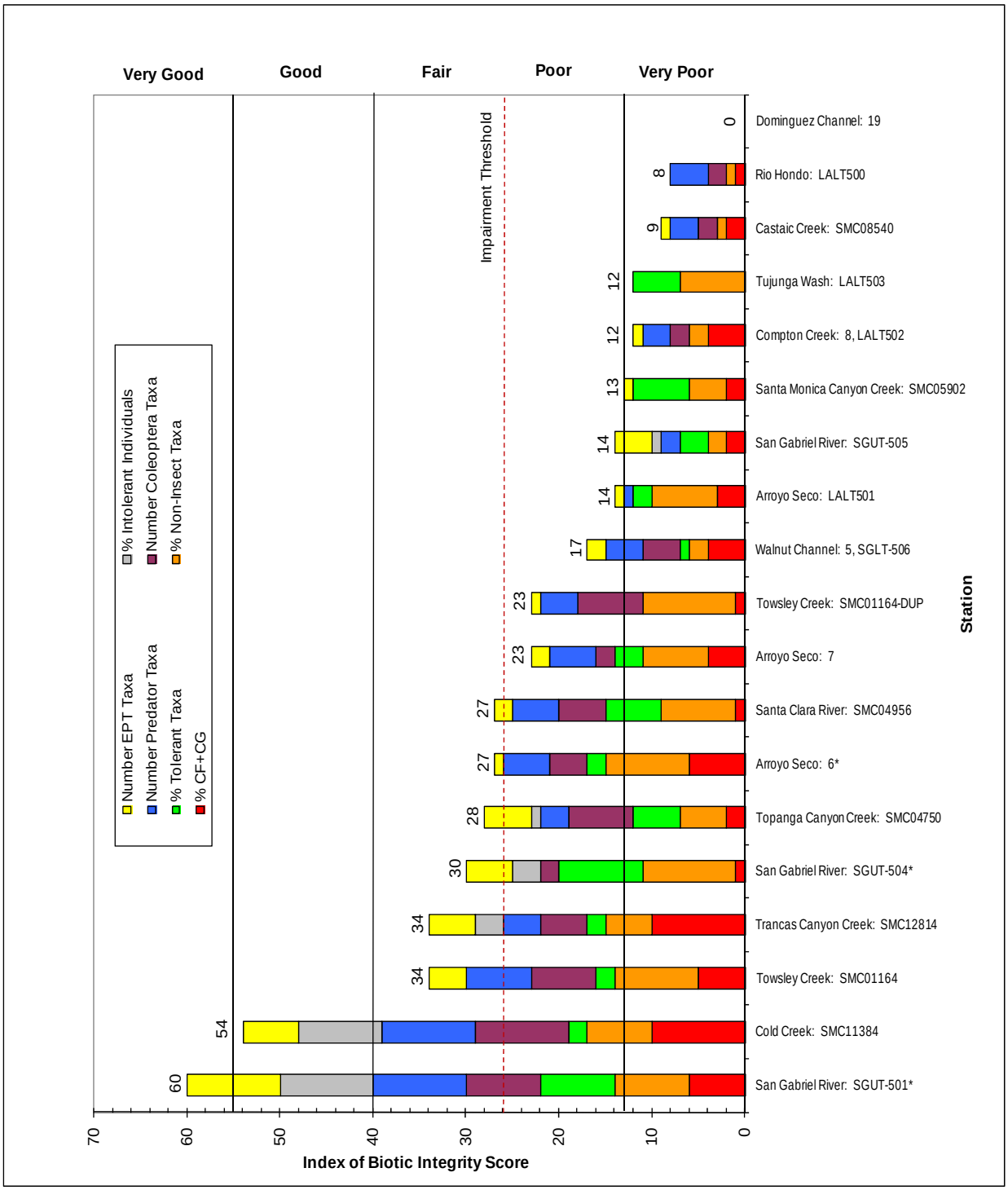


Figure 4. Index Biotic Integrity Scores for Los Angeles County Bioassessment Sites for 2011 (0–70 scale)

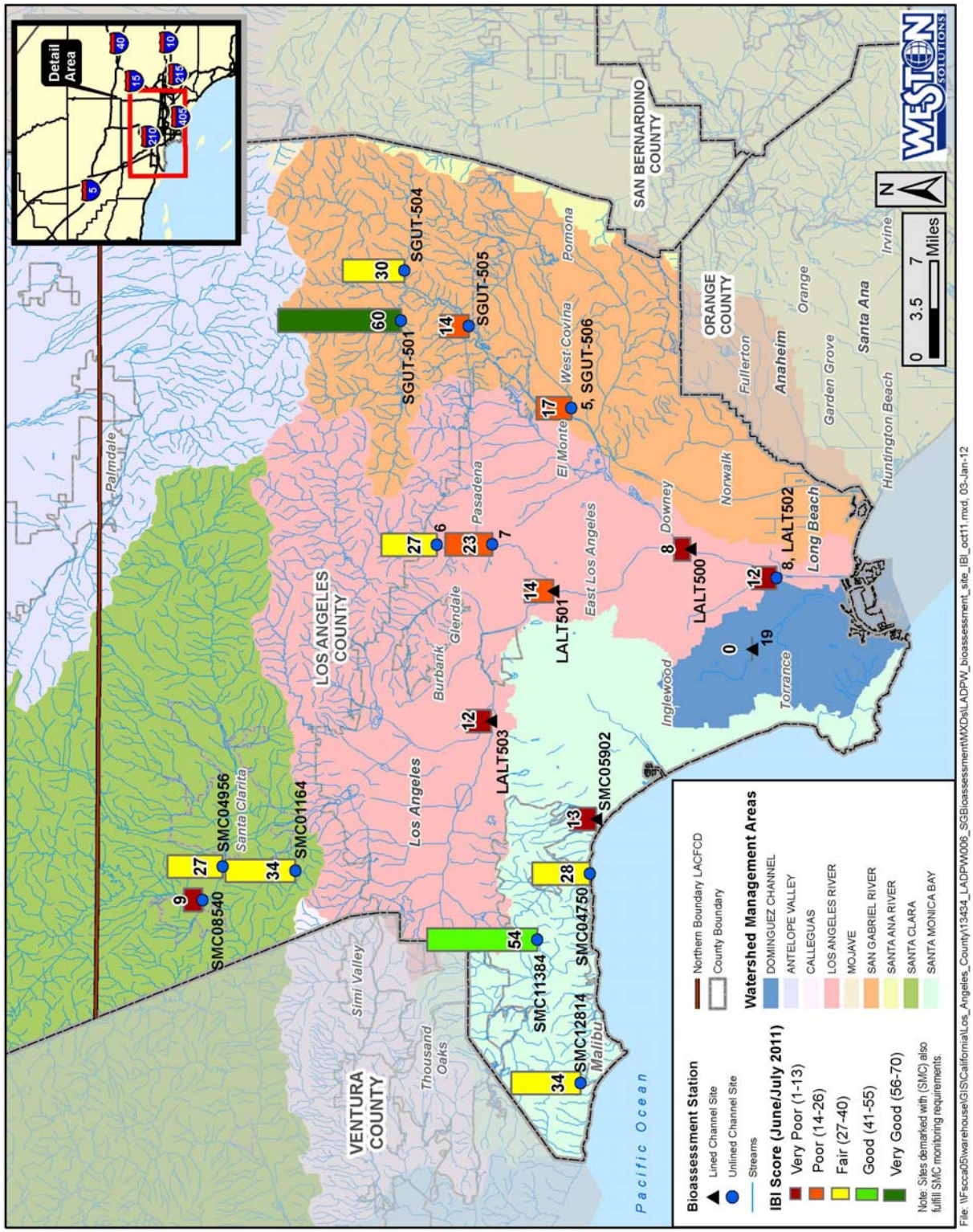


Figure 5. Stream Bioassessment Monitoring Locations with Index of Biotic Integrity Scores per Site for 2011

Comparison of Concrete-Lined Channels and Unlined Channels

In the 2011 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, SMC05902–Santa Monica Channel. 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. It is unclear at this point in time what the BMI colonization potential of concrete-lined channels would be if the water quality were equivalent to reference conditions.

In 2011, the concrete-lined channel sites had IBI scores of 14 or less and benthic quality ratings of Poor and Very Poor (Figure 6). 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 IBI scores, but because these sites were dominated by urban runoff, water quality may have had an additional impact. All of the lined sites had low taxa richness, were heavily dominated by collector taxa (86% to 99% of the community), lacked sensitive taxa, and had two 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 7. 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 2011 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 0.026. When the p-value is less than 0.05, the difference is significant; 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 7. The minimum and maximum IBI scores are indicated by the upper and lower horizontal lines (whiskers), the 25th percentile is represented by the bottom of the shaded box, the median is the line near the middle of the box, and the 75th 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 25th or 75th 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.

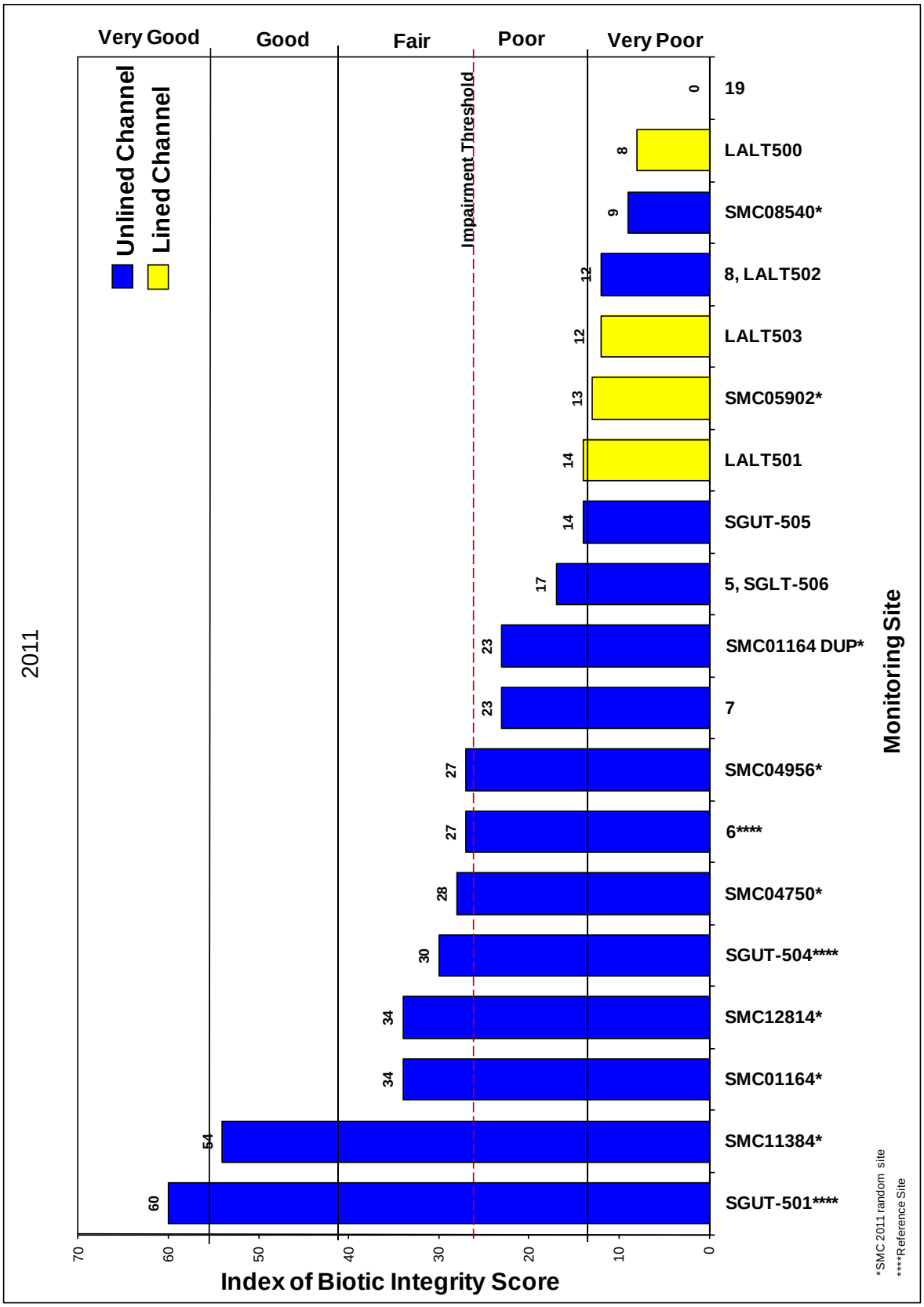


Figure 6. Index Biotic Integrity Scores for Concrete-Lined versus Unlined Channels for 2011 Survey

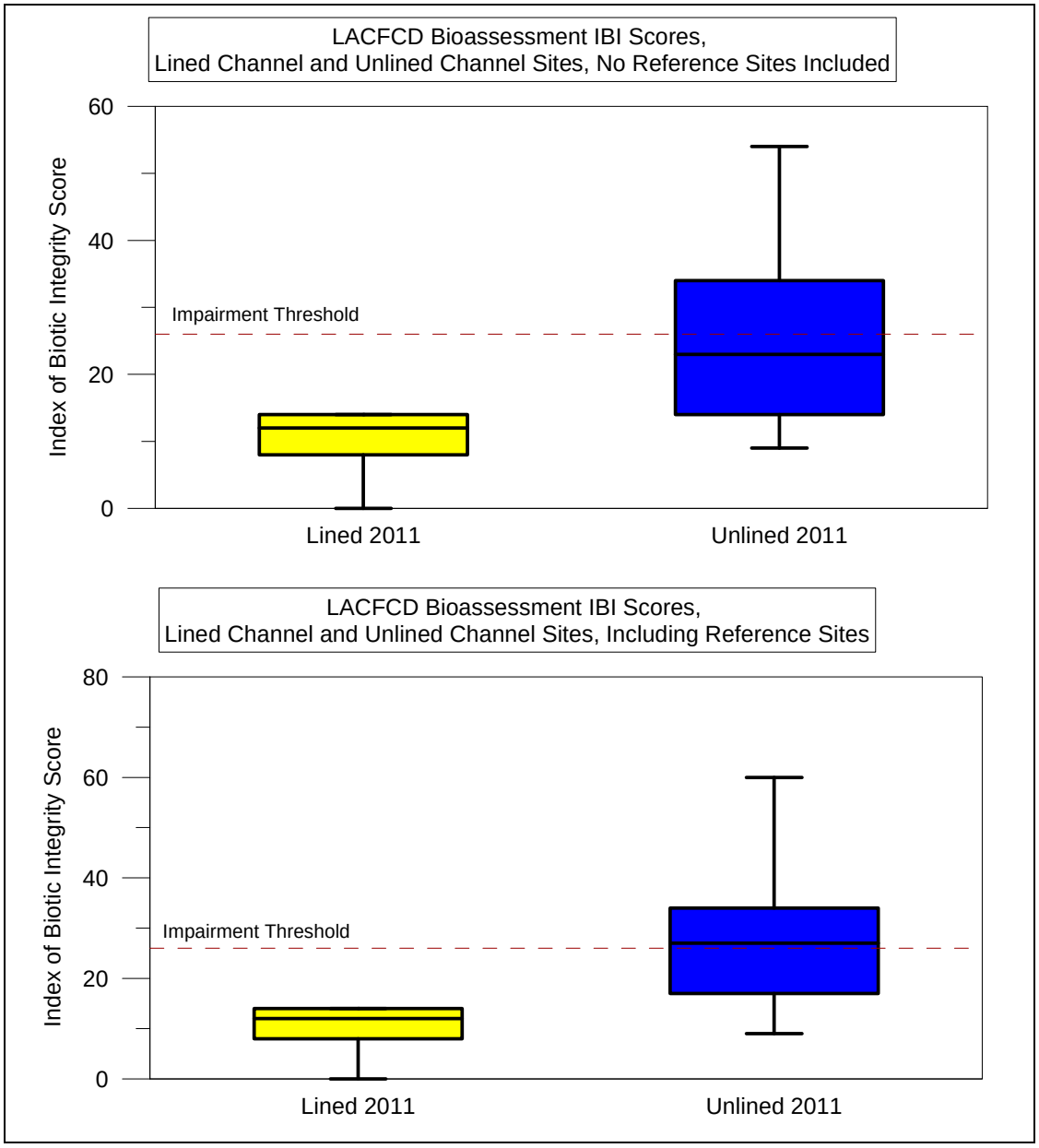


Figure 7. Comparison of Concrete-Lined and Unlined Channel Sites for 2011

Without considering reference sites, the mean IBI scores of the urban unlined sites were higher than the 75th percentile (top of the shaded box) of the concrete-lined sites and, therefore, were rated slightly superior to the lined sites. This difference was greater than was seen in historical analyses (WESTON, 2011). When reference sites were considered, this difference was even more apparent: the p-value decreased to .014, the unlined sites were clearly statistically superior to the concrete-lined sites, and the mean IBI score of the unlined sites was just 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, elevation, or organism tolerance, although this information was added to the cluster diagram to facilitate intertpretation (Appendix B.8).

The 2011 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 four site clusters, labeled 1 through 4 and A through D, 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. The sites are also labeled with elevation codes indicating low (i.e., less than 500 feet above sea level), medium (i.e., 500 to 1,500 feet above sea level), and high (i.e., above 1,500 feet above sea level) elevations.

Overall site clustering showed that site clusters A and D had the greatest degree of separation from clusters B and C. Cluster A had three of the five concrete-lined channel sites plus two soft-bottomed sites within flood control channels. Cluster A primarily contained open-space sites with little or no urban runoff (with the exception of Site 7). Site cluster B contained two of the concrete-lined sites plus Site 6 and two of the Santa Clara River watershed sites. Site cluster C contained all of the upper San Gabriel River sites plus the Topanga Canyon Creek site. These clusters appeared closely associated with IBI scores for the sites: cluster A had the lowest IBI scores and cluster B had low to mid-level scores with a range of 13-27. Clusters C and D had the highest IBI scores, with most sites scoring well above the impairment threshold.

The sites in cluster A were best characterized by having high numbers of taxa in taxa cluster 1. Most of the taxa in cluster 1 were highly tolerant organisms such as *Hyalella*, Ostracods, corixids (water boatmen) and Chironomids. These taxa are also indicative of slow current and fine particulate organic matter.

Site cluster B was associated with taxa cluster 2, and the most abundant taxa included the caddisfly *Hydroptila*, the black fly *Simulium*, and the mayfly *Baetis*. *Simulium* is often abundant in relatively fast current areas and *Hydroptila* and *Baetis* are often abundant in sites with heavy filamentous algae cover. Both of these physical habitat characteristics were present at the sites in cluster B.

Site cluster C contained all of the upper San Gabriel River sites plus Topanga Canyon. The sites of cluster C were most associated with taxa clusters 2 and 3, and were best represented by the caddisfly *Hydropsyche* and the mites *Atractides*, *Lebertia*, and *Sperchon*. Many of these sites had sensitive taxa present that were dropped from the analysis because they were unique to the each site.

Site cluster D contained several sites with little or no urban runoff with many sensitive taxa. Cluster D was most associated with taxa cluster 4, including the predaceous diving beetles *Agabus* and *Stictotarsus*, the caddisfly *Gumaga*, and the damselflies *Argia* and *Archilestes*.

Comparison of the 2011 cluster analysis to previous years' cluster analyses (Appendix B.8) showed a consistent pattern of three station cluster types corresponding to Poor, Fair, and Good physical habitats parallel to IBI scores that also separated into Poor, Fair, and Good BMI community quality ratings.

4.5 All Watersheds' Survey Results for 2003 through 2011

Study information from 2003 through 2010 (BonTerra, 2004; WESTON, 2005; WESTON, 2006; WESTON, 2007; WESTON, 2008; WESTON, 2009; WESTON, 2010; WESTON, 2011) was compared to the 2011 data to assess year-to-year variance and trends in biotic integrity of the streams. Regional macroinvertebrate community structure was relatively similar in the first 8 survey years (i.e., years prior to 2011), and the 10 most abundant taxa remained fairly consistent. Additionally, in nearly all of the survey years, the 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 in 2005 and 6–Arroyo Seco, which was impacted in 2009 by erosion 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, and 136 in 2011 but because the taxonomic effort was increased to SAFIT Level II, these values are not comparable to the historical surveys. Consequently, the 2009 to 2011 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 – 2003-2011
Since 2003, 56 sites have been monitored in the Bioassessment Program; 18 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).

Using a whisker–box plot to compare the two channel types, the mean 2003–2011 IBI scores of the unlined sites were significantly superior to the concrete-lined sites in the lower watershed areas (Figure 8). When the reference sites were added to the analysis, a greater difference between site types resulted; mean IBI scores of unlined sites were significantly superior to those of the concrete-lined sites.

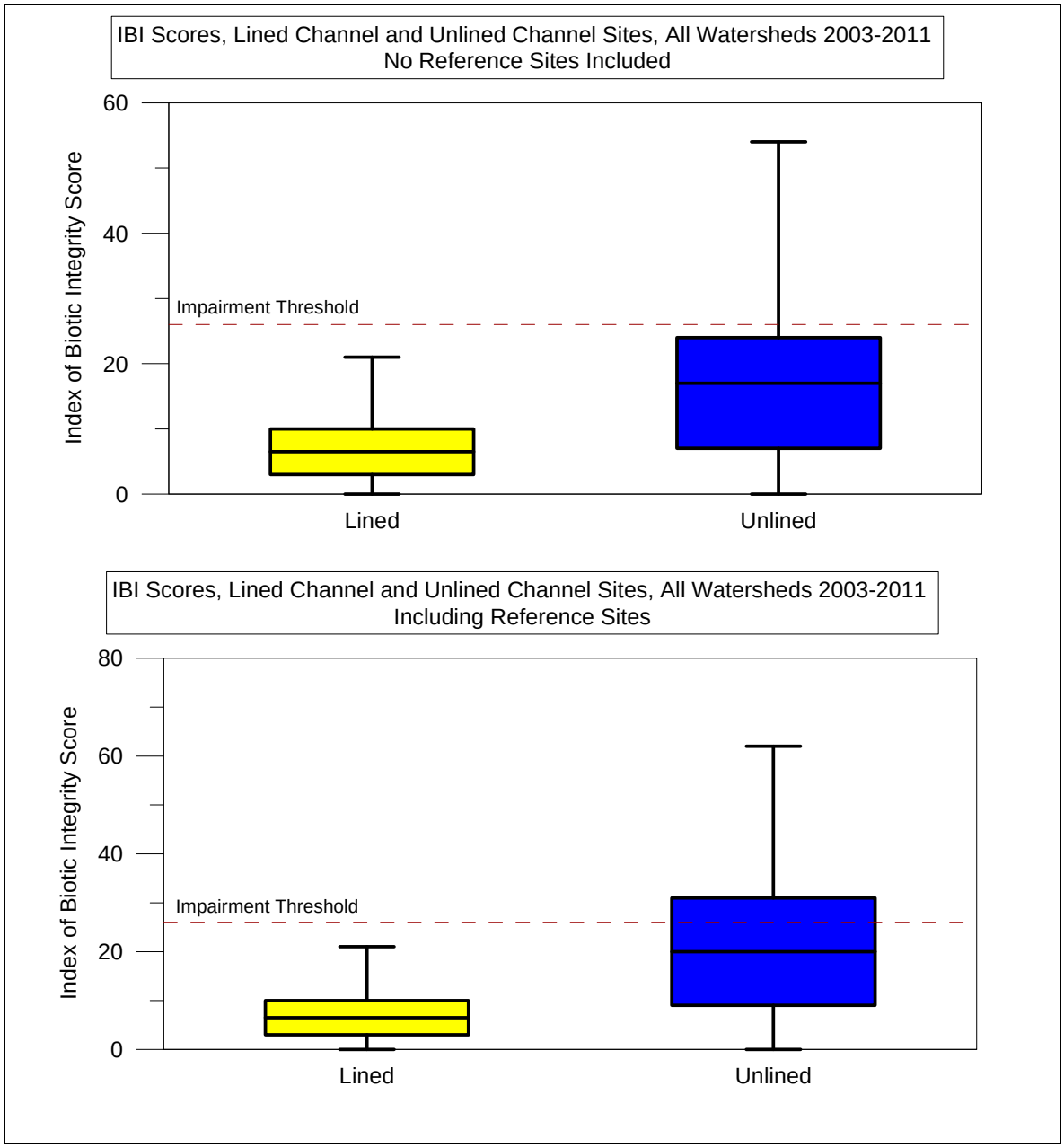


Figure 8. Comparison of Concrete-Lined and Unlined Channel Sites, All Watersheds for 2003–2011

Comparison of Index of Biotic Integrity Scores and the California Rapid Assessment Method Scores for all Watersheds for 2009, 2010, and 2011

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 because the CRAM analysis was initiated in 2009. As noted in Section 4.3, the CRAM scores were not re-assessed in 2010 for the targeted sites, with the exception of 6–Arroyo Seco, and CRAM was applied only to the SMC sites in 2011.

The results of the analysis were a coefficient of determination (R^2) of 0.564 (Figure 9). This results in a correlation of 0.751. This result shows that a relationship exists between CRAM and IBI scores. Figure 9, shows what appears to be three groupings of sites: those with the lowest CRAM and IBI scores, which includes most of the lined channel sites; those with moderate to high CRAM scores, but which are relatively close to the IBI threshold; and those with both high CRAM and IBI scores, which includes the reference sites SMC02548–Rustic Canyon Creek and SMC11384–Cold Creek. CRAM appears to correlate 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 include urban aspects of the watershed).

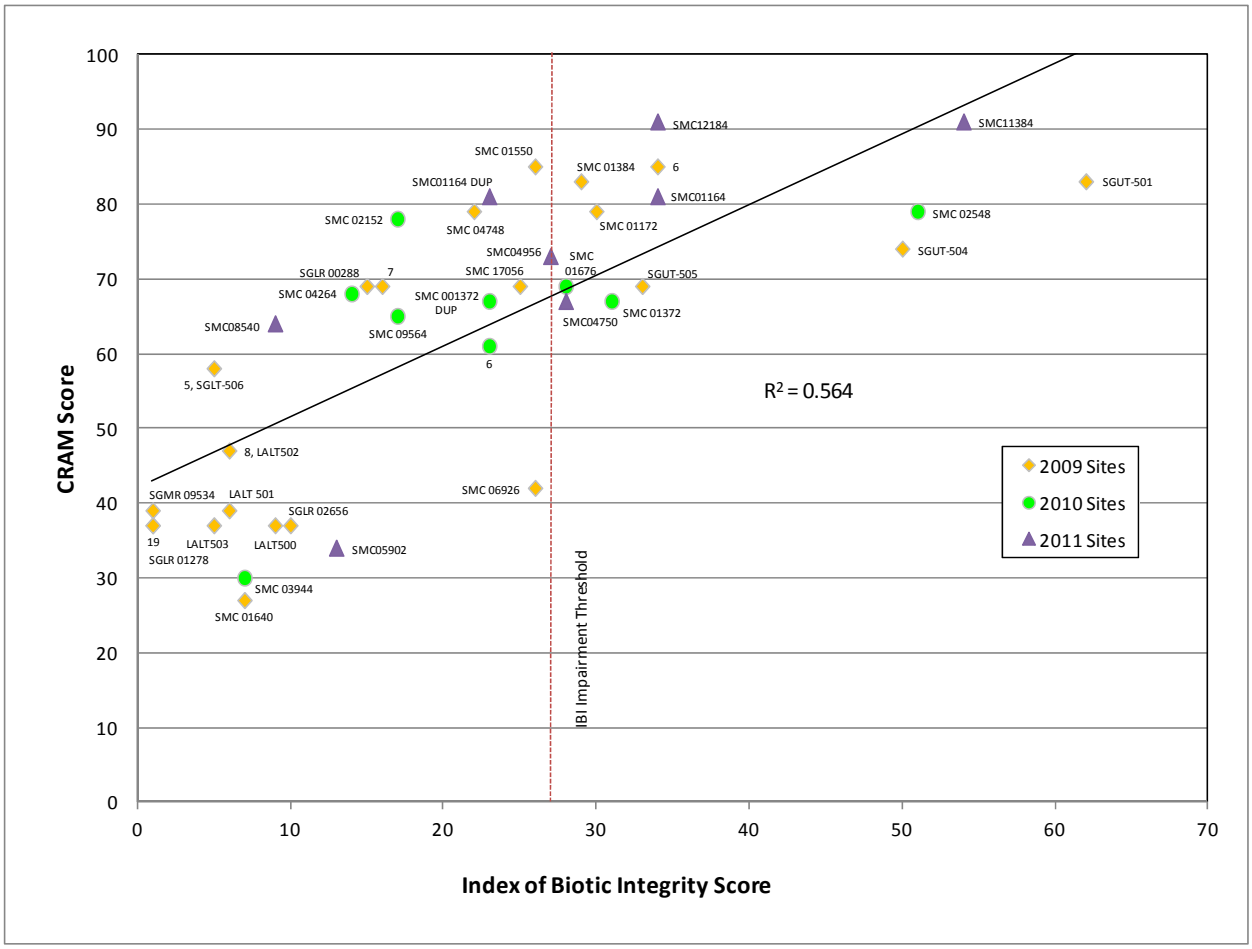


Figure 9. Correlation of California Rapid Assessment Method and Index of Biotic Integrity Scores for 2009, 2010, and 2011

Cluster Analysis for 2003–2011

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 of the whole time span were similar to the 2011 results, with four major taxa clusters and four site clusters, labeled 1 through 4 and A through D, respectively. This analysis confirmed that the BMI communities are different based on their location in the watershed and their channel type.

The site clusters fell into two general groups, with clusters A and B containing low to mid-elevation urban sites plus all of the concrete-lined channel sites and clusters C and D containing the reference sites and less developed, mid-elevation sites. The BMI assemblages and IBI scores of the sites also confirmed that the higher elevation, less urbanized portions of the watersheds and the unlined sites (clusters C and D) were of superior quality to the low elevation sites with greater urbanization. The taxa clusters were also in two general groups, with clusters 1 and 3 containing the ubiquitous and moderately to highly tolerant taxa and clusters 2 and 4 containing all of the Coleoptera (beetle) taxa and intolerant (sensitive) taxa.

Site cluster A was most associated with taxa clusters 1 and 3, represented by highly tolerant, ubiquitous BMI and most of the non-insect taxa. Site cluster A also seemed to have two distinct sub-clusters, one of which was entirely concrete-lined channel sites. Site cluster B was primarily associated with taxa cluster 3 only.

Nearly all of the sensitive taxa were in taxa cluster 4. Site cluster D was associated with the intolerant taxa of taxa cluster 4, best characterized by the caddisflies, *Lepidostoma* sp., *Agapetus* sp., *Micrasema* sp., *Tinodes* sp., and *Wormaldia* sp.; the stoneflies, *Isoperla* sp. and *Malenka* sp. and the mayflies, *Serratella* sp. and *Epeorus* sp. Site cluster D was also highly associated with taxa cluster 2, which contained most of the Coleoptera taxa.

Site cluster C was limited to sites in the Santa Clara River mainstem and had a strong correlation with taxa cluster 3, which was characterized by the damselfly, *Hetaerina americana*, the beetle *Tropisternis*, and the mayfly, *Tricorythodes* as well as several taxa in taxa cluster 1.

5.0 2003–2011 SURVEY RESULTS BY WATERSHED

Study information from 2003 through 2011 (BonTerra, 2004; WESTON, 2005; WESTON, 2006; WESTON, 2007; WESTON, 2008; WESTON, 2009; WESTON, 2010; WESTON, 2011) 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 reaches were relocated very close to previous years' surveys and were historically sampled at the same time of year (mid-fall), except for the four San Gabriel River Watershed sites, sampled in June 2008. Since 2009, the sampling 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 2011. 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.

5.1 San Gabriel River Watershed Survey Results for 2003–2011

The San Gabriel River Watershed has been sampled in 18 different locations from 2003 through 2011 (Figure 10). One site, 5, SGLT-506–Walnut Channel, has been sampled in all eight surveys, but the remaining sites have been sampled a maximum of six 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 is somewhat unique in that it 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 several "spreading grounds" that retain water for groundwater recharge. The bioassessment monitoring sites have signaled this difference with higher IBI scores (Figure 11) and better physical habitat rankings for the upper watershed sites 4, SGUT-501, SGUT-504, and SGUT-505.

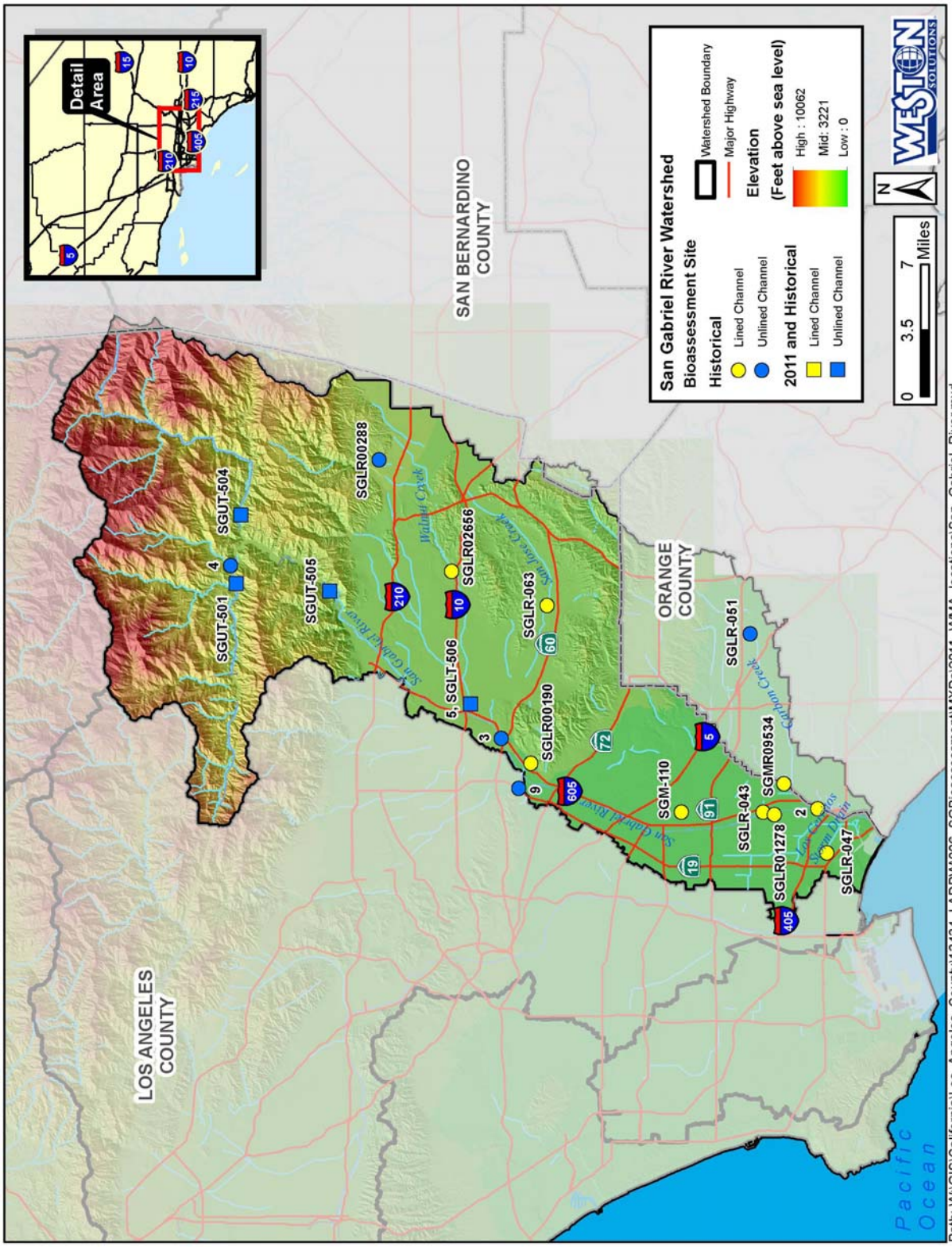


Figure 10. Bioassessment Monitoring Sites in the San Gabriel River Watershed for 2003–2011

Mean Metric Analysis for 2003–2011

Table 5 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 2011 taxa richness values were adjusted to taxonomic Level I from Level II.

Table 5. San Gabriel River Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2011

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*	3	42.0	21.0	38.4%	53.9%
San Gabriel River	SGUT-504*	6	26.0	11.8	10.2%	77.1%
San Gabriel River	SGUT-505	6	23.8	8.7	5.0%	72.8%
San Gabriel River	SGLR00190	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	9	13.8	2.0	0.0%	85.6%
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 to 2011 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 over 62% 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 23.8 to 42.0. 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 8.7 to 21.0. Intolerant taxa were

absent from all lower watershed sites and comprised from 3.1 to 38.4% of the benthic community in the upper watershed. The percent collector–filterers plus collector–gatherers (i.e., collector taxa) ranged from 53.9% at SGUT-501 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 53.9 to 85.0% collector taxa.

Comparison of Index of Biotic Integrity Scores for 2003–2011

SGUT-501–San Gabriel River was the highest ranking site by IBI scores in the watershed (Table 6). It was also at the highest elevation (Table 1), had the coldest water temperature, and had the lowest specific conductivity of all the San Gabriel River Watershed sites (Appendix B.4). 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, although the lowest IBI score to datewas recorded in 2011. 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 Ostracods 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 6. San Gabriel River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2011

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	Mean IBI Score	IBI Range
San Gabriel River	4*	30	38								34.0	8
San Gabriel River	SGUT-501*							62	56	60	59.3	6
San Gabriel River	SGUT-504*				42	34	33	34	50	30	37.2	20
San Gabriel River	SGUT-505				20	25	18	33	29	14	23.2	19
San Gabriel River	SGLR00288							15			15.0	
San Gabriel River	SGLR02656							10			10.0	
San Gabriel River	SGLR00190						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	SGMR09534							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	8.3	17
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 2003–2011

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 (Figure 11). 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 0.124 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 0.004, 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 very similar to the unlined sites in the lower watershed (Figure 12). 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 were superior to 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.

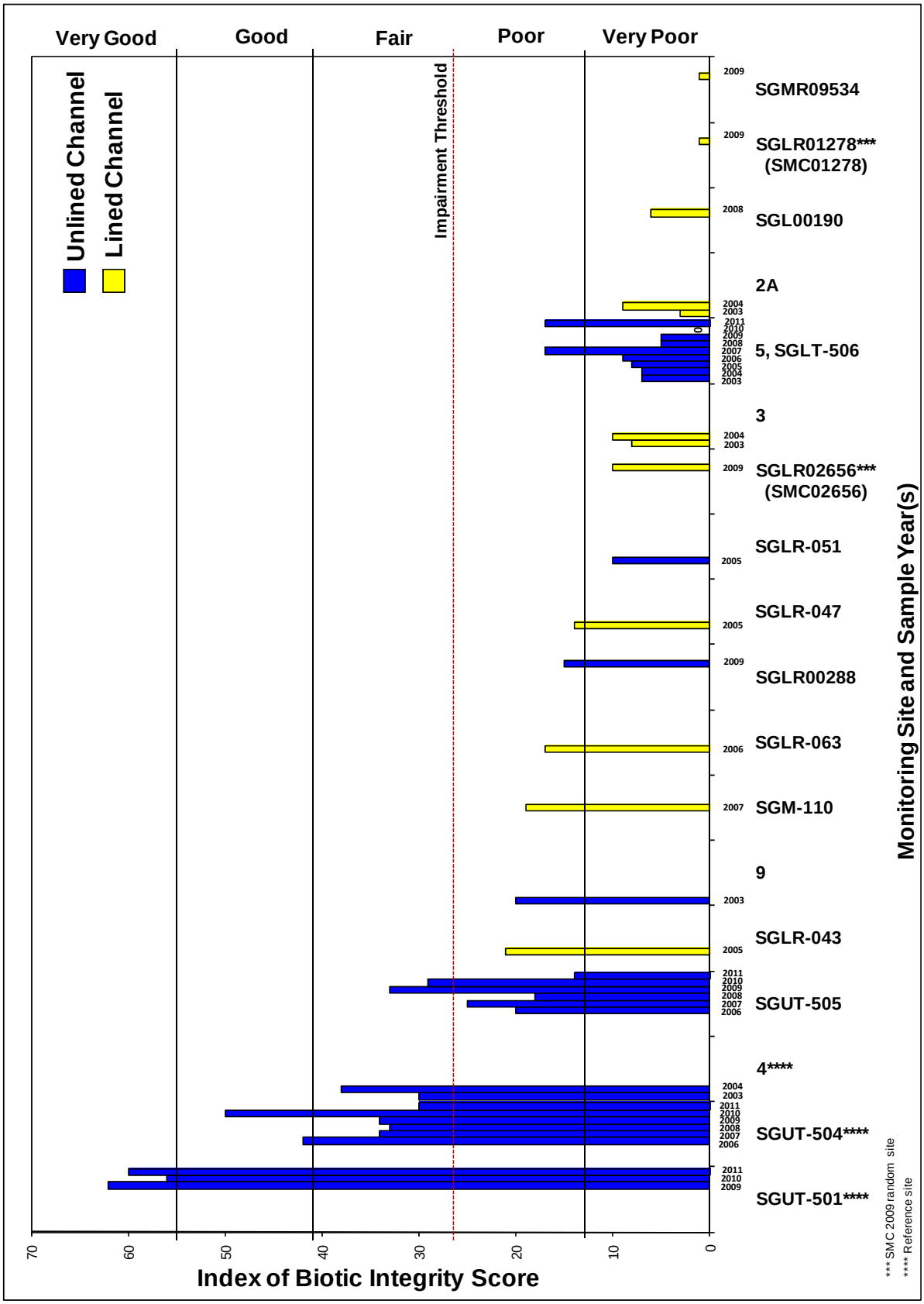


Figure 11. Index of Biotic Integrity Scores for Concrete-Lined and Unlined Channel Sites, San Gabriel River Watershed for 2003–2011

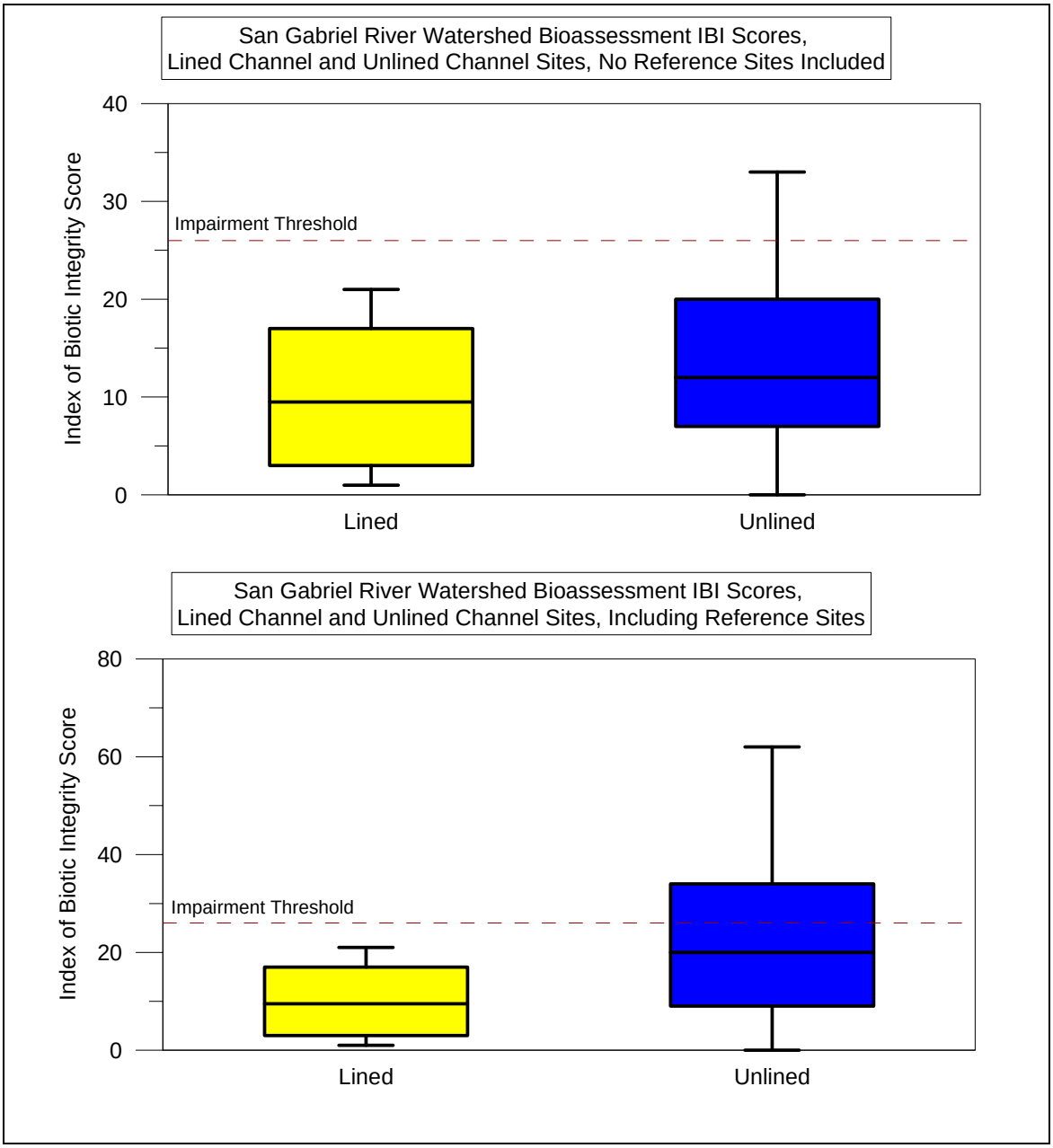


Figure 12. Comparison of Concrete-Lined and Unlined Channel Sites, San Gabriel River Watershed for 2003–2011

Comparison of Index of Biotic Integrity Scores and Elevation for 2003–2011

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 0.841. The correlation was significant, based on a critical value of 0.301 (43 samples and an alpha of 0.05). These results indicate that site IBI scores were significantly correlated to elevation.

An illustration of these results is shown in Figure 13, a linear correlation of IBI scores and elevation. The coefficient of determination is shown on the graph as a measure of how well the data points fit a linear model. It is evident that the relationship between IBI scores and elevation is significant (R^2=0.71) and that IBI scores increased with elevation in this watershed.

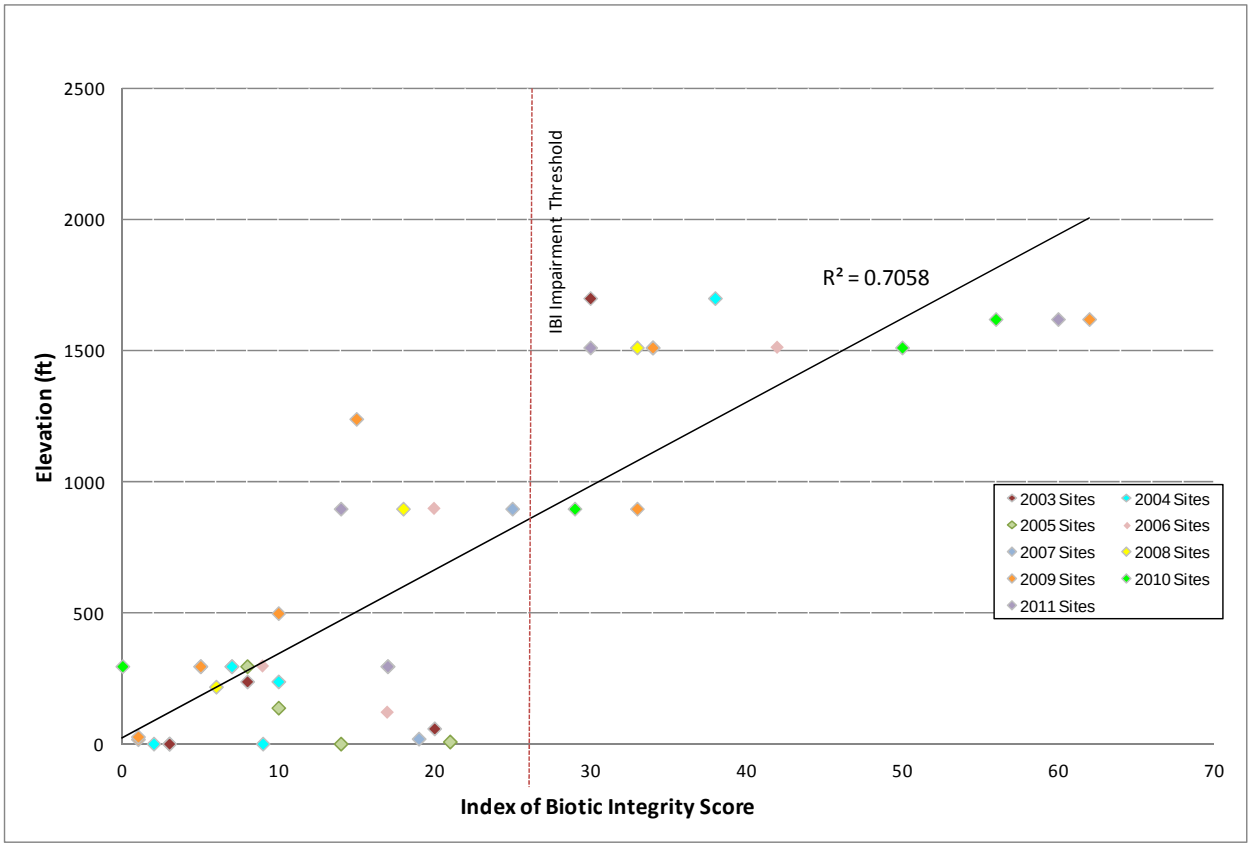


Figure 13. Correlation of Index of Biotic Integrity Scores and Elevation, San Gabriel River Watershed for 2003–2011

5.2 Los Angeles River Watershed Survey Results for 2003–2011

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 14). 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 and had 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 range of reference conditions has not been documented for this watershed.

The watershed has been sampled in nine locations from 2003 through 2011. Sites 8, LALT-502–Compton Creek and 7–Arroyo Seco have been sampled in every survey, and all other sites have been sampled at least four 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.

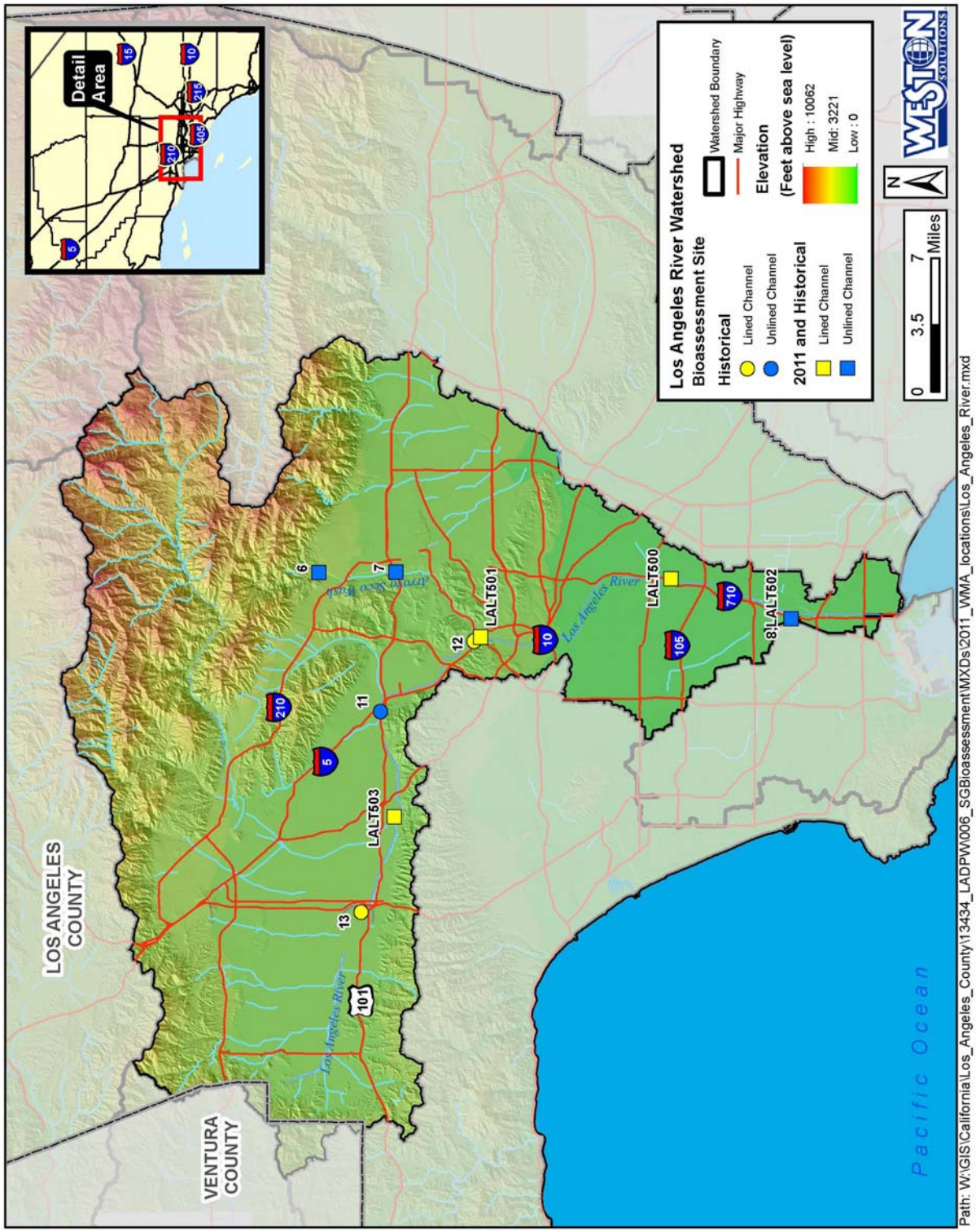


Figure 14. Bioassessment Monitoring Sites in the Los Angeles River Watershed for 2003–2011

Mean Metric Analysis for 2003–2011

Table 7 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 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 (29.9 and 9.2, 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 were found at 7–Arroyo Seco. The mean percent collector–filterers plus collector–gatherers ranged from 79.8 to 98.2% in the lower watershed and was 58.1% at 6–Arroyo Seco. These metrics indicate Poor biotic conditions in the lower watershed and Good biotic conditions at 6–Arroyo Seco.

Table 7. Los Angeles River Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2011

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Arroyo Seco	6*	7	29.9	9.2	2.1%	58.1%
Arroyo Seco	7	9	16.4	2.9	0.0%	79.8%
Arroyo Seco	LALT501	4	13.3	2.5	0.0%	96.0%
Tujunga Wash	LALT503	4	13.3	1.8	0.0%	89.3%
Rio Hondo	LALT500	4	14.0	1.8	0.0%	90.7%
Compton Creek	8, LALT502	9	11.9	1.3	0.0%	93.0%
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%

yellow highlight = concrete-lined channel site
blue highlight = unlined channel site
*= reference site
**2009 to 2011 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Index Scores for 2003–2011

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 38.6 of 70 and a quality rating of Good (Table 8). 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 the 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 back above the impairment threshold, but was still significantly lower than in the pre-2010 surveys. 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 14.5 and a quality rating of Poor, although its 2010 and 2011 IBI scores increased 4 and 5 points, respectively, from any previous sample year. This is the only site in the watershed that may have been trending upward over the 9 years of samples, as presented graphically in Figure 15. Two sites, LALT501–Arroyo Seco and LALT503–Tujunga Wash, had

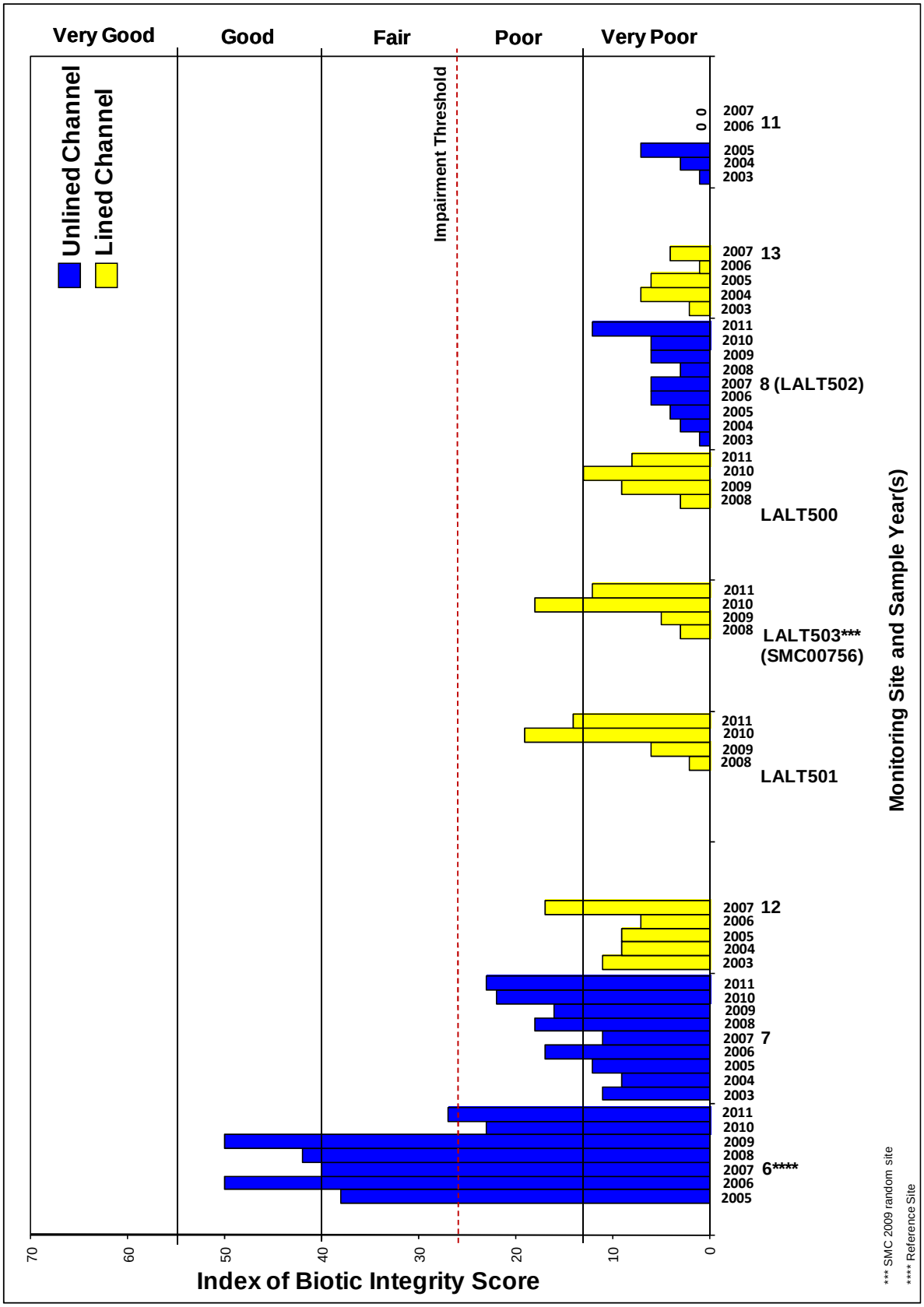


Figure 15. Index of Biotic Integrity Scores for Concrete-Lined and Unlined Channel Sites, Los Angeles River Watershed for 2003–2011

significantly higher IBI scores in 2010 than in any previous survey, with scores of 19 and 18, respectively, and the second and third highest ranges in scores, respectively, over the years. LALT500–Rio Hondo also had an IBI score that was the highest to date, although all three of these lined sites decreased in 2011. The IBI score for 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 2011

Table 8. Los Angeles River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2011

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	Mean IBI Score	IBI Range
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
Tujunga Wash	LALT503						3	5	18	12	9.5	15
Arroyo Seco	6*			38	50	40	42	50	23	27	38.6	27
Arroyo Seco	7	11	9	12	17	11	18	16	22	23	14.5	14
Arroyo Seco	LALT501						2	6	19	14	10.3	17
Rio Hondo	LALT500						3	9	13	8	8.3	10
Compton Creek	8, LALT502	1	3	4	6	6	3	6	6	12	5.2	11

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 2003–2011

All of the concrete-lined channel sites monitored in the lower watershed had IBI scores indicating impaired biotic integrity (Figure 15). 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 0.888, 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 0.202, and the unlined sites were statistically different from the concrete-lined sites. However, if more high-quality, unlined upper watershed sites 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 very 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 (Figure 15).

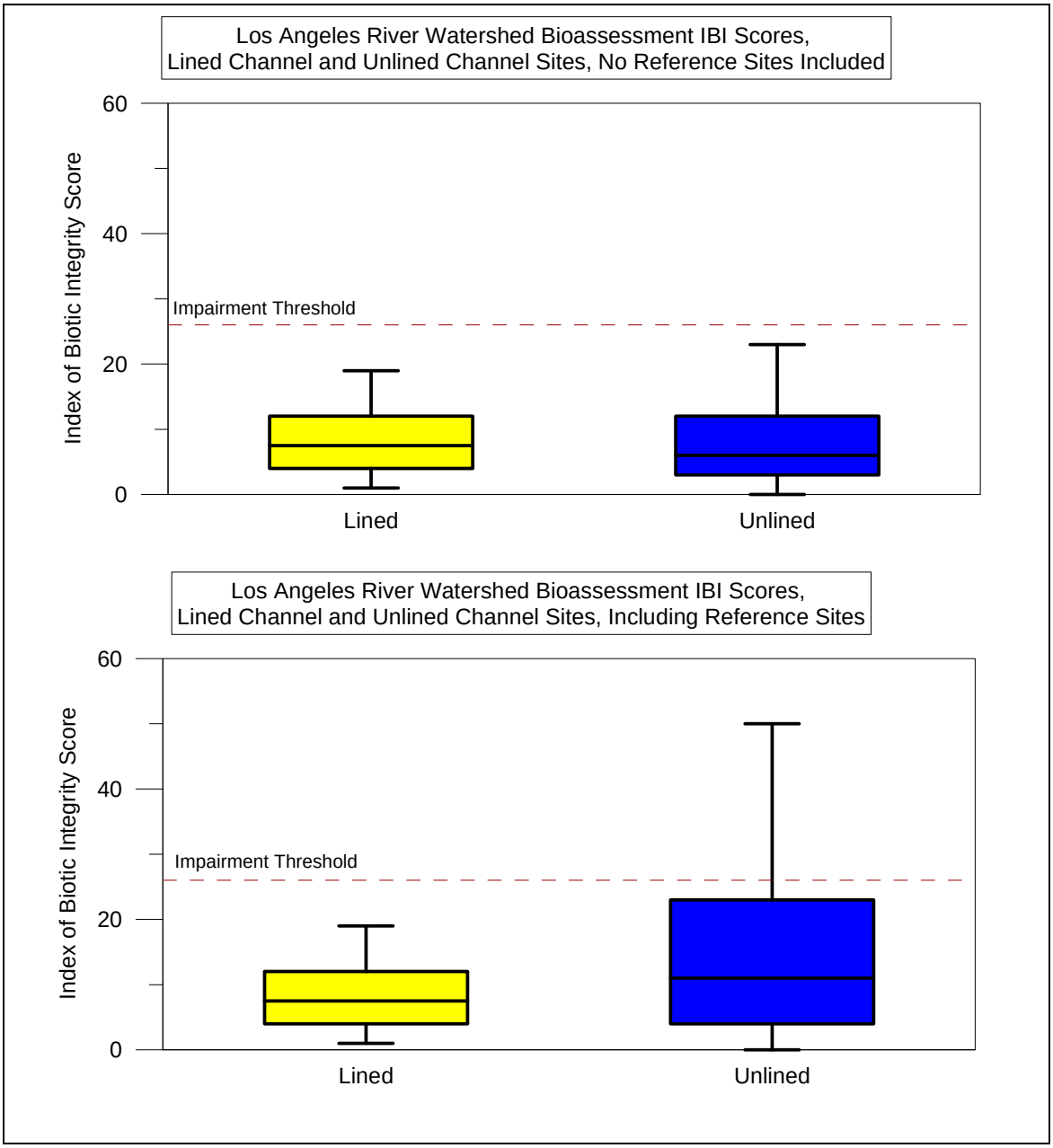


Figure 16. Comparison of Concrete-Lined and Unlined Channel Sites, Los Angeles River Watershed for 2003–2011

Comparison of Index of Biotic Integrity Scores and Elevation for 2003–2011

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 0.686. The correlation was significant based on a critical value of 0.276 (51 samples and an alpha of 0.05). This result indicates that site IBI scores were significantly and positively correlated with elevation.

An illustration of these results is shown in Figure 17, a linear correlation of IBI scores and elevation. The coefficient of determination is shown on the graph as a measure of how well the data points fit a linear model. It is evident that although the relationship is significant (R^2=0.49), a relatively wide range of elevation values exists for sites with low IBI scores.

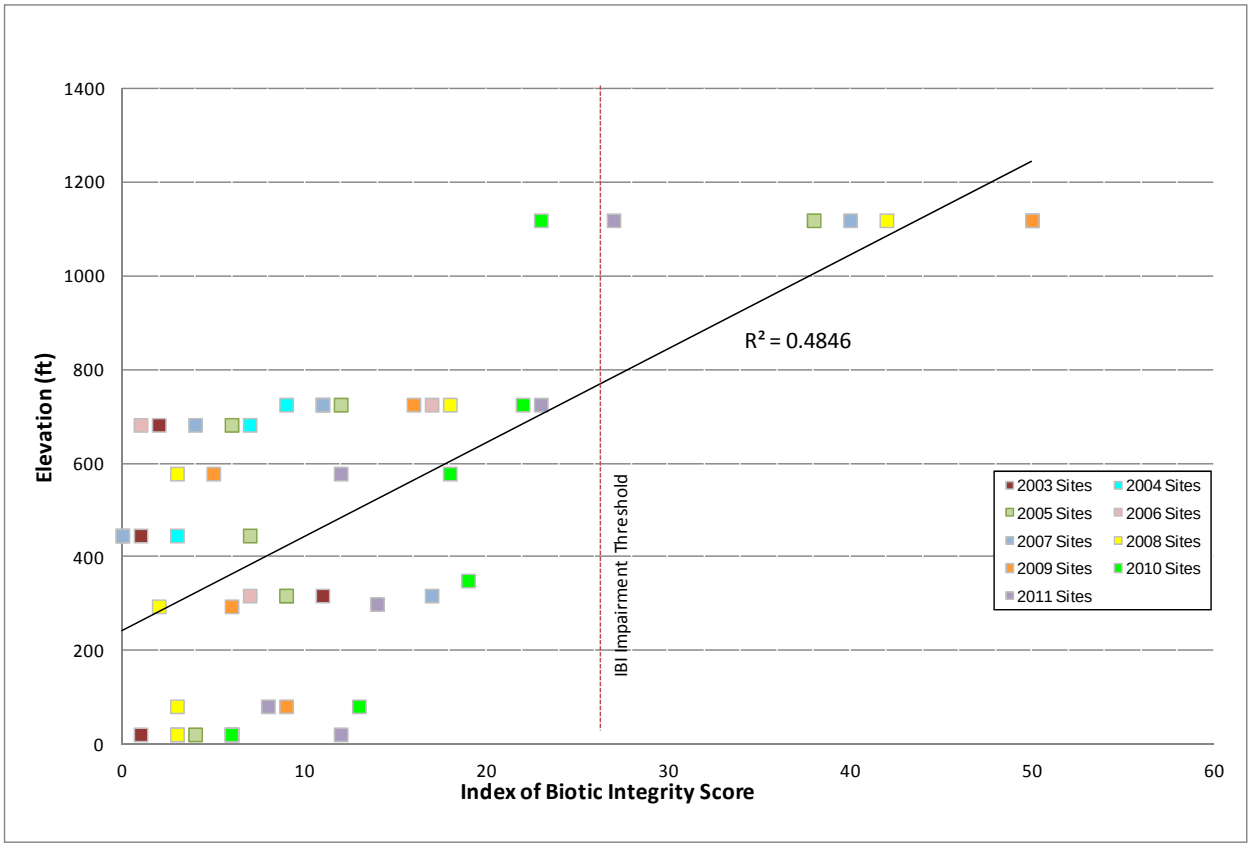


Figure 17. Correlation of Index of Biotic Integrity Scores and Elevation, Los Angeles River Watershed for 2003–2011

5.3 Dominguez Channel Watershed Survey Results for 2003–2011

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 monitored in Dominguez Channel and has been sampled every year since 2003 (Figure 18). Although the site was relocated approximately 0.5 miles upstream in 2006, the elevation change was only 5 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 just 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 for this watershed.

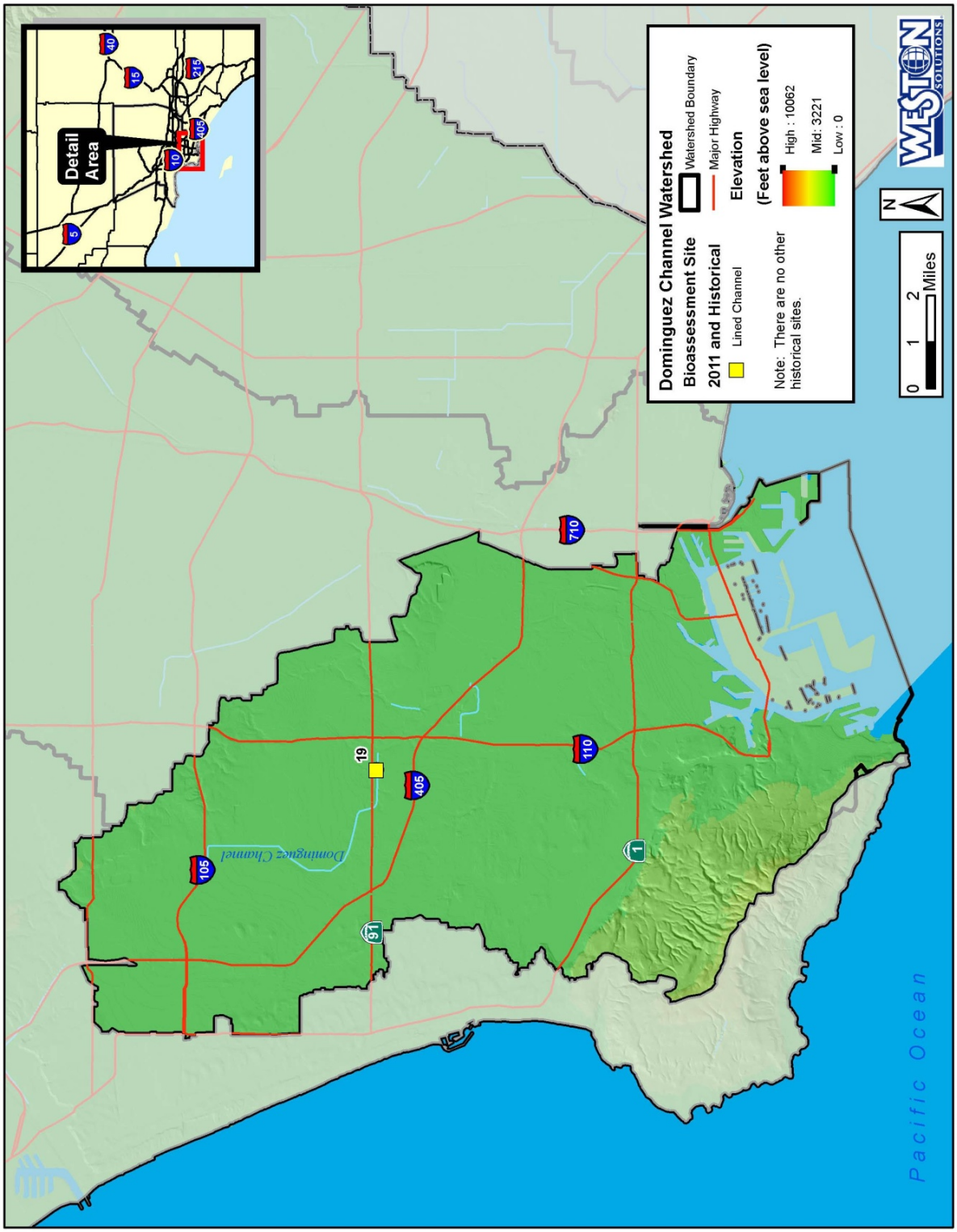


Figure 18. Bioassessment Monitoring Site in the Dominguez Channel Watershed for 2003–2011

Mean Metric Analysis for 2003–2011

Table 9 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 9. Dominguez Channel Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2011

Monitoring Reach	Station Number	Number Samples	Taxa Richness**	EPT Taxa	Percent Intolerant Taxa	Percent Collector-Filterers plus Collector-Gatherers
Dominguez Channel	19	9	9.5	0.2	0.0%	94.8%

yellow highlight = concrete-lined channel site

**2009 to 2011 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 2.1 (Table 10 and Figure 19). 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, the IBI score was back down to 0. Figure 20 shows the IBI score ranges in a box plot.

Table 10. Dominguez Channel Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2011

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	Mean IBI Score	Range
Dominguez Channel	19	3	6	0	1	0	1	1	7	0	2.1	7

yellow highlight = concrete-lined channel site

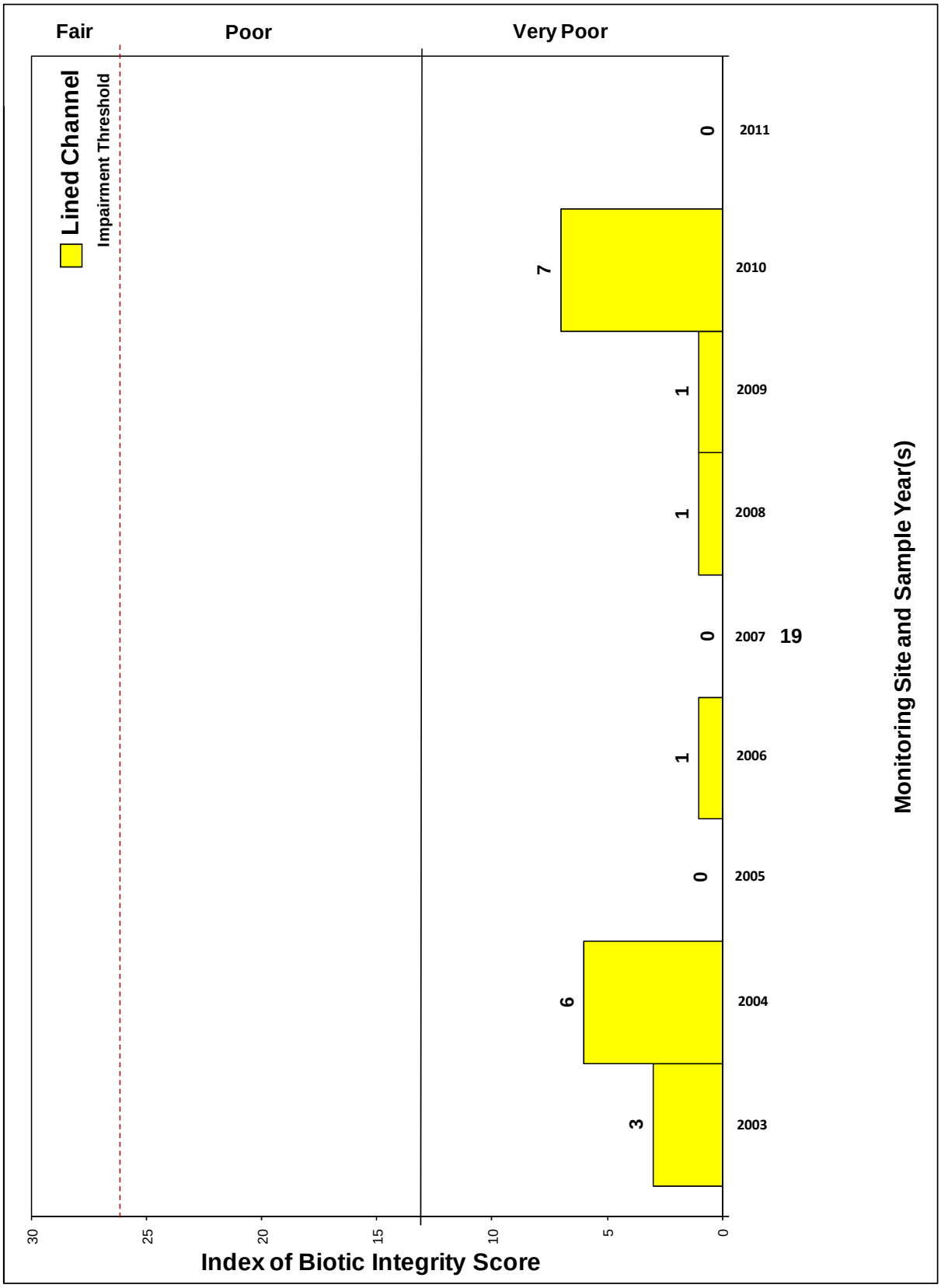


Figure 19. Index of Biotic Integrity Scores for Concrete-Lined Channel Sites, Dominguez Channel Watershed for 2003–2011

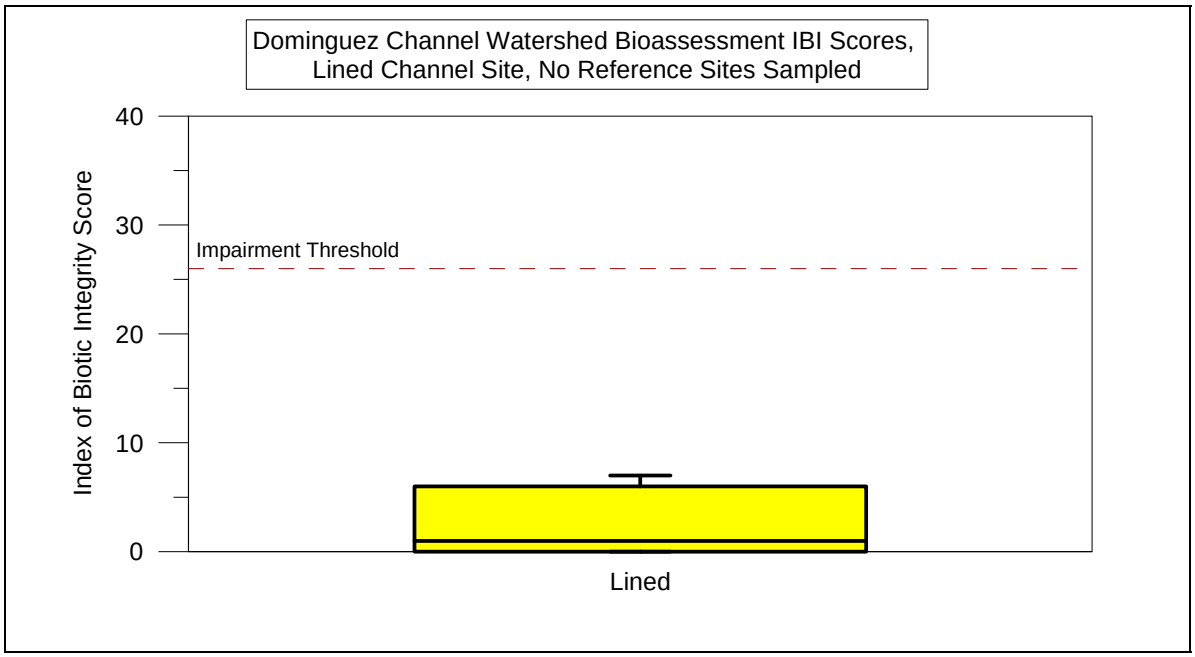


Figure 20. Index of Biotic Integrity Scores, Dominguez Channel Watershed for 2003–2011

5.4 Santa Monica Bay Watershed Survey Results for 2003–2011

The Santa Monica Bay Watershed shown in Figure 21 encompasses the Ballona Creek Watershed, the Malibu Creek Watershed, and several other small coastal drainages (e.g., Topanga Canyon, Trancas Canyon, and Rustic Canyon). 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 in 18 different locations from 2003 through 2011. 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 also sampled, 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, two of which, SMC03944–Cheseboro Channel and SMC5902–Santa Monica Channel, were located in concrete-lined channels. One notable organism that was collected in SMC02152–Malibu Creek (2010) and SMC012814–Trancas Canyon Creek (2011) was snails in the family Hydrobiidae, which were extremely abundant (Appendix B.1). In Malibu Creek none of the specimens were mature enough to be identified to genus level, but the sexually mature specimens in Trancas Canyon Creek had the distinguishing taxonomic characters of the invasive New Zealand mud snail (*Potamopyrgus antipodarum*).

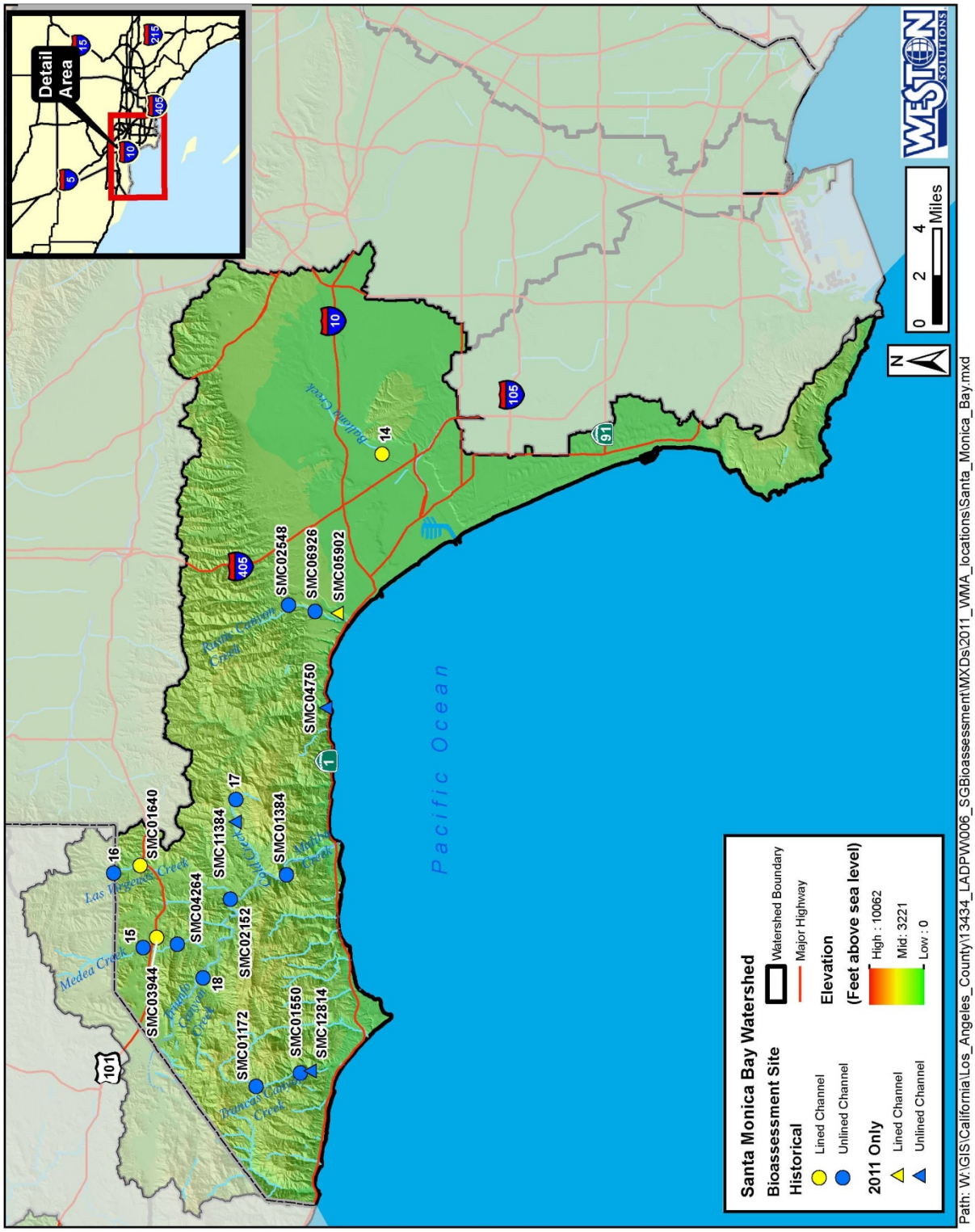


Figure 21. Bioassessment Monitoring Sites in the Santa Monica Bay Watershed for 2003–2011

Mean Metric Analysis for 2003–2011

Table 11 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 reference site 17–Cold Creek, SMC11384–Cold Creek, and SMC02548–Rustic Canyon Creek indicated higher quality benthic communities than all other sites in this watershed. These three sites had very high percentages of intolerant (sensitive) taxa and moderately high diversity of EPT taxa. Five of the sites were of substantially poorer quality than the majority, including 14–Ballona Creek, 15–Medea Creek, SMC01640–Las Virgenes Creek, SMC03944–Cheseboro Channel, and SMC05902–Santa Monica Channel. These sites had mean taxa richness of less than 12, two EPT taxa or less, no intolerant taxa, and greater than 76% collector taxa. All other sites had moderate taxa richness, low to moderate EPT taxa, and intolerant taxa were present in most.

Table 11. Santa Monica Bay Watershed Selected Metric Values, Mean of Annual Surveys for 2003–2011

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*	6	31.5	11.0	34.5%	22.3%
Cold Creek	SMC11384	1	43.0	13.0	23.2%	32.0%
Triunfo Creek	18	5	26.8	2.8	0.4%	64.4%
Malibu Creek	SMC01384	1	22.0	7.0	3.0%	33.8%
Malibu Creek	SMC02152	1	20.0	3.0	0.0%	24.2%
Cheseboro Canyon Channel	SMC03944	1	6.0	1.0	0.0%	95.8%
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 to 2011 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Integrity Scores for 2003–2011

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 12). Site 17–Cold Creek was consistently the highest-rated site in the

Bioassessment Program for those years and an SMC site further downstream in Cold Creek (SMC11384) also had a relatively high IBI score in 2011. Since 2009, the results from SMC sites sampled in the Santa Monica Bay Watershed have revealed several streams with unimpaired biotic conditions, including Rustic Canyon Creek, Topanga Canyon Creek, and Trancas Canyon Creek. 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.

Two sites were sampled in Rustic Canyon, 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 (Table 11, Table 12, and WESTON, 2010). 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. The proximity of these two sites provides an excellent example of the presumed influence that urban runoff may have on BMI assemblages.

Table 12. Santa Monica Bay Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2011

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	Mean IBI Score	Range
Ballona Creek	14	6	10	7	5	10	4				7.0	6
Santa Monica Channel	SMC05902									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				50.5	13
Cold Creek	SMC11384									54	54.0	
Triunfo Creek	18	22		20	18	19	15				18.8	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	

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 2003–2011

Four of the 18 sites monitored in the Santa Monica Bay Watershed were in fully concrete-lined channels (Figure 22). All of these concrete-lined sites had mean IBI scores rated Very Poor in all surveys, and five of the unlined sites were rated 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 reference sites were excluded, a p-value of 0.005 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 0.002, 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 23). 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 not designated reference sites but had high quality BMI communities. The results of this analysis indicated a greater difference between the channel types compared to the 2009 and 2010 analyses (WESTON, 2010 and 2011) resulting from the addition of several high IBI scores in 2011.

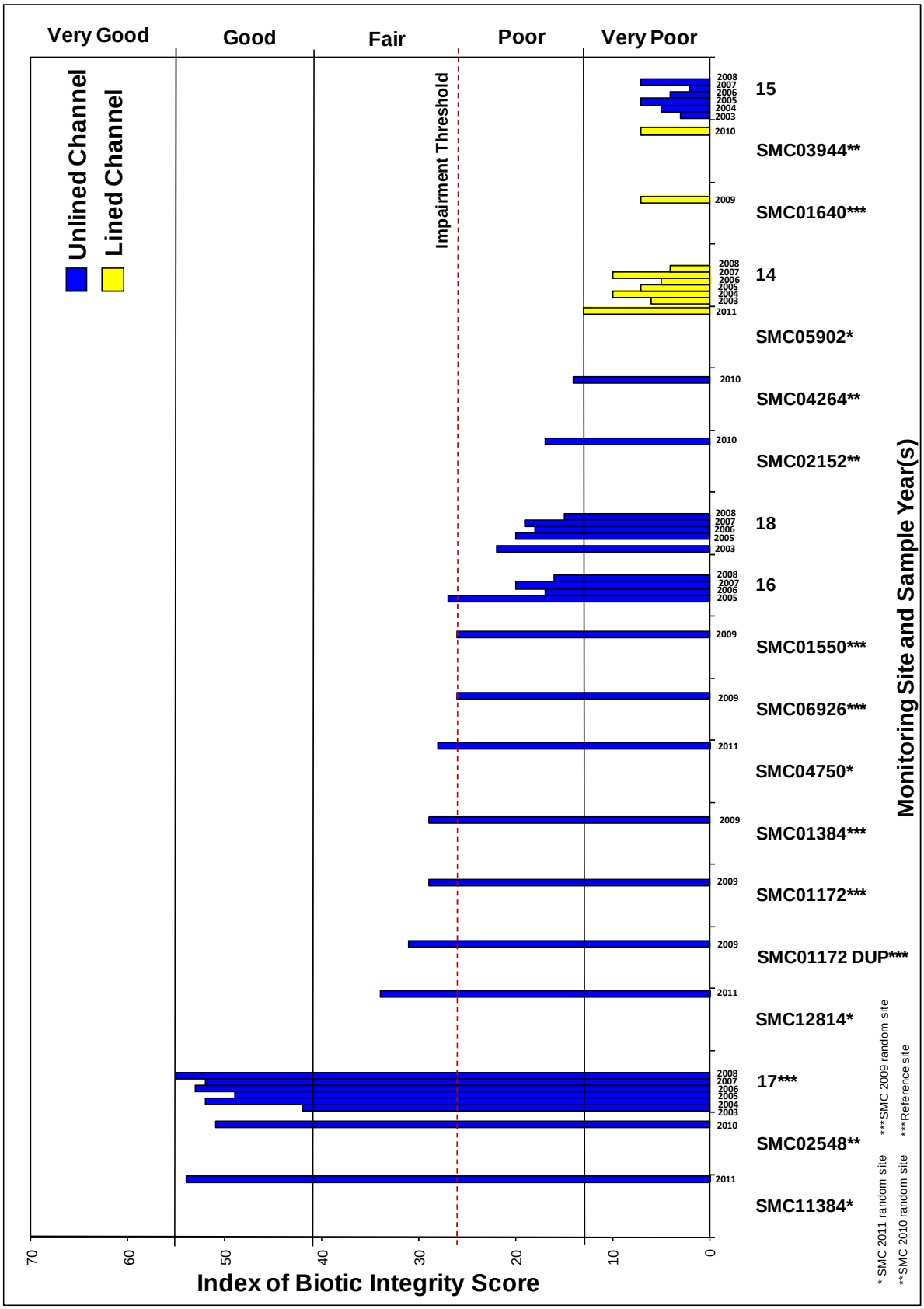


Figure 22. Index of Biotic Integrity Scores for Concrete-Lined and Unlined Channel Sites, Santa Monica Bay Watershed for 2003–2011

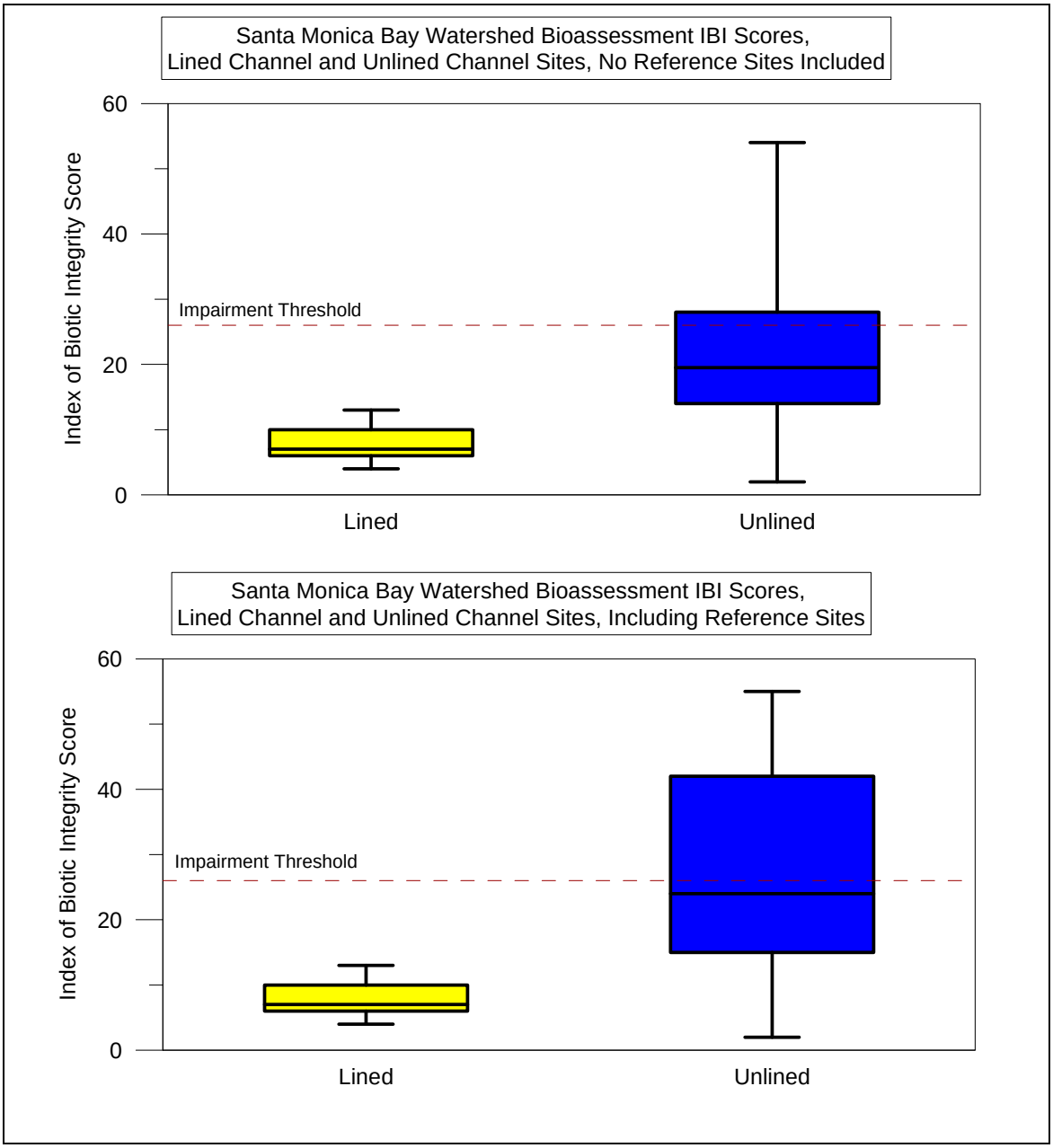


Figure 23. Comparison of Concrete-Lined and Unlined Channel Sites, Santa Monica Bay Watershed for 2003–2011

Comparison of Index of Biotic Integrity Scores and Elevation for 2003–2011

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 -0.083. The correlation was negative and not significant based on a critical value of 0.309 (41 samples and an alpha of 0.05). This result indicates that site IBI scores were not significantly related to elevation in this watershed, and the negative correlation indicates that IBI scores decreased somewhat with increasing elevation. This is likely due to a greater amount of urban development in the upper watershed and extensive forest land in the lower coastal watersheds in the Malibu area.

An illustration of these results is shown in Figure 24, a linear correlation of IBI and elevation. The coefficient of determination is shown on the graph as a measure of how well the data points fit a linear model. It is evident from this graphic that the relationship between IBI scores and elevation in this watershed was weak, slightly negative, and statistically insignificant with an R^2 of 0.007.

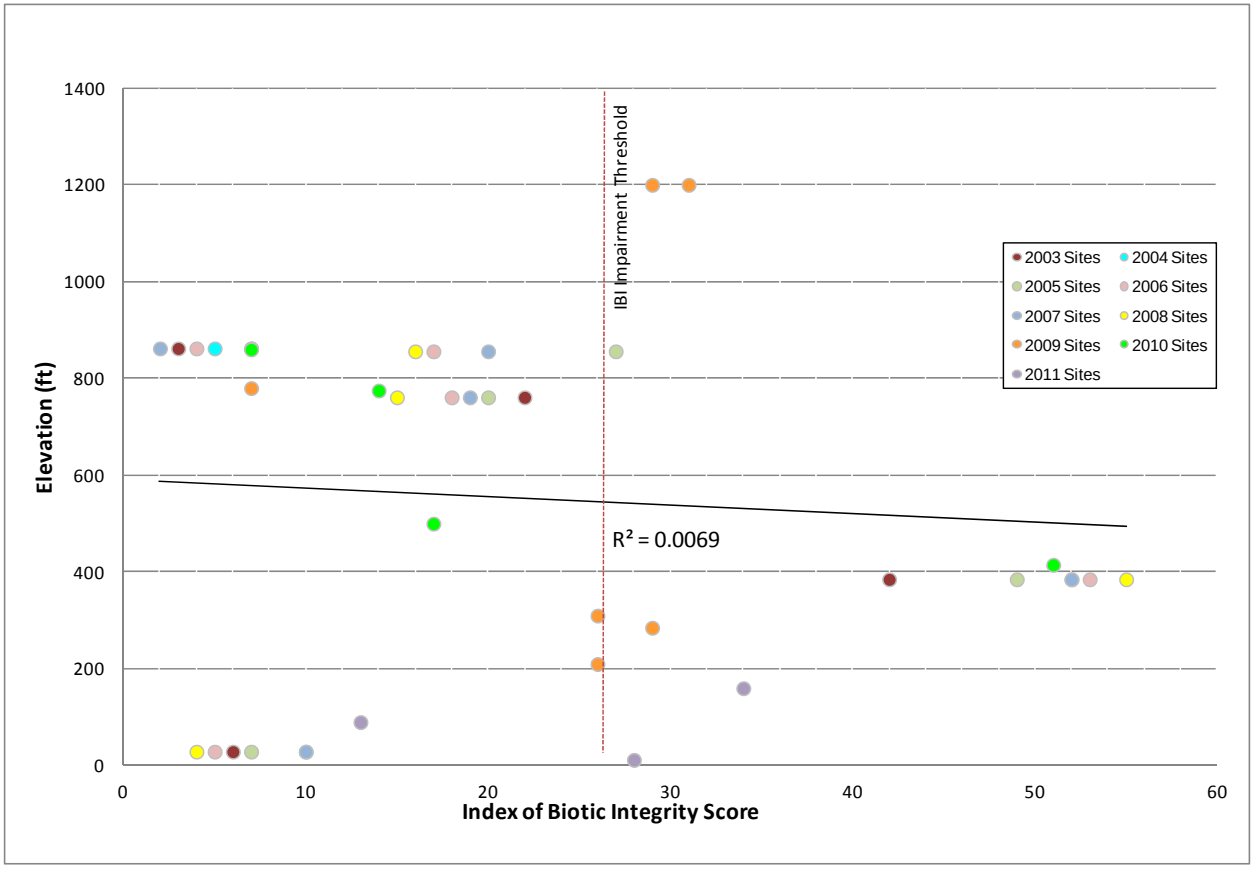


Figure 24. Correlation of Index of Biotic Integrity Scores and Elevation, Santa Monica Bay Watershed for 2003–2011

5.5 Santa Clara River Watershed Survey Results for 2003–2011

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 25). 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 activities of the City of Santa Clarita.

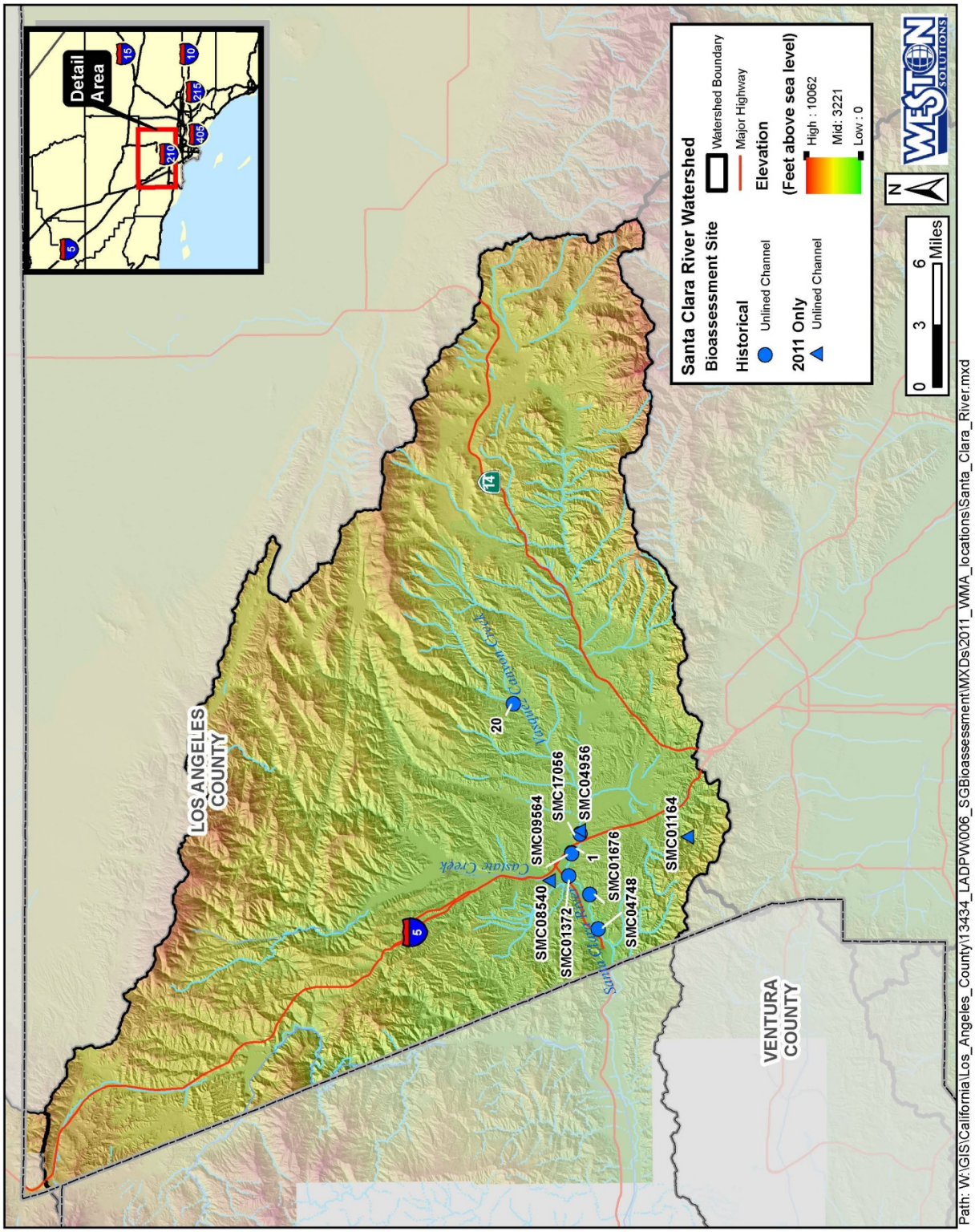


Figure 25. Bioassessment Monitoring Sites in the Santa Clara River Watershed for 2003–2011

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 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. In 2011, one site was in the Santa Clara River mainstem (SMC04956), one site was in Castaic Creek (SMC8540), and one site was in Towsley Creek (SMC01164). The Towsley Creek site may have qualified as a reference site. Duplicate samples were collected at Towsley Creek, although they were collected 4 weeks apart.

Mean Metric Analysis for 2003–2011

Table 13 shows the mean values of four individual metrics that are considered strong indicators of ecological health. Eight of the nine sites monitored in the Santa Clara River watershed had similar mean metric values, while SMC01164−Towsley Creek had a somewhat higher quality BMI community. Excluding Towsley Creek, mean taxa richness ranged from 14 to 25, there were four to six EPT taxa at each site, and no intolerant taxa were collected. Collector taxa were generally present in moderate percentages. At Towsley Creek, the mean taxa richness of the duplicate samples was 32.5 and intolerant taxa were present. A significant difference existed between the duplicate samples, with the June 24 sample showing a much higher quality BMI community than the July 22 sample. Taxa richness decreased from 41 to 24 (Appendix B.3), EPT taxa decreased from 8 to 2, and collector taxa increased from 59.0% to 85.4%. Percent intolerant taxa, however, remained stable at 0.2% and this may have indicated that water quality was likely similar and that the differences were due to natural variability or seasonal effects.

The similarity of the results for the Santa Clara River mainstem sites was not surprising because the sites were relatively close to one another and the physical conditions of the riverbed were similar at each site (i.e., all sites had substrates that were dominated by unconsolidated coarse sand in low-gradient reaches).

Table 13. Santa Clara River Watershed Selected Metric Values, Annual Surveys for 2003–2011

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%
Towsley Creek	SMC01164/ SMC01164 Dup	2	32.5	5.0	0.2%	74.4%
Santa Clara River	SMC04956	1	23.0	4.0	0.0%	92.6%
Castaic Creek	SMC08540	1	18.0	3.0	0.0%	85.0%

blue highlight = unlined channel site
**2009 to 2011 taxa richness values adjusted from Level II to Level I taxonomy values

Comparison of Index of Biotic Integrity Scores for 2003–2011

The nine sites in the Santa Clara River Watershed had IBI scores in the Poor to Fair range (Table 14, Figure 26, and Figure 27). 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 altered the streambed and flushed out most of the emergent vegetation, resulting in a low IBI score for that year. In 2010, two sites in the Santa Clara River mainstem that had not been sampled in the past, SMC01372 and SMC01676, scored above the impairment threshold. In 2011, the Towsley Creek site June 24 sample also was above the impairment threshold but the July 22 sample was not.

Table 14. Santa Clara River Watershed, Comparison of Index of Biotic Integrity Scores for 2003–2011

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	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	
Towsley Creek	SMC01164/ SMC01164 Dup									34/23	28.5	11
Castaic Creek	SMC08540									9	9.0	

blue highlight = unlined channel site
no highlight = not sampled

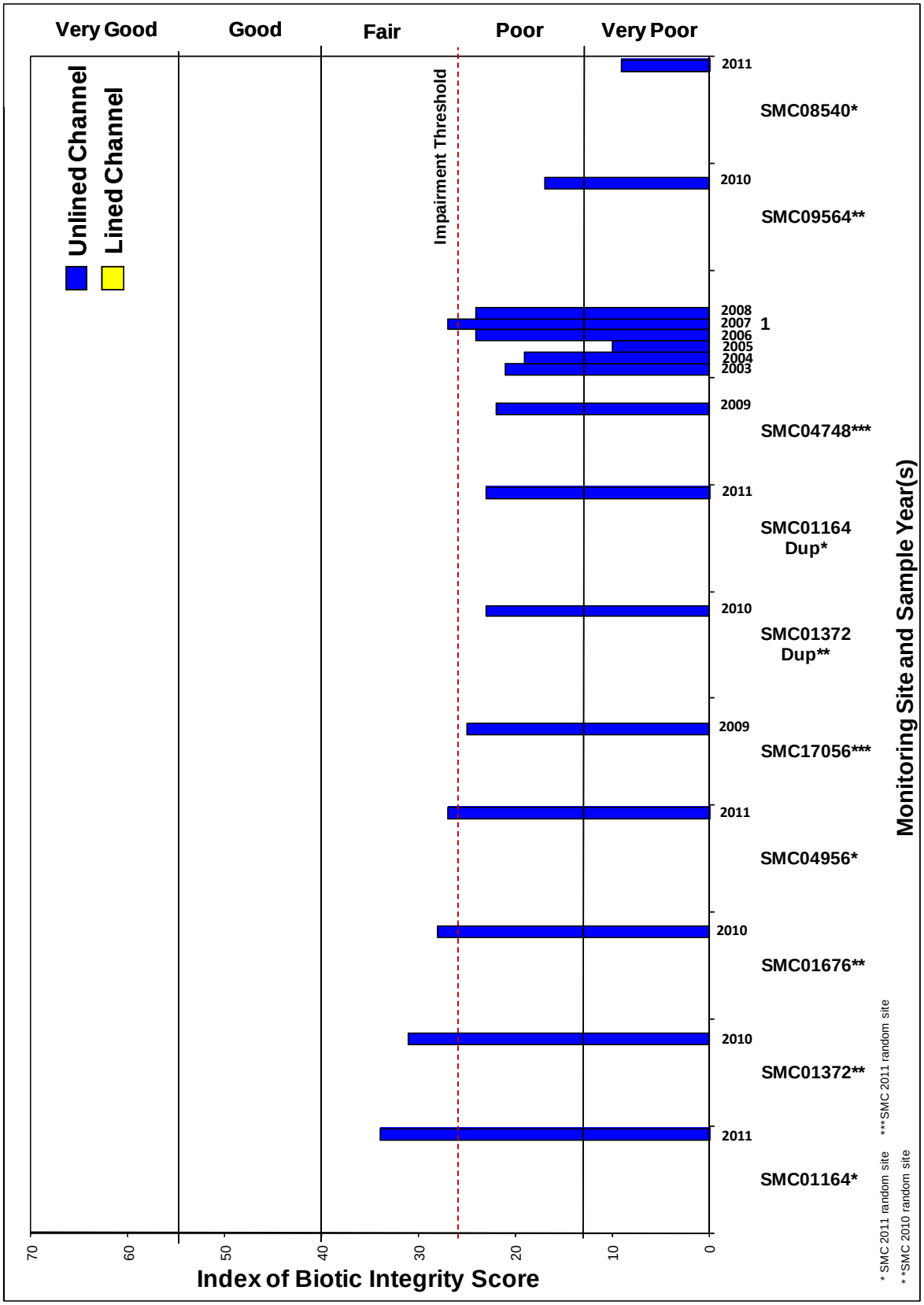


Figure 26. Index of Biotic Integrity Scores for Unlined Channel Sites, Santa Clara River Watershed for 2003–2011 (no concrete-lined sites)

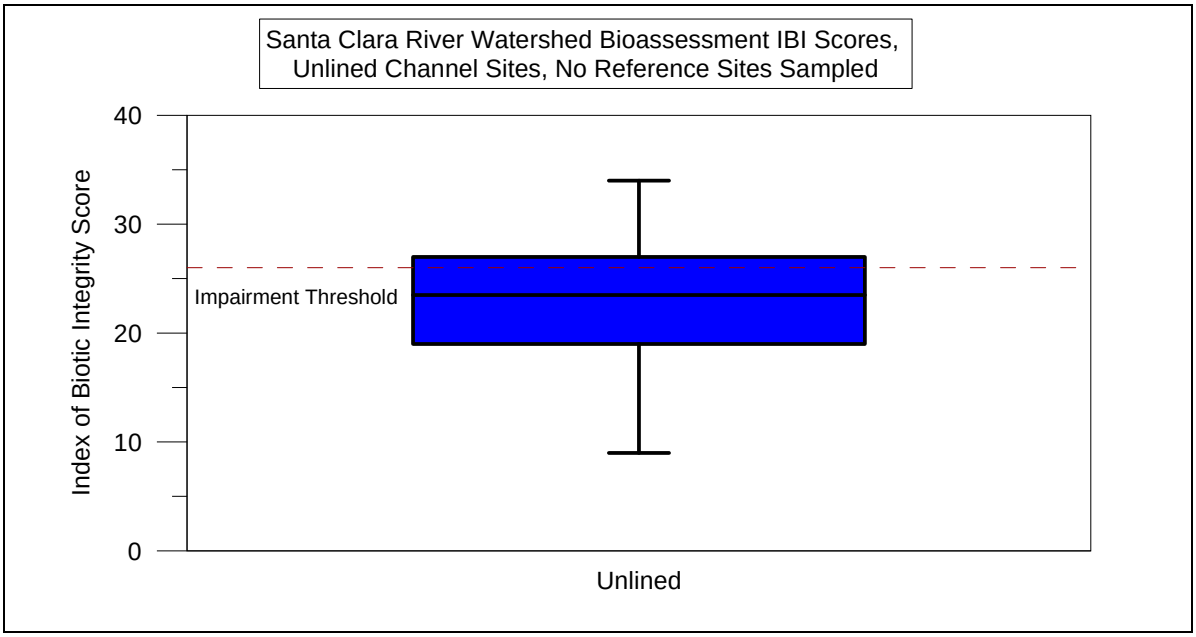


Figure 27. Index of Biotic Integrigy Scores, Santa Clara River Watershed for 2003–2011

Comparison of Index of Biotic Integrity Scores and Elevation for 2003–2011

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 0.307. The correlation was insignificant based on a critical value of 0.503 (16 samples and an alpha of 0.05). These results indicate that site IBI scores were not significantly correlated to elevation and that they increased only slightly with increasing elevation. This result is in contrast to the 2010 results, which showed a slightly (but not significantly) negative relationship. The positive correlation in 2011 was driven by the addition of Towsley Creek at an elevation of 1,600 feet and a higher quality BMI community; all the other sites were within approximately 200 feet elevation of one another, and the majority of the IBI scores were relatively similar.

An illustration of the results is shown in Figure 28, a linear correlation of IBI and elevation. The coefficient of determination is shown on the graph as a measure of how well the data points fit a linear model. It is evident from this graphic that the relationship between IBI and elevation in this area of the watershed was weak and slightly positive, with an R^2 of 0.09.

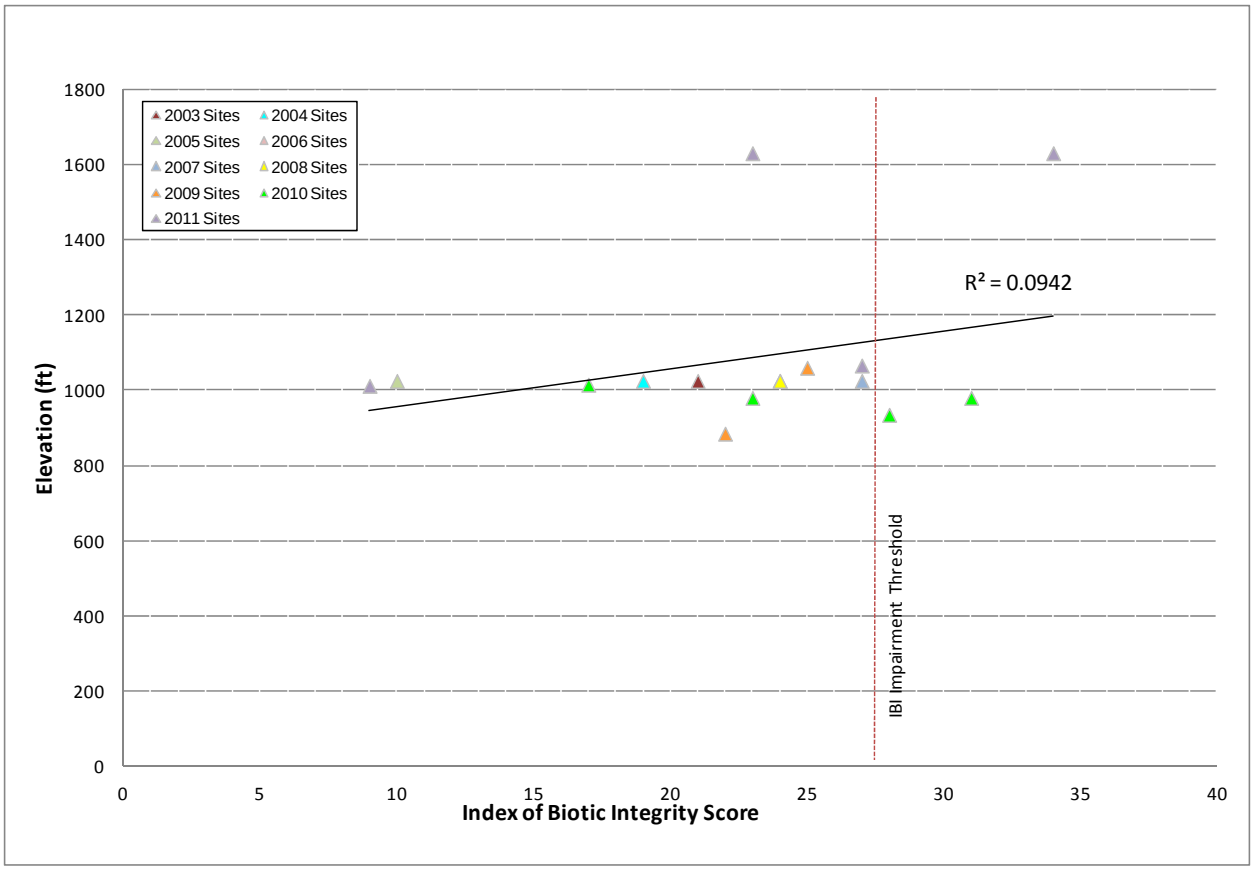


Figure 28. Correlation of Index of Biotic Integrity Scores and Elevation, Santa Clara River Watershed for 2003–2011

6.0 SUMMARY

Eighteen receiving water monitoring reaches representing five watersheds in the County were sampled for BMI and were assessed for physical habitat quality between June and July 2011. 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 56 different sites have been sampled, and four of the sites have been sampled in every survey.

Taxonomic evaluation of the 2011 samples yielded approximately 138 different taxa from 10,398 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 2011, the most abundant organism collected throughout the County was the mayfly *Baetis* sp. Mayflies in the family Baetidae and 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 collector–gatherer feeding group. In 2011, all but two sites, SMC11384–Cold Creek and SMC12814–Trancas Canyon Creek, were dominated by organisms in this FFG. The Trancas Canyon Creek site was dominated by scrapers in the family Hydrobiidae, and the sexually mature specimens were identified as the invasive New Zealand mud snail, *Potamopyrgus antipodarum*.

The 2011 IBI scores of the monitoring reaches ranged from 0 (Very Poor) to 60 (Very Good) of a maximum of 70 points. SGUT-501–San Gabriel River was the highest rated site, and SMC11384–Cold Creek, SMC01164–Towslwy Creek, and SMC12814–Trancas Canyon Creek were the second, third, and fourth highest rated sites, with IBI scores of 60, 54, and 34, respectively. Five of the other 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.

Analysis of individual metrics as well as total IBI scores showed that in the San Gabriel and Los Angeles 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 correlation existed between site elevation and IBI scores. In the Santa Monica Bay and Santa Clara Watersheds, however, this correlation was very weak, and IBI scores either decreased or increased with elevation, although the correlation was not statistically significant. In Santa Monica Bay, 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 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 difference between concrete-lined and unlined sites was greater in the 2008 and 2009 data than in data from 2003 to 2007 and 2010. This was due to several lower Los Angeles River sites that were in concrete-lined channels yet had IBI scores similar to other unlined lower watershed sites. In 2011, a much greater difference existed between the lined and

unlined sites. When this analysis was performed by watershed, the lower Los Angeles River Watershed site results did not show a difference between concrete-lined and unlined sites, whereas in the San Gabriel River Watershed and Santa Monica Bay Watershed, the difference between concrete-lined and unlined site results was much greater. Correlation analysis between CRAM physical habitat scores and IBI scores (performed in 2010) indicated a significant relationship between physical habitat and biotic integrity. The analysis also indicated three groups of sites that corresponded with (1) the concrete-lined and altered channel sites, (2) the natural channel sites within the urban landscape, and (3) the natural channel open space sites.

Comparison of the IBI scores for 9 survey years (i.e., 2003–2011) 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 40 of the 56 monitoring sites. The only site that may be trending toward a statistically significant improvement in the BMI community is 7–Arroyo Seco.

The two-way cluster analysis of 2011 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 IBI score, 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, the Santa Clara River Watershed sites with unconsolidated sandy substrates clustered together, and four of the five fully concrete-lined sites clustered together. 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 had fairly 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 2011 had results similar to the 2011 data, with overall stronger associations between BMI assemblages, site IBI scores, and site physical characteristics than shown in the analysis that considered only the 2011 sites.

7.0 FUTURE PROJECTIONS FOR BIOASSESSMENT

As the science of bioassessment monitoring continues to evolve, further changes in monitoring protocols and methods and in the regulatory climate 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.

Currently, the methodology for stream physical habitat assessment incorporates two separate protocols (i.e., SWAMP and CRAM). In 2009, CRAM was first implemented, and was performed at all sites, although it was only required to be performed at SMC sites. In 2010 and 2011, CRAM was conducted only at the SMC sites (and 6-Arroyo Seco in 2010, due to major habitat disruption at that site). 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 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. Re-calibrating the IBI for low-gradient, depositional stream reaches is another potential improvement of current stream bioassessment methodologies. Reference conditions for this habitat type were not adequately incorporated in the development of the IBI, and these types of sites may be designated as impaired when water quality is good and sensitive organisms are present but in very low numbers.

There is also research in progress to develop algal biological metrics and an algae-specific IBI for southern California. The research is being conducted by SCCWRP through grant funding from the United States Environmental Protection Agency and will incorporate data generated from a variety of NPDES monitoring programs. The algal IBI was in draft form at the end of 2011 and may become a very useful tool in ambient surface water monitoring. Algae respond more quickly and to different ecological stressors than BMI (particularly nutrients and sediment), and there is a general consensus that these two monitoring tools are complementary and that the addition of algae measurement will provide a more comprehensive understanding of anthropogenic impacts to the stream biota. Algae sample collection 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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