Morro Bay National Estuary Program's Implementation Effectiveness Program For the Morro Bay Watershed

Data Summary Report

2015

Ann Kitajima, Monitoring Program Manager
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Morro Bay National Estuary Program
601 Embarcadero, Suite 11
Morro Bay, CA 93442

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CONTENTS

1.0 INTRODUCTION

The Morro Bay National Estuary Program's Monitoring Program conducted environmental monitoring throughout the Morro Bay watershed to track both ambient water quality trends and the outcome of specific implementation projects.

The time period of data for this report is January 2008 through September 2015. Where this is not the case, the time period for the data is provided. Data was collected by volunteers and program staff with funding support from the following sources: CWA Section 319(h), Proposition 50 Coastal Nonpoint Source Pollution Control Program, ARRA funding through the Clean Water State Revolving Fund, CWA Section 320, and Clean Water State Resolving Fund (CWSRF).

DATA ANALYSIS: OVERVIEW

The Morro Bay National Estuary Program (MBNEP) monitoring program has conducted monitoring in the following areas: creek water quality, creek discharge volume, fecal indicator bacteria, stream cross section profiling, riparian bioassessment and macroinvertebrate analysis, bay water quality, phytoplankton, shorebird monitoring, Surface Elevation Tables, and algae documentation. The following table summarizes the parameters monitored through these efforts and the frequency of monitoring.

Component	Sub-component	Analytes	Frequency	Year Data Collection Initiated	Number of Sites
Water Quantity	Flow	instantaneous flow volume (depth and width of water, velocity)	monthly	1995	21 total
Bacteria	Bacteria	total coliform, *E. coli*, *Enterococcus* spp.	monthly	2002	8 bay and 24 creek sites
		Fecal coliform	Monthly, quarterly	2013	15 bay and 2 creek sites
Water Quality - Chemistry & Nutrients	Freshwater Sampling	temperature, dissolved oxygen concentration (mg/L), dissolved oxygen percent saturation (%), turbidity, pH, conductivity, nitrate as N, orthophosphate as P	monthly	2001	21 total

Component	Sub-component	Analytes	Frequency	Year Data Collection Initiated	Number of Sites
	Estuarine Sampling (Dawn Patrol)	dissolved oxygen, salinity, temperature	monthly	2002	7 total
	Shoreline freshwater seeps	Nitrate as nitrogen	Monthly	2014	5
Geomorphology	Cross-Sectional Profiles	cross-sectional area, bankfull width and depth, floodprone width, channel slope	variable, depending on rainfall	1993	22 (all Chorro Basin)
	Bay Sediment Monitoring (SETs)	change in surface elevation, mean sediment accretion	variable, depending on rainfall	2004	6 salt marsh, 4 mudflat
	California Rapid Assessment Method (CRAM)	Hydrology, habitat types, site stability	Variable	2008	3 sites on Walters Creek
Biotic	Bioassess-ment	canopy cover, bank stability, substrate measurement, stream gradient, temperature, dissolved oxygen, conductivity, pH, alkalinity, SAFIT Level II taxonomic classification	annually	1995	15 water-shed sites (not all sites monitored each year)
	Algal Cover	point-intercept data (percent cover)	annually	2011	15 creek sites (not all sites monitored each year)

Component	Sub-component	Analytes	Frequency	Year Data Collection Initiated	Number of Sites
	Plankton Diversity	community density and diversity, % *Alexandrium* spp., % *Pseudonitzschia* spp.	monthly	1998	north T-Pier
	Shorebird Monitoring	species count, population count	annually	1988	15 sectors in bay, sand spit and strand
	Eelgrass Mapping	eelgrass acreage, other aquatic vegetation acreage	biennially	2003	baywide
	Eelgrass Monitoring	shoot density	biannually	2012	baywide

Water quality data collected by the program is compared to various standards to understand its implications. The Central Coast Region Basin Plan contains standards established to protect the beneficial uses of water bodies within this immediate region. Another source of criteria for analyzing local data is the Central Coast Ambient Monitoring Program (CCAMP). Managed by the Central Coast Regional Water Quality Control Board (CCRWQCB), CCAMP provides additional informal attention levels for various chemical analytes. While these are not regulatory standards, they provide a regional context for the data.

NOTE ON REPORT STRUCTURE

The water quality, bacteria, bioassessment and algae data are discussed in a single section called Creek Data Analysis. The discussions are focused around each waterbody, rather than each analytical constituent. Thus, the chapter for Dairy Creek will include discussion of monitoring parameters for the sites on that waterbody. The Morro Bay watershed was divided into the following chapters based on subwatersheds: Dairy Creek, Pennington Creek, San Luisito Creek, San Bernardo Creek, Chorro Creek, and Los Osos and Warden Creeks.

A summary section titled Creek Water Quality Sites Overview contains overview plots of the data by parameter, with sites across all waterbodies compared amongst each other. Monitoring methods for each parameter are described in this section.

The MBNEP's bay monitoring efforts are combined in a separate section, which includes shorebird surveys, bay bacteria, bay water quality, and phytoplankton enumeration.

Within this report, each monitoring site is referenced with a three-letter code. In an effort to improve consistency with historical and ongoing collaborative monitoring efforts, some monitoring site codes have been updated. These changes are noted throughout the text.

Data from stormwater, eelgrass and sediment monitoring efforts are not included in this report. Separate reports were developed for each of these topics and are available on the program's website, www.mbnep.org/library/.

The data included in this report was collected by monitoring program staff and volunteers between January 2008 and September 2015, unless otherwise stated. In each section, the number of samples and time period during which they were collected is summarized to provide context for the analysis. Previous data reports included additional data (going back as early as 2002). For ease of presentation, this report does not include this earlier data.

Additionally, some parameters for some sites were not included in the data visualizations and tables in this report's analysis. Long-term monitoring has demonstrated consistent compliance with Basin Plan standards and other benchmark levels of concern for select parameters at many of the sites. For parameters at sites where data is showing minimal or no cause for concern, statistical analysis and graphical representations were not generated for this report. In the Creek Water Quality Sites Overview section, a narrative description describes the method, frequency and other details on how data was collected. If bioassessment and algae data were not included in a discussion section, it is because they were not monitored in 2015.

The final section of the document includes a discussion of implementation effectiveness analysis, where monitoring and analysis were conducted specifically to understand the effectiveness of various implementation efforts throughout the watershed.

2.0 Creek Data Analysis

The following analysis includes data collected from the creeks throughout the Morro Bay watershed.

Creek Water Quality Sites Overview

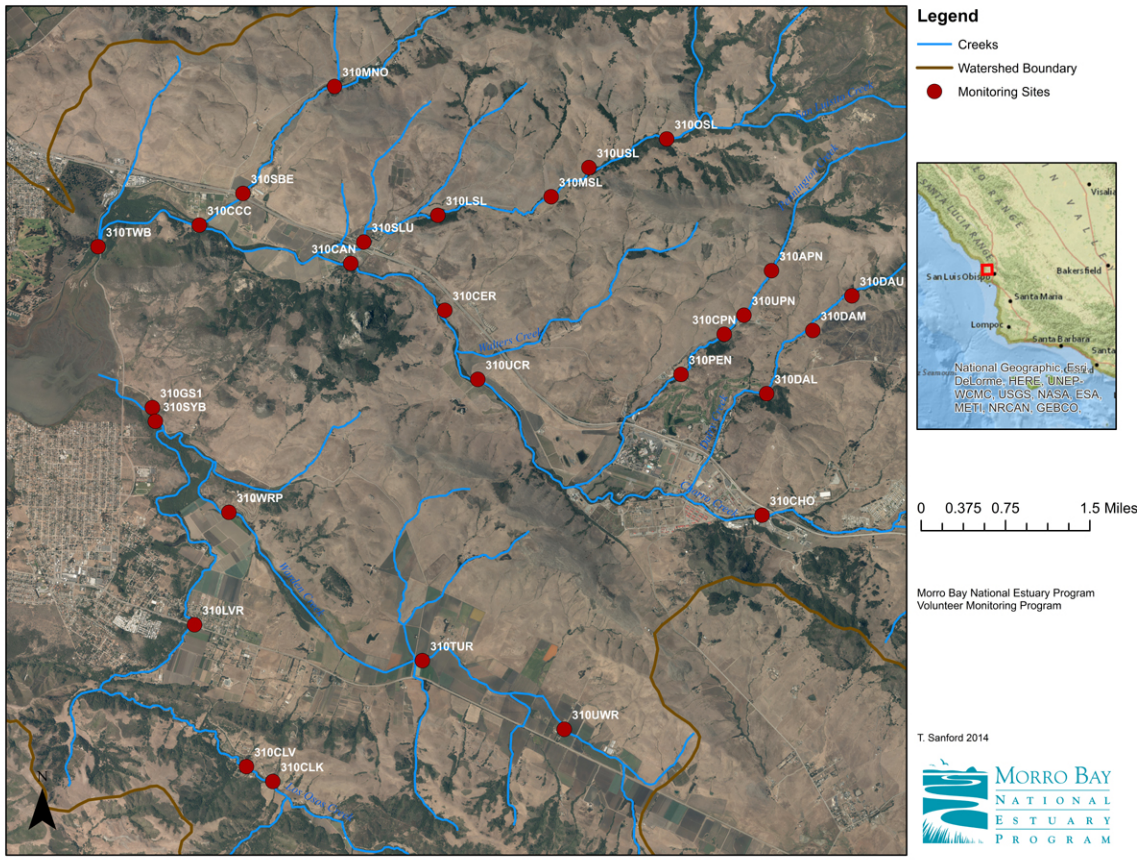
Data presented in this section compares water quality data among sites throughout the watershed. The length of the data record varies among sites. Unless otherwise stated, the data included in the analysis spans from January 2008 through September 2015. The table below details the program's creek monitoring sites.

Site Code	Waterbody	Description
CHO	Chorro Creek	Chorro Creek at Camp San Luis Obispo, near Hwy 1
UCR	Chorro Creek	Chorro Creek bridge crossing upstream of Gilardi Road at the Cal Poly bridge
CER	Chorro Creek	Chorro Creek crossing between Gilardi and Canet Roads on the Chorro Creek Ecological Reserve
CAN	Chorro Creek	Chorro Creek at Canet Road bridge off Hwy 1
CCC*	Chorro Creek	Chorro Creek at Chorro Creek Road
TWB	Chorro Creek	Chorro Creek at South Bay Blvd bridge, near State Park Road
DAU	Dairy Creek	Dairy Creek at El Chorro Regional Park and Camp SLO Boundary, at the creek crossing
DAM	Dairy Creek	Dairy Creek upstream of dog park, near locked gate across road
DAL	Dairy Creek	Dairy Creek upstream of culvert under park entrance road

Site Code	Waterbody	Description
APN	Pennington Creek	Upper Pennington Creek, above well field at road crossing
UPN	Pennington Creek	Upper Pennington Creek, stream crossing near Cal Poly Beef Unit corrals
CPN	Pennington Creek	At the Pennington Creek Rd bridge, on the border of Cal Poly property
PEN	Pennington Creek	Pennington Creek at El Chorro Outdoor School amphitheater
OSL	San Luisito Creek	San Luisito Creek on private ranch
USL	San Luisito Creek	San Luisito Creek on private ranch, upper
MSL	San Luisito Creek	San Luisito Creek on private ranch, middle
LSL	San Luisito Creek	San Luisito Creek on private ranch, lower
SLU	San Luisito Creek	San Luisito Creek at Adobe Road bridge crossing
MNO*	San Bernardo Creek	San Bernardo Creek, upstream of SBE
SBE	San Bernardo Creek	San Bernardo Creek at Adobe Road crossing
CLV	Los Osos Creek	Clark Valley branch at road crossing
CLK	Los Osos Creek	Clark Valley branch upstream of road crossing
LVR	Los Osos Creek	Bridge over Los Osos Valley Road
UWR	Warden Creek	Warden Creek upstream of TUR
TUR	Warden Creek	Warden Creek crossing under Turri Road near Los Osos Valley Road
WRP	Warden Creek	Warden Creek near former landfill
SYB	Los Osos Creek	Los Osos Creek on Turri Road near South Bay Blvd
GS1	Los Osos Creek	Los Osos Creek on Turri Road, downstream of SYB
COO	Coon Creek	Coon Creek trail at first bridge in Montana De Oro State Park

Note: Coon Creek, which is not in the Morro Bay watershed, is monitored as a control site for comparison to watershed sites. It is not included on the following map.

**The CCC site was formerly referenced as UCF in previous reports. The MNO site was formerly referenced as MSB in previous reports.*



TEMPERATURE

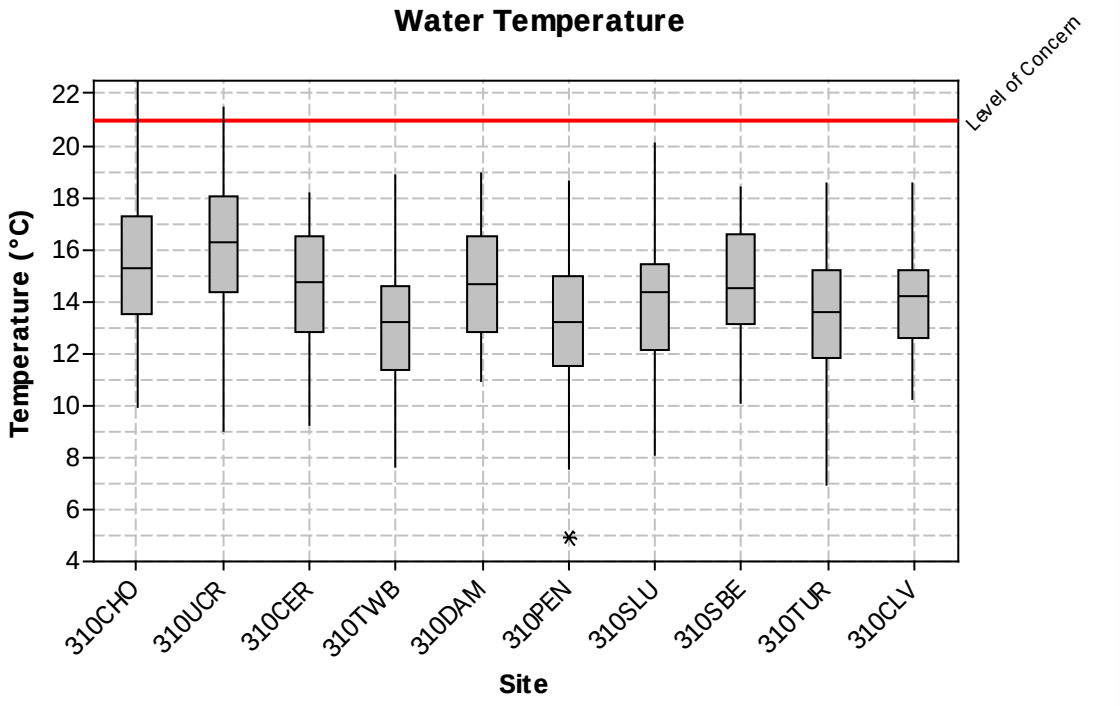
Water temperature was measured as part of the water quality monitoring effort, which could take place at any time during daylight hours, not necessarily at a consistent time of day. Water quality was generally monitored at each site once or twice monthly, depending on volunteer availability and site hydrology.

Temperature data was collected with a YSI Model 85 multi-parameter meter, which uses a thermistor to determine water temperature in degrees Celsius. The meter's range is -5 to +65 °C with a resolution of 0.1 °C.

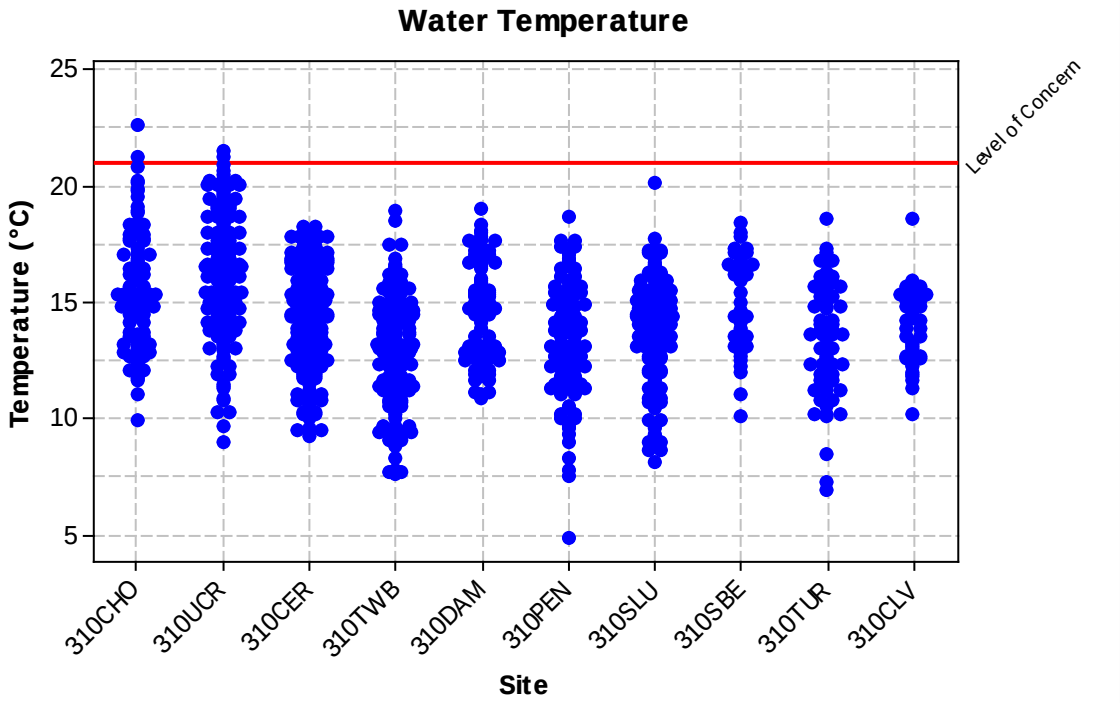
The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk.

The level of concern for protection of steelhead habitat is 21 °C, which is a CCRWQCB 303(d) Listing Guidance Value.

Water temperatures have very rarely exceeded levels of concern throughout the lengthy data record for most creek sites. Thus, detailed multi-year analysis was not conducted for all of the creek sites. Multi-year comparison graphs were created for water temperatures on Chorro Creek (CHO, UCR, CER and TWB), Dairy (DAM), Pennington (PEN), San Luisito Creek (SLU), San Bernardo Creek (SBE), Warden Creek (TUR), and Los Osos Creek (CLV), due to its relationship to dissolved oxygen concentrations.



The data for the same sites is also presented as a scatter plot to show the variability in the data.



DISSOLVED OXYGEN

Dissolved oxygen saturation and concentration were measured as part of the water quality monitoring effort, which could take place at any time during daylight hours, not necessarily at a consistent time of

day. Dissolved oxygen was monitored at each site once or twice monthly, depending on volunteer availability and site hydrology.

Program volunteers measured dissolved oxygen (DO) concentration and percent saturation during each water quality field visit. Data was collected with a YSI 85 meter utilizing Clark Cell technology. The YSI 85 meter measures a range of 0 to 200% for saturation with a resolution of 0.1%. For DO concentration, the meter's range is 0 to 20 mg/L with a resolution of 0.01 mg/L.

The Central Coast Basin Plan regulatory standard states that at no time shall DO concentrations fall below 7.0 mg/L. Because this criteria is rarely violated, a detailed analysis was not conducted for comparison of this analyte across multiple sites. For creeks where dissolved oxygen has been variable or failed to consistently meet benchmarks, a more detailed analysis was included.

TURBIDITY

Turbidity was measured as part of the water quality monitoring effort, which could take place at any time during daylight hours, not necessarily at a consistent time of day. Water quality was usually monitored at each site once or twice monthly, depending on volunteer availability and site hydrology.

Turbidity data was collected using a HACH 2100P field meter, which makes use of the auto ranging nephelometric method of measurement. The meter has a range of 0 to 1,000 NTU and a resolution of 0.01 NTU.

The Basin Plan lists a level of concern of 25 NTU for protection of aquatic life in cold water (beneficial use COLD) and 40 NTU for protection of aquatic life in warm waters (WARM). The data record across all sites shows infrequent exceedances of these criteria (2.3% of 1,977 records exceeded 25 NTU, 1.0% of the samples exceeded 40 NTU). Exceedances are typically correlated with storm events, and do not reflect impaired ambient water quality conditions. Because these standards are rarely exceeded, a more detailed year-by-year analysis for each creek was not conducted.

CONDUCTIVITY

Conductivity was measured as part of the water quality monitoring effort, which could take place at any time during daylight hours, not necessarily at a consistent time of day. Water quality monitoring was conducted at each site once or twice monthly, depending on volunteer availability and site hydrology.

Temperature-corrected conductivity data was collected using a YSI 85 meter with nickel electrodes. The meter has a range of 0 to 200,000 uS/cm with a resolution of 0.1 uS/cm.

The Central Coast Basin Plan includes a conductivity objective of 3,000 uS/cm to protect the Agriculture beneficial use. Elevated conductivity levels, as a measure of dissolved solids, can be indicative of pollution such as agricultural or road drainage runoff. At the majority of the sites, conductivity data rarely approaches the Basin Plan standard. Because these standards are rarely exceeded, a more detailed year-by-year analysis for each creek was not conducted. The only sites of concern are located on Warden Creek. This data is detailed in the Warden and Los Osos Creeks portion of Section 2.

PH

Beginning in July 2010, program volunteers measured pH during each water quality field visit using a pH probe. The meter has a range of -1.0 to 15.0 pH units, with a resolution of 0.1 pH units. Prior to July 2010, pH paper was used for the measurement. The paper has a range of 4.5 to 10.0 with a resolution

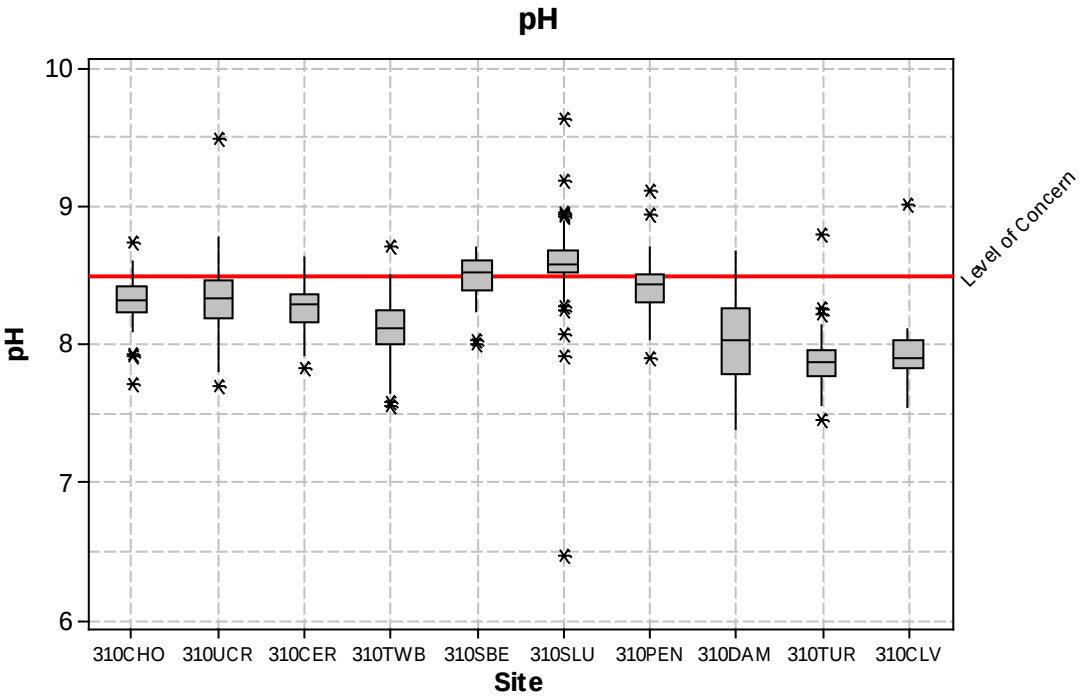
of 0.5 pH units. Following extensive quality control comparisons of the probe and paper data with lab analysis, the pH probes appeared to be very accurate, whereas the pH paper was consistently underestimating the pH.

The following analysis includes electronic pH probe data only, from July 2010 through September 2015.

Per the Central Coast Basin Plan, pH concentrations must remain between 6.5 and 8.3 to be protective of the recreational contact beneficial use (REC-1). For protection of aquatic life, the Basin Plan standard is between 7.0 and 8.5 (COLD, WARM). The elevated pH values in subwatersheds of the Chorro Valley are thought to be related to the local geology.

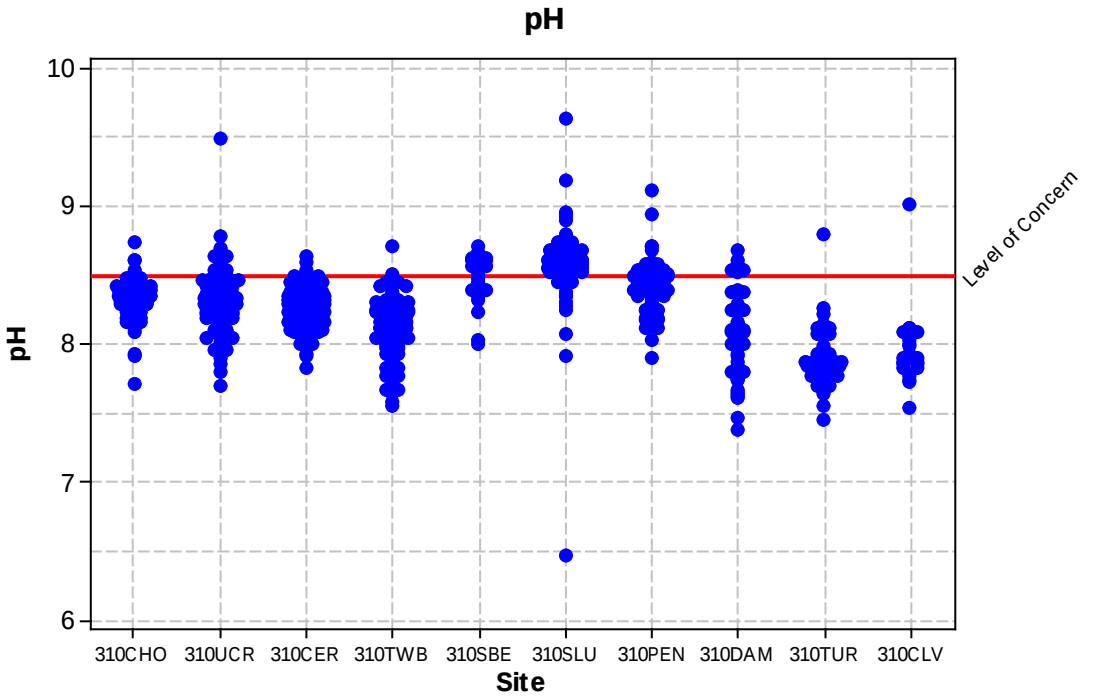
Because pH results are not considered to be of concern in the watershed, a more detailed annual analysis for each creek was not conducted.

The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk.



** Values include pH meter data from July 2010 through September 2015.*

The data for the same sites is also presented as a scatter plot to show the variability in the data.



NUTRIENTS

Orthophosphates as phosphorus (P) and nitrate as nitrogen (N) were measured as part of the water quality monitoring effort. Monitoring could take place at any time during daylight hours, not necessarily at a consistent time of day. Samples were collected by staff and volunteers, and analysis was conducted at the program office using chemical test kits and meters.

The program's methodology for orthophosphates as P analysis has changed over the years in an effort to improve the quality of the data. All methods utilized an ascorbic acid reaction. Volunteer-generated data prior to April 2004 was discarded due to the determined inaccuracy of the test kit. From early 2004 through mid-2006, a HANNA meter and HANNA reagent were used. From mid-2006 through mid-2007, a YSI 9000 meter with YSI reagent was used. From mid-2007 to December 2013, the analysis method used a HANNA Low Range Phosphate colorimeter (HI 93713) with HACH PhosVer 3 Phosphate Reagent. The meter has a range from 0.02 to 2.50 mg/L with a resolution of 0.01 mg/L. In February 2014, the program began using a HACH DR/890 with the PhosVer 3 Phosphate Reagent. Out-of-range samples were analyzed by diluting the sample with deionized water and multiplying the result by the dilution factor. This is a simple colorimeter which was selected because it is safe and easy to use, but it does not yield data with the same precision and accuracy as lab-generated data. The project quantitation limit (PQL) for the HACH DR/890 meter was determined to be 0.11 mg/L orthophosphate as P.

The CCAMP informal attention level is 0.12 mg/L as P, a value created specifically for the Pajaro River but adapted for the Morro Bay watershed. Orthophosphates frequently exceeded attention levels and are monitored closely on Chorro Creek downstream from the California Men's Colony (CMC) Wastewater Treatment Plan (WWTP) outfall. This data is provided in the Chorro Creek section of the report. Although orthophosphate concentrations are not of concern on Los Osos and Warden Creeks, the data was analyzed for comparison to Chorro Creek to illustrate how the nutrient issues differ

between those two subwatersheds. Orthophosphate analysis is included in the report sections for Chorro, Warden and Los Osos Creeks.

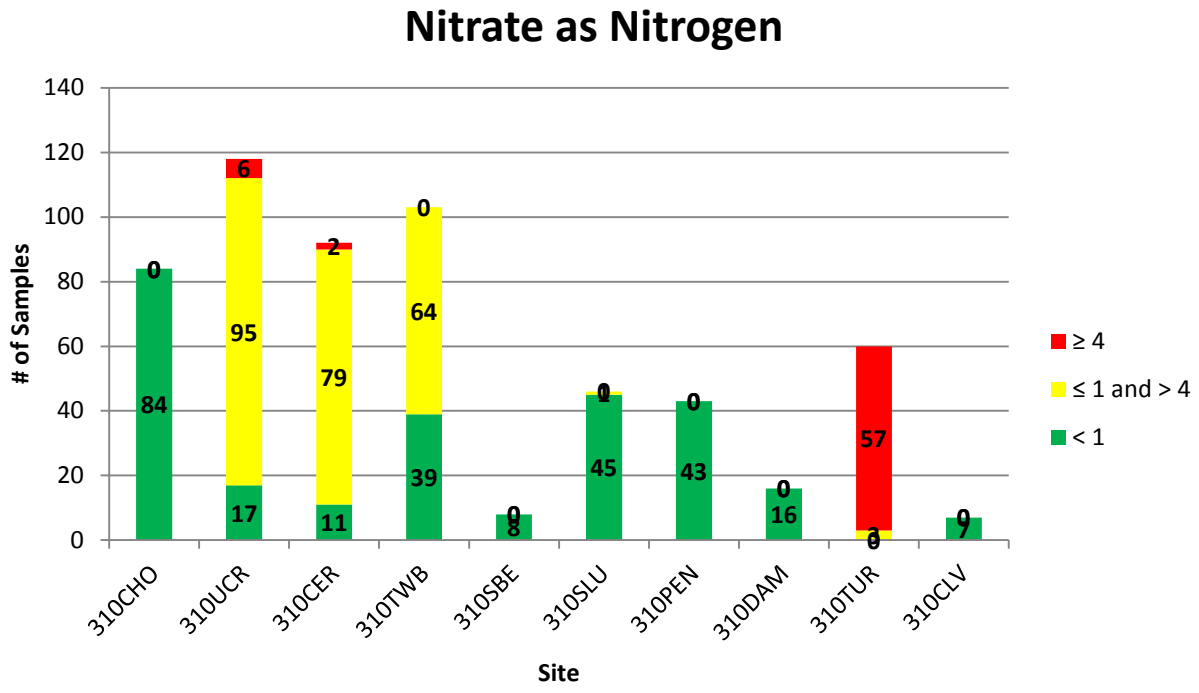
Nitrates as nitrogen were monitored from 2002 through 2011 with a LaMotte test kit (method 3354) that uses a zinc reduction reaction. The method utilizes a color change reaction and compares the reacted sample to a color chart with gradations at 0, 1, 2, 4, 6, 8, 10 and 15 mg/L. For this method, readings between 0 and 1 were considered to be non-detects and were reported as 0.5 mg/L for the purpose of analysis. This is a simple test kit which was selected because it is safe and easy to use, but it does not yield data with the same precision and accuracy as lab generated data and thus should be considered to be screening level data.

Beginning in January 2012, the MBNEP changed analysis methods and began using a HACH model DR/890 colorimeter run with Method 10020, a chromotropic acid method. The test can enumerate a range from 0 to 30 mg/L nitrates as N. In comparisons of split samples with laboratory analysis, the meter is much more accurate than the previously used LaMotte method. In February 2014, the meter was replaced with the next generation version, the HACH DR/900 using the same chromotropic acid method. The PQL for the meter was determined to be 1.0 mg/L NO_3-N.

The following plot shows the number of samples with nitrate concentrations in three categories: less than 1 mg/L, less than or equal to 1 and greater than 4 mg/L, and greater than or equal to 4 mg/L. The graph combines data from the HACH colorimeter and from analysis by a certified lab.

The CCRWQCB 303(d) Listing Guidance Value for nitrates as nitrogen is 1 mg/L for the protection of aquatic life, along with other evidence including depressed DO levels and excess algal growth.

Nutrients are primarily of concern on Chorro, Los Osos and Warden Creeks. Thus, more detailed analyses were conducted for those sites. The tributaries to Chorro Creek seldom exceeded the levels of concern, so no additional analysis was conducted.



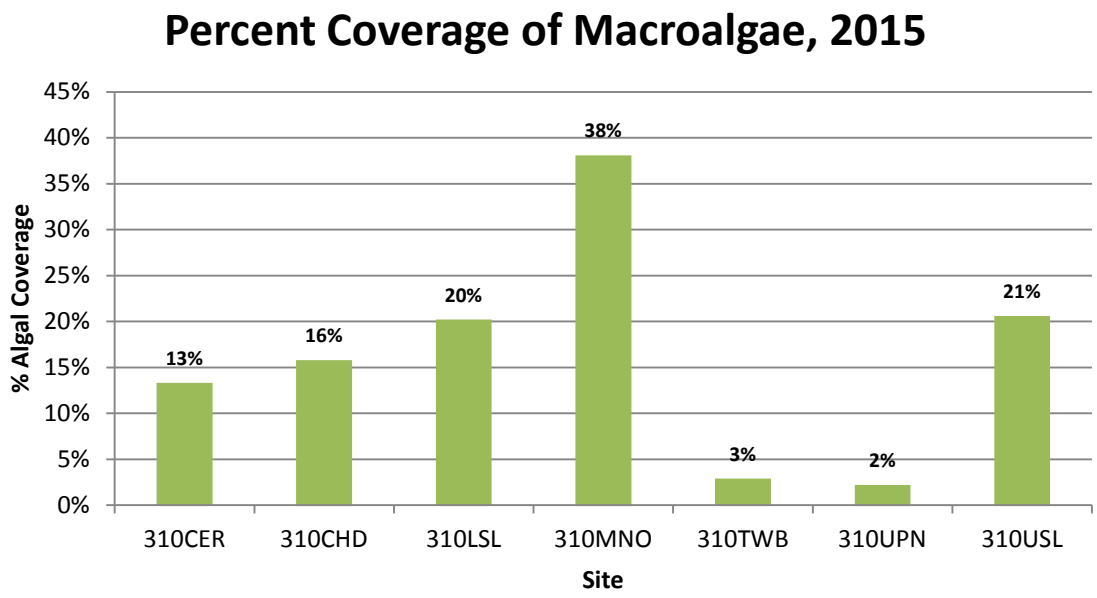
As the nitrate method PQL is so close to the level of concern, the program began quarterly nitrate sampling in late 2015 at a subset of sites throughout the watershed. Analysis will be conducted by a certified laboratory.

ALGAE DOCUMENTING

Since 2011, algae data has been collected using the *Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California*, 2010. The protocol involves recording the presence or absence of macroalgae and filamentous algae while collecting habitat assessment data throughout a 150 meter reach of the stream. The complete SWAMP algae monitoring protocol, including sample collection and analysis, was not conducted due to limited financial and staff resources.

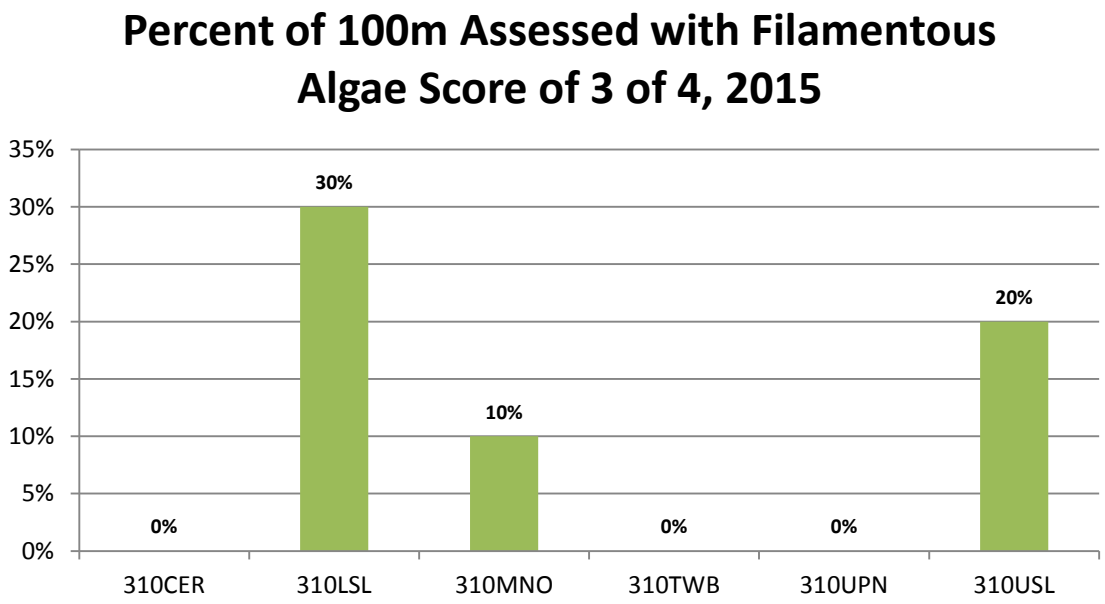
The CCRWQCB utilizes the data in assessing 303(d) listings and de-listings, as well as TMDL implementation effectiveness. Algal blooms can be considered supporting information when making a decision to list a waterbody as impaired, in particular when nutrient concentrations are elevated and dissolved oxygen concentrations are erratic.

Betty Fetscher of the Southern California Coastal Water Research Project, one of the authors of the SWAMP algae monitoring protocol, recommended calculating the percent coverage of macroalgae and the percent of heavy filamentous algae coverage. The following graph displays the percent coverage of macroalgae present during the habitat assessment I n2015. This was calculated by tallying the number of assessed points at a site where water was present. The number of wet points in the creek with macroalgae present was tallied, and a percent algal coverage was calculated. Ideally, sites have less than 40% coverage of algae.



As part of the habitat assessment, the percent coverage of filamentous algae was scored for defined areas 5 m above and 5 m below each of ten transects assessed within each site. Each assessment area (10 m of wetted reach) was assigned a score between 0 to 4, with 0 indicating less than 5% algae coverage, 1 indicating less than 10% coverage, 2 indicating 10 to 40% coverage, 3 indicating 40 to 75% coverage, and 4 indicating greater than 75% coverage. Ms. Fetscher recommended tallying the areas

scored with a 3 or 4 out of the 100 m assessed at each site. The graph below shows the percent of area with filamentous algae scores of 3 or 4 out of the 100 m assessed at each site in 2015.



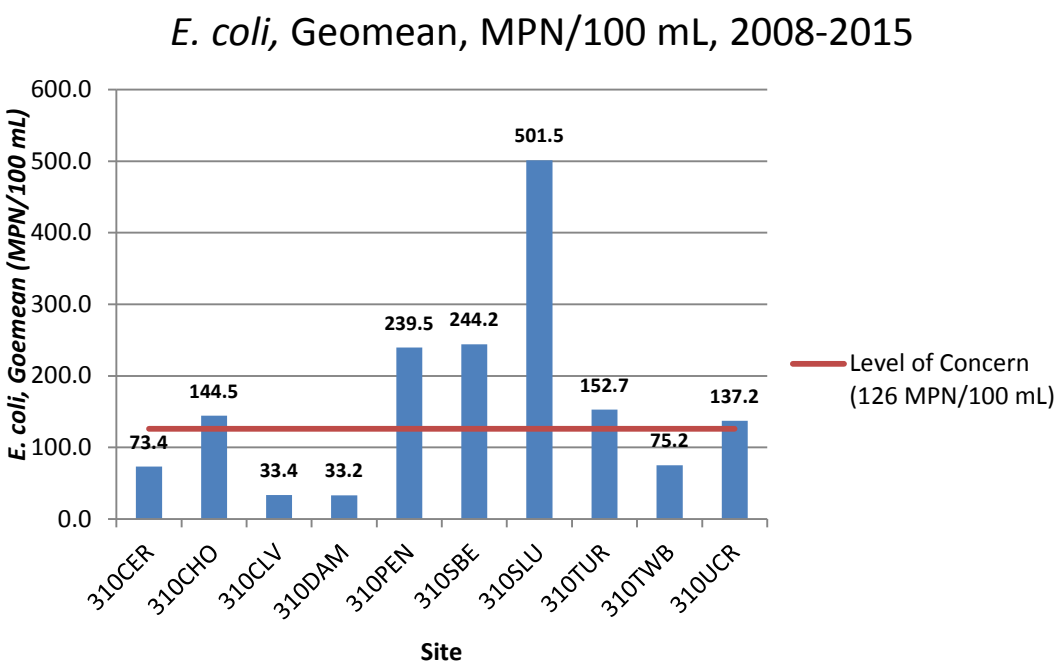
BACTERIA

The MBNEP monitored total coliform and *E. coli* bacterial indicators. Monthly samples were collected and then analyzed by staff and volunteers with the IDEXX method using Colilert-18 reagent. Analysis took place at the Morro Bay-Cayucos Wastewater Treatment Plant Laboratory. Bacteria monitoring was not timed to coincide with water quality monitoring at these sites.

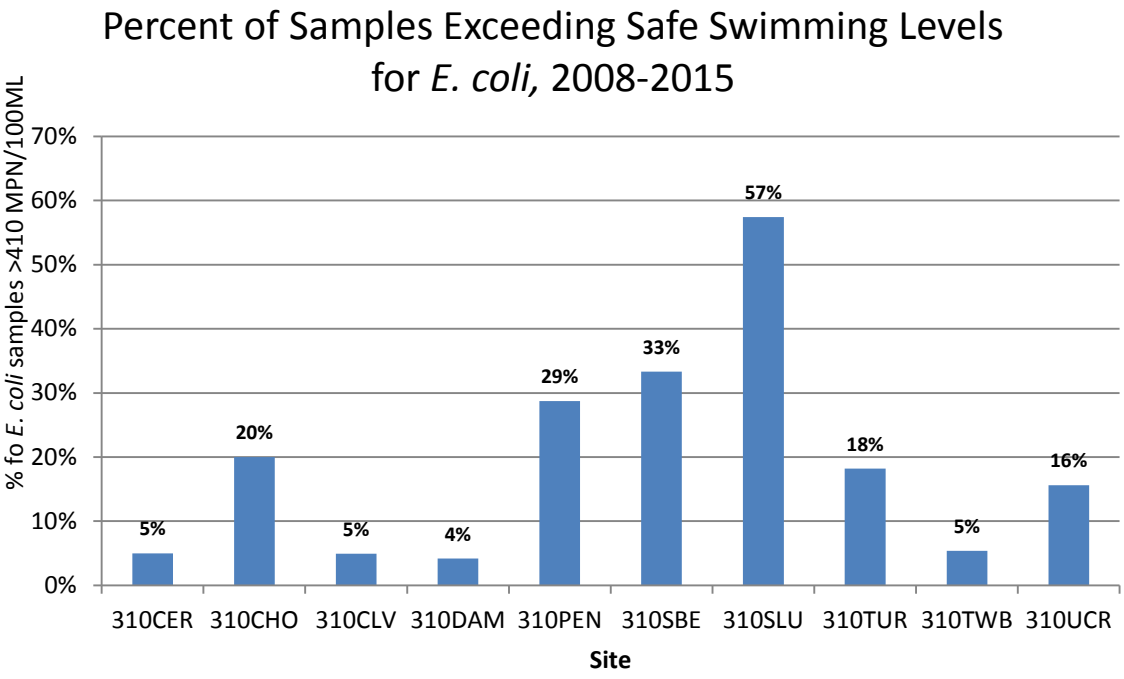
Based on typical sample dilutions, the range of detection for the test is from < 1 MPN/100 mL to 24,196 MPN/100 mL. The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV), which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples, should not exceed 410 MPN/100 mL.

Due to frequent exceedances of the safe swimming standard for *E. coli*, detailed bacteria analysis has been conducted for each creek.

The following graph shows the geomean of *E. coli* data collected from January 2008 through September 2015 for select sites.



The following graph indicates the percent of *E. coli* results from 2008 through September 2015 that were greater than 410 MPN/100 mL. Ideally less than 10% of sample would exceed this threshold.

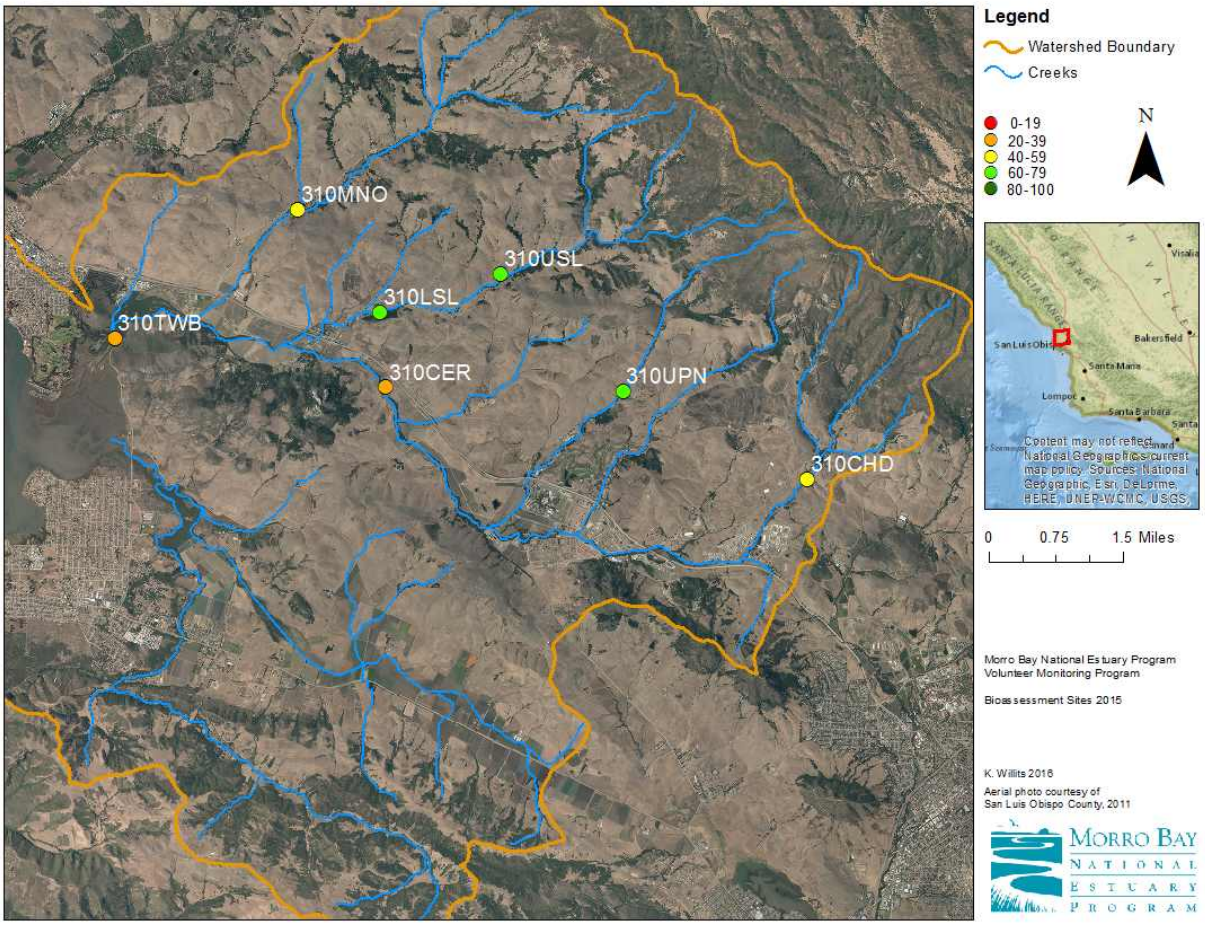


MACROINVERTEBRATES

Data collected between 2007 and 2015 utilized the SWAMP bioassessment procedures titled *Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California*, which was approved in spring 2007. The method involves monitoring a 150 m reach at each creek site using the reach-wide benthos procedure.

Measurements and observations on substrate, water depth, canopy cover, bank stability and other physical parameters were taken at each of 11 equidistant transects and ten inter-transects. Macroinvertebrate samples were collected from each transect, rotating between the margin and center of the creek. The samples were composited into a single sample which was sent to a lab for sorting and counting until 600 organisms were identified. The lab provided a count of the individual taxa as well as several calculated metrics.

The metrics included in this report are taxa richness, EPT richness, EPT% and IBI score. These metrics are detailed in site specific chapters later in this report. The Index of Biotic Integrity (IBI) score used in this report is the Southern California Coastal IBI developed by the Aquatic Bioassessment Laboratory of the California Department of Fish & Wildlife. IBI scores of 0 to 19 are considered to be very poor, 20 to 39 are poor, 40 to 59 are fair, 60 to 79 are good, and 80 to 100 are very good. The figure below demonstrates the site locations and IBI scores for sites monitored in 2015. The following table displays the IBI score for each creek site monitored from 2008 through 2015.

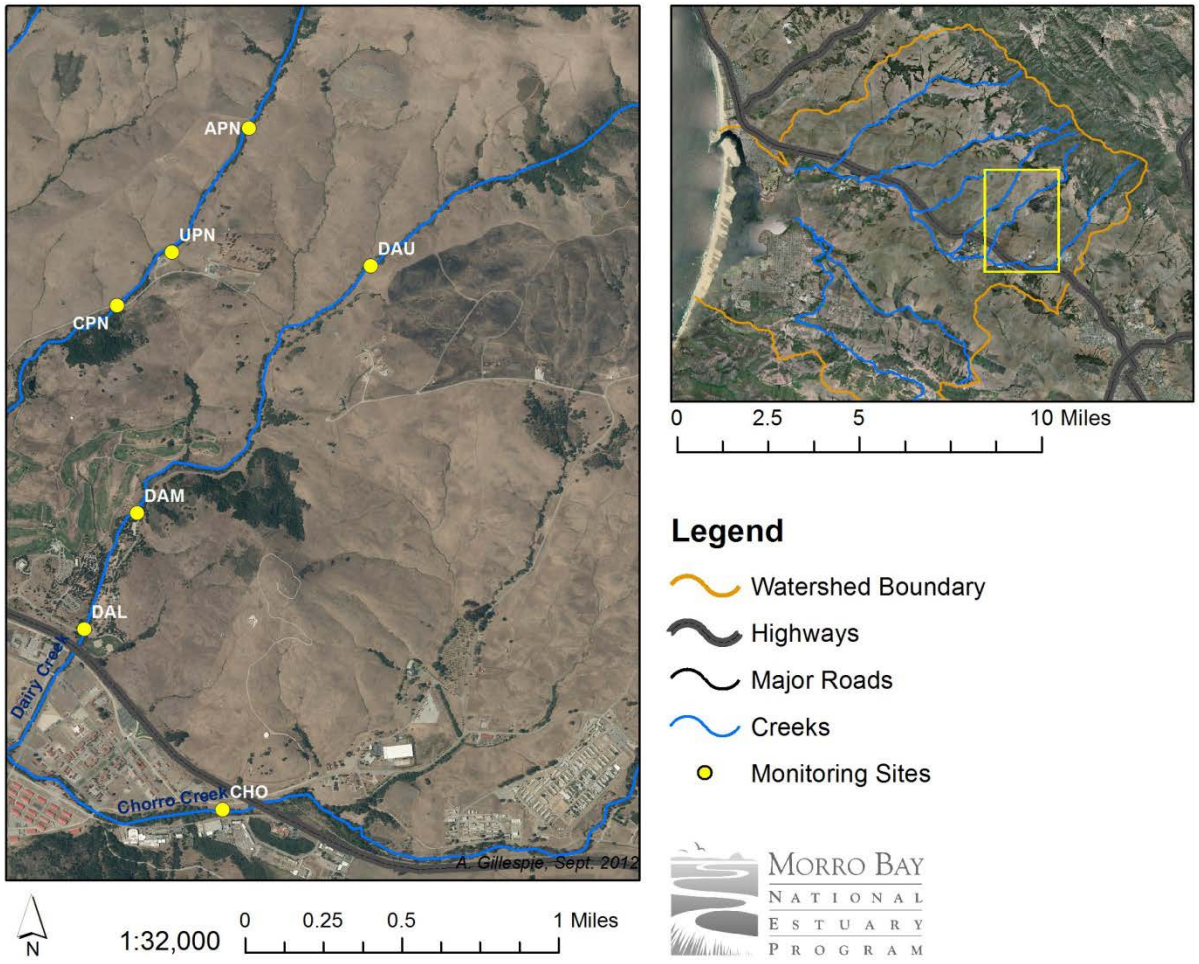


	CHD	CER	TWB	DAU	DAM	DAL	UPN	WAL	USL	LSL	USB	MNO	CLK	310LVR	310COO
2008 IBI Score	44.3	30.0	55.8	80.1	50.1	50.1	78.7	38.6	*	67.2	*	75.8	58.6	*	81.5
2009 IBI Score	57.2	*	*	91.5	74.4	*	*	*	*	70.1	*	*	*	*	*

	CHD	CER	TWB	DAU	DAM	DAL	UPN	WAL	USL	LSL	USB	MNO	CLK	310LVR	310COO
2010 IBI Score	*	*	*	71.5	52.9	60.1		28.6	91.5	75.8	77.2	67.2	65.8	41.5	*
2011 IBI Score	54.3	34.3	*	58.6	65.7	*	85.7	*	58.6	54.3	*	62.9	52.9	48.6	*
2012 IBI Score	*	47.1	45.7	*	*	*	84.3	*	*	72.9	*	74.3	70.0	*	*
2013 IBI Score	*	22.9	54.3	*	*	*	80.0	*	60.0	40.0	*	71.4	*	*	*
2014 IBI Score	*	30.0	41.4	*	*	*	78.6	*	65.7	55.7	*	44.3	*	*	*
2015 IBI Score	50.0	32.9	24.3	*	*	*	61.4	*	68.6	67.1	*	48.6	*	*	*
Average IBI	51.9	32.9	51.9	75.4	60.8	55.1	78.1	33.6	70.0	62.9	77.2	63.5	61.8	45.1	81.5

DAIRY CREEK

SITE MAP AND DESCRIPTION



The Dairy Creek subwatershed encompasses an area of approximately 2.5 square miles. The watershed is predominately utilized as rangeland for beef cattle operations. Most of the watershed is publicly-owned by the County of San Luis Obispo, the U.S. Forest Service, Cal Poly and Camp San Luis Obispo (California Army National Guard). The MBNEP monitors Dairy Creek at three sites in El Chorro Regional Park: Dairy Creek, Upper (DAU), Dairy Creek, Middle (DAM) and Dairy Creek, Lower (DAL). These sites were established in the early 1990's as part of the National Monitoring Program (NMP), and data collection was continued by the MBNEP following the conclusion of the NMP in 2001.

At the three Dairy Creek sites, water quality, bacteria and bioassessment monitoring were conducted when adequate flows were present. Bioassessment was not conducted at any of the Dairy Creek sites in 2012, 2013, 2014 and 2015 due to lack of surface flows.

WATER QUALITY N VALUE SUMMARY

A challenge with monitoring at Dairy Creek was the intermittent nature of the flow. DAL rarely flowed year-round. Flows appeared to go sub-surface above DAM and re-appear at the small impoundment waterfall where the monitoring site is located. Site DAU flowed for more of the year, although flows typically become quite low or non-existent by the end of the dry season.

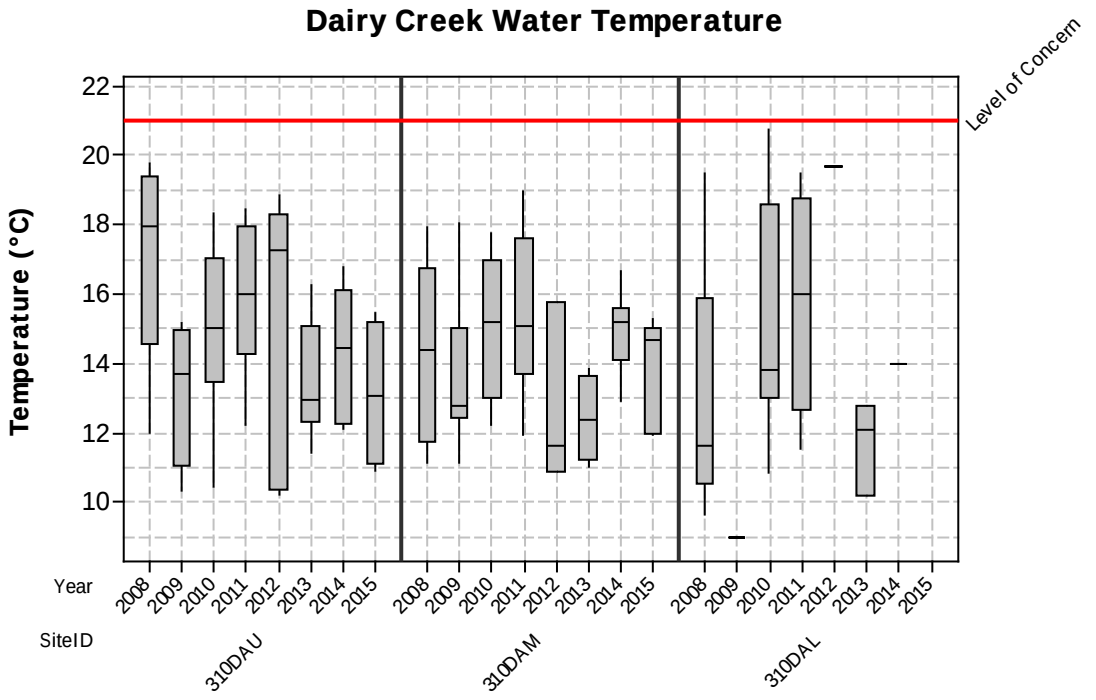
TEMPERATURE

The following tables provide an overview of the data, following a format recently adopted by the CCRWQCB in their own analysis of impaired waterbodies. In this analysis, dry season encompasses May to November and the wet season includes December through April.

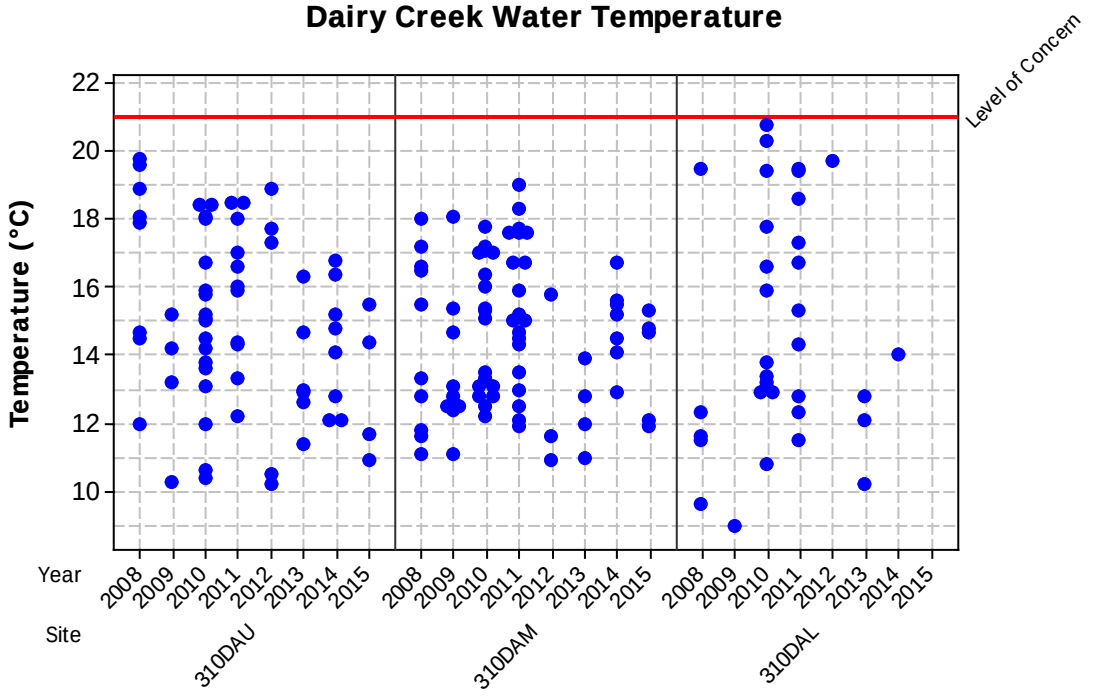
DAU	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	16.9	13.2	14.9	15.9	14.9	13.5	14.3	13.1
Dry Season Average	18.9	14.2	16.5	17.4	18.0	-	15.6	-
Wet Season Average	13.7	12.9	13.7	14.0	10.4	13.5	13.9	13.1
Range	7.8	4.9	8.0	6.3	8.7	4.9	4.7	4.6
n	8	4	18	11	5	6	8	4
# Exceedances for Wet Season	0	0	0	0	0	0	0	0
# Exceedances for Dry Season	0	0	0	0	0	-	0	-
% Exceedances for Entire Year	0	0	0	0	0	0	0	0

DAM	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	14.4	13.6	14.9	15.4	12.8	12.4	14.9	13.8
Dry Season Average	16.0	16.4	16.6	17.1	15.8	-	16.1	-
Wet Season Average	12.9	12.8	13.2	13.8	11.3	12.4	14.5	13.8
Range	6.9	7.0	5.6	7.1	4.9	2.9	3.8	3.4
n	10	9	18	20	3	4	7	5
# Exceedances for Wet Season	0	0	0	0	0	0	0	0
# Exceedances for Dry Season	0	0	0	0	0	-	0	-
% Exceedances for Entire Year	0	0	0	0	0	0	0	0

The following plot shows the mean water temperature for each year, with the results grouped by site. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk. The 21 °C level of concern for protection of steelhead habitat is a CCRWQCB 303(d) Listing Guidance Value, which is indicated on the graph by a red line.



The following graph shows the same data in scatter plot format.



DISSOLVED OXYGEN

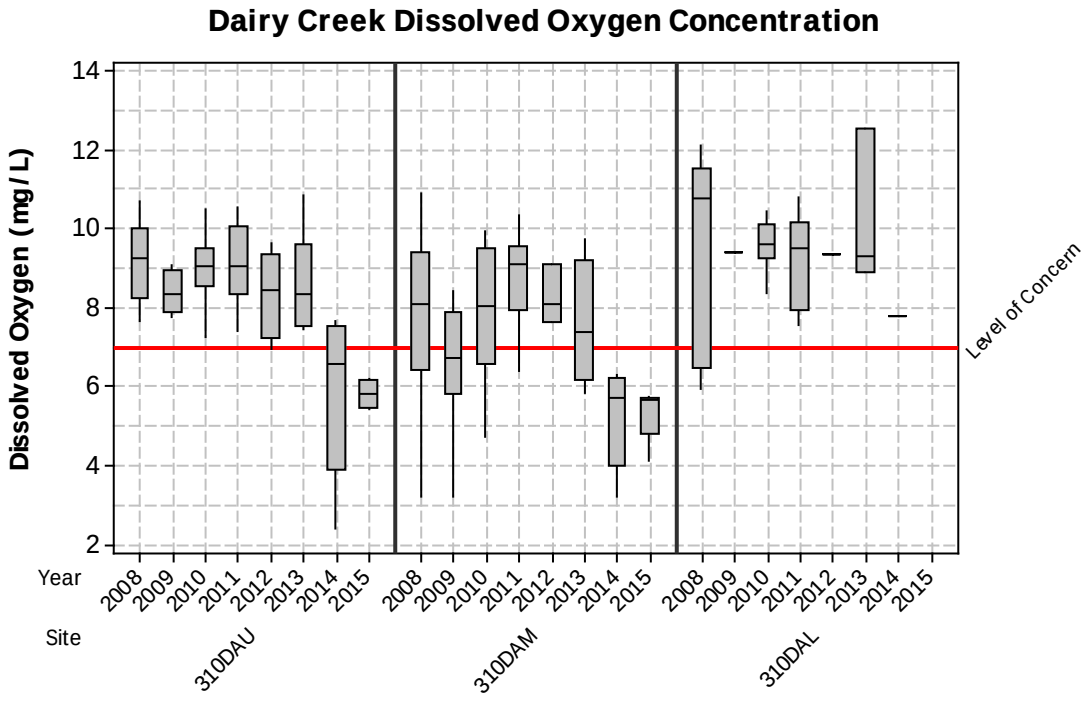
The following tables provide an overview of the dissolved oxygen concentration data, following a format recently adopted by the CCRWQCB in their own analysis of impaired waterbodies. In this

analysis, dry season encompasses May to October and the wet season includes November through April.

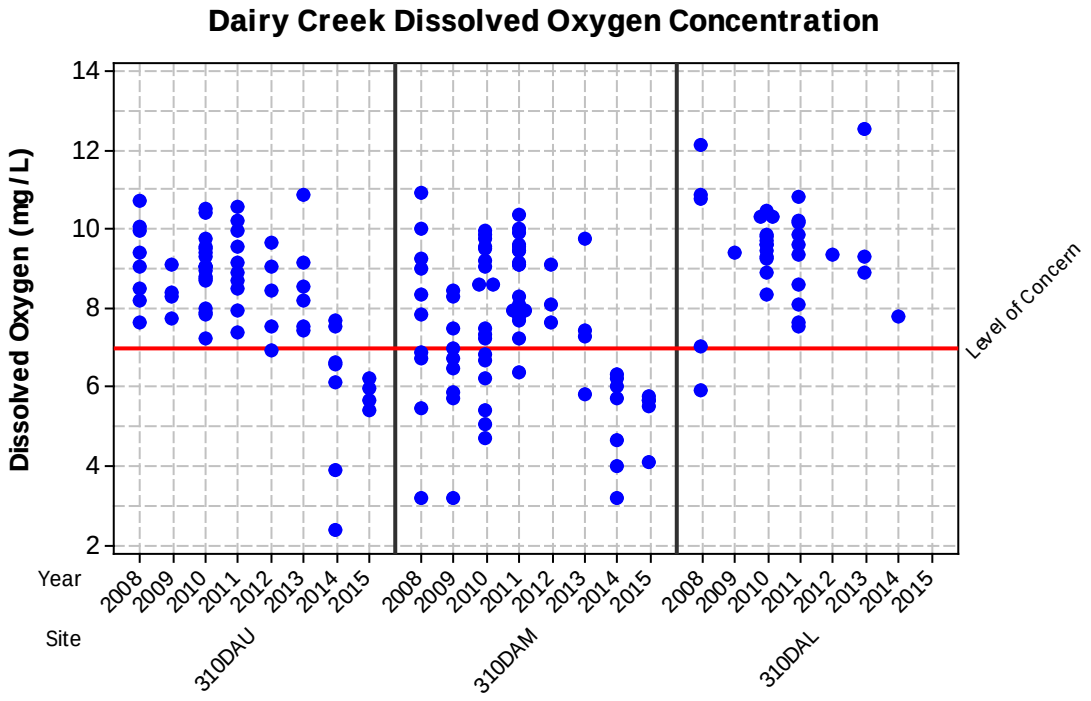
DAU	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	9.2	8.4	9.0	9.1	8.3	8.6	5.8	5.8
Dry Season Average	8.5	7.7	8.7	8.8	7.6	-	3.1	-
Wet Season Average	10.2	8.6	9.2	9.5	9.4	8.6	6.9	5.8
Range	3.1	1.4	3.3	3.2	2.7	3.4	5.3	0.8
n	8	4	18	10	5	6	7	4
# Exceedance for Wet Season	0	0	0	0	0	0	3	4
# Exceedance for Dry Season	0	0	0	0	1	-	2	-
% Exceedance for Entire Year	0	1	1	1	20	0	71	100

DAM	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	7.8	6.6	7.8	8.7	8.3	7.6	5.2	5.3
Dry Season Average	6.3	4.4	6.7	8.1	8.1	-	3.6	-
Wet Season Average	9.2	7.2	8.9	9.3	8.4	7.6	5.8	5.3
Range	7.7	5.3	5.3	4.0	1.5	4.0	3.1	1.7
n	10	9	18	18	3	4	7	5
# Exceedance for Wet Season	1	3	1	0	0	1	5	5
# Exceedance for Dry Season	3	2	5	1	0	-	2	-
% Exceedance for Entire Year	40	56	33	6	0	25	100	100

The following plot shows the mean dissolved oxygen concentrations for each year, with the results grouped by site. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk. The Central Coast Basin Plan regulatory standard states that at no time shall DO concentrations fall below 7.0 mg/L, represented by the red line.



The following plot presents the same data presented in scatter plot form.



BACTERIA

The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) in 410 MPN/100 mL, which approximates the

90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

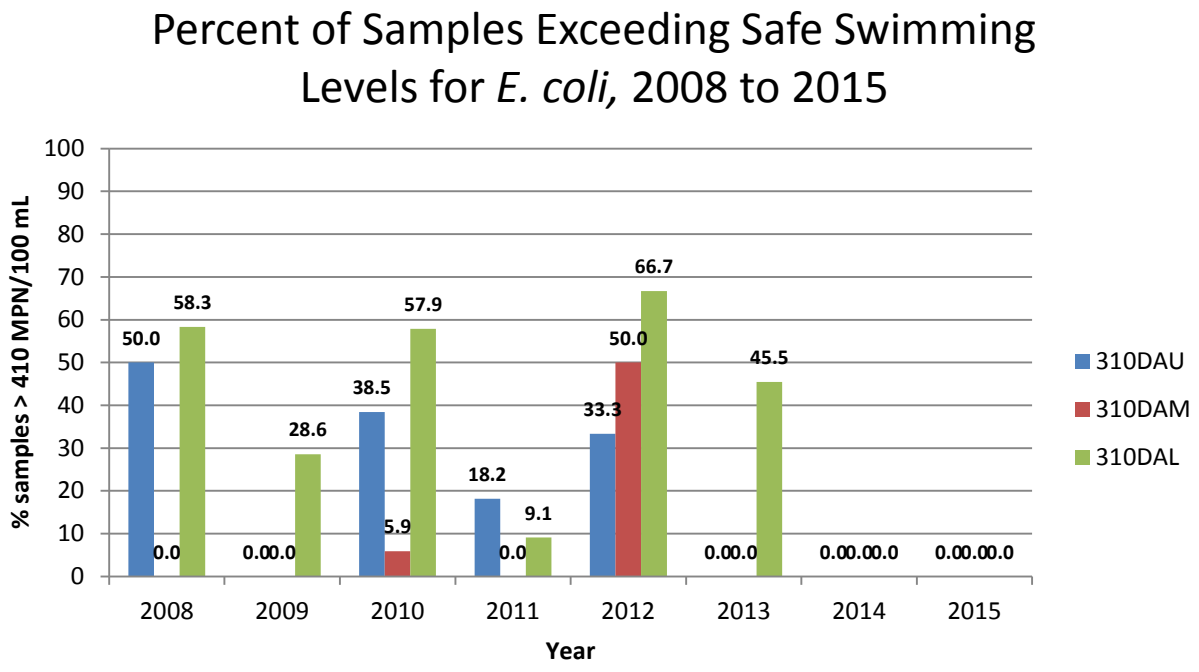
The following table contains the number of bacteria samples collected each year at the sites and the number and percent of samples that exceeded the STV criteria of 410 MPN/100 mL.

	2008	2009	2010	2011	2012	2013	2014	2015
DAU n	12	7	19	11	9	11	7	4
>410 MPN/100 mL	7	2	11	1	6	5	0	0
DAU % Exceed	58.3%	28.6%	57.9%	9.1%	66.7%	45.5%	0.0%	0.0%

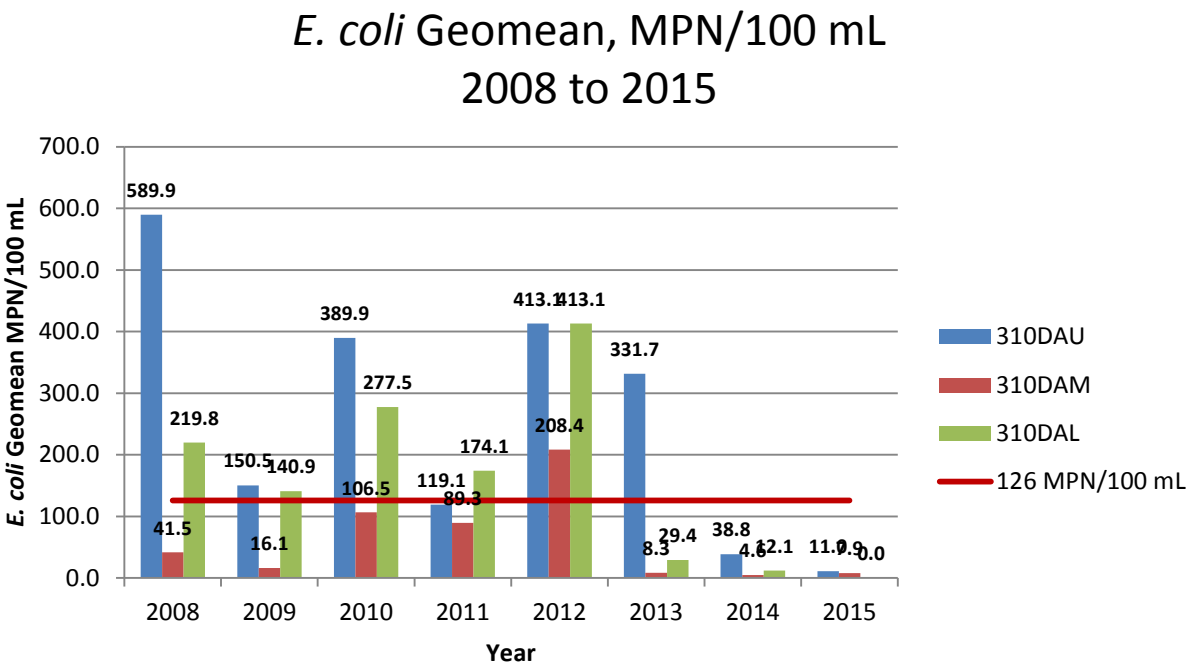
DAM n	10	9	17	11	4	7	7	7
>410 MPN/100 mL	0	0	1	0	2	0	0	0
DAL % Exceed	0.0%	0.0%	5.9%	0.0%	50.0%	0.0%	0.0%	0.0%

DAL n	6	7	13	11	3	5	1	-
>410 MPN/100 mL	3	0	5	2	1	0	0	-
DAM % Exceed	50.0%	0.0%	38.5%	18.2%	33.3%	0.0%	0.0%	-

The following graph depicts the percent of samples that exceeded the STV criteria of 410 MPN/100 mL for *E. coli* each year.

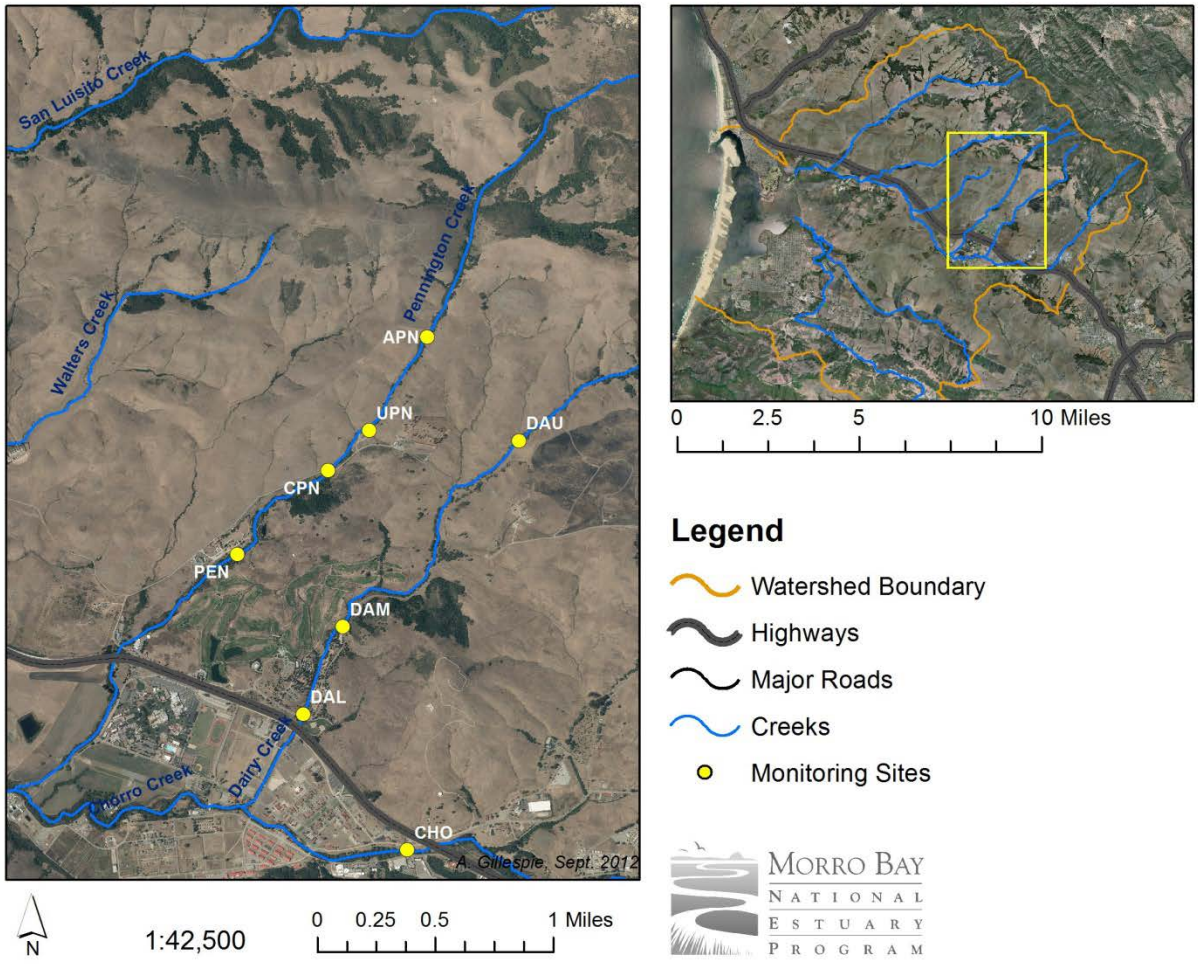


The following graph illustrates the geomean of the *E. coli* data on Dairy Creek from January 2008 through September 2015.


E. coli Geomean, MPN/100 mL
2008 to 2015
E. coli Geomean MPN/100 mL
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
589.9
41.5
219.8
150.5
16.1
140.9
389.9
106.5
277.5
119.1
89.3
174.1
413.1
208.4
413.1
331.7
8.3
29.4
38.8
4.6
12.1
11.0
9.5
0.0
2008
2009
2010
2011
2012
2013
2014
2015
Year
310DAU
310DAM
310DAL
126 MPN/100 mL

PENNINGTON CREEK

SITE MAP AND DESCRIPTION



The Pennington Creek subwatershed encompasses an area of approximately 3.1 square miles. The watershed is predominantly utilized as parkland and beef cattle rangeland. Most of the acreage is publicly-owned by the County of San Luis Obispo, the U.S. Forest Service and Cal Poly State University. The Rancho El Chorro Outdoor School and the Cal Poly Escuela Ranch Cattle Enterprise operation dominate the acreage in the watershed.

The MBNEP has conducted long term monitoring for water quality and bacteria on Pennington Creek at two sites. The PEN site is located near the outdoor amphitheater and picnic area at the Ranch El Chorro Outdoor School. This site was established in the early 1990s as part of the National Monitoring Program (NMP), and data collection was continued by the MBNEP following the conclusion of the NMP in 2001. The CPN site is approximately 0.5 miles upstream from PEN at the bridge crossing on Pennington Creek Road. This site was established in 2007 with cooperation from Cal Poly State University.

In support of planned water conservation projects, two upstream sites were added to the monthly water quality monitoring regime in this watershed. Frequent water quality monitoring, including flow monitoring, was begun in January 2011 on two sites (APN and UPN). The UPN site was established as a

macroinvertebrate monitoring site in 2006 but was not included as part of regular ongoing water quality monitoring efforts until 2010. The APN site is currently only monitored for water quality and bacteria.

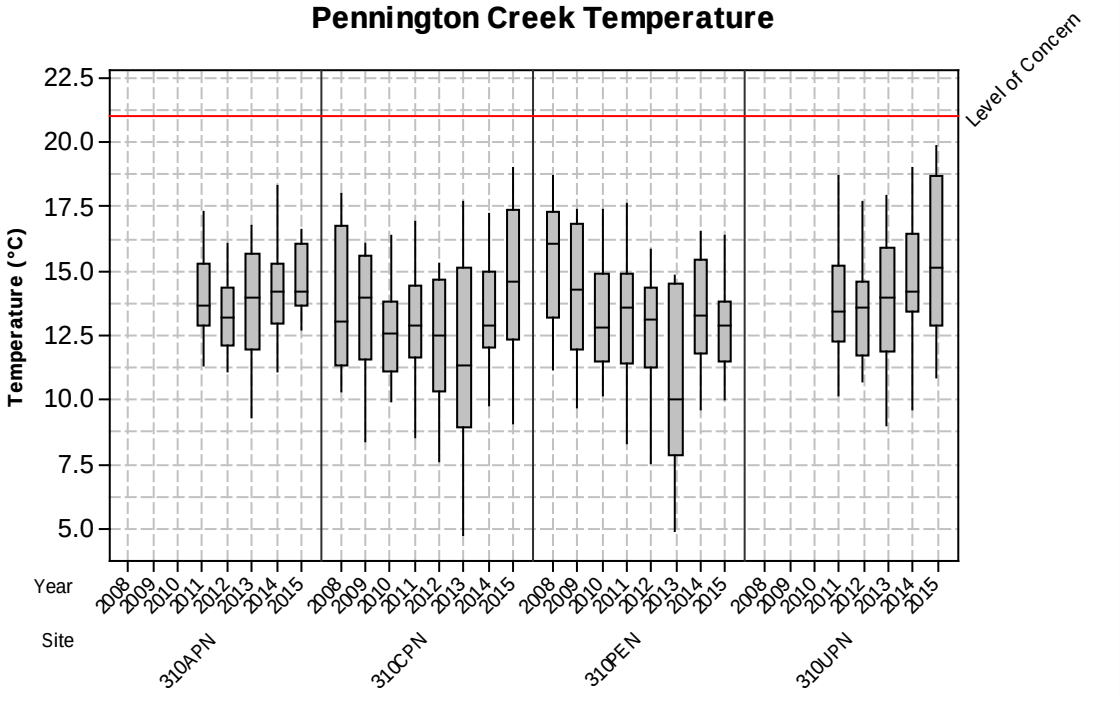
Water quality monitoring on the four sites on Pennington Creek are monitored in sets of two. Teams are assigned to APN and UPN as a set of sites or to CPN and PEN. The team monitors both sites on the same day, one immediately after the other. At all four sites, water quality and bacteria monitoring are conducted. At UPN, bioassessment monitoring is conducted each spring.

Although Pennington Creek is a perennial stream, summer flows can become too shallow to facilitate monitoring. Flow data for this creek is limited by the shallow depth of surface flows and large cobbles which prevent accurate measurement of water velocity.

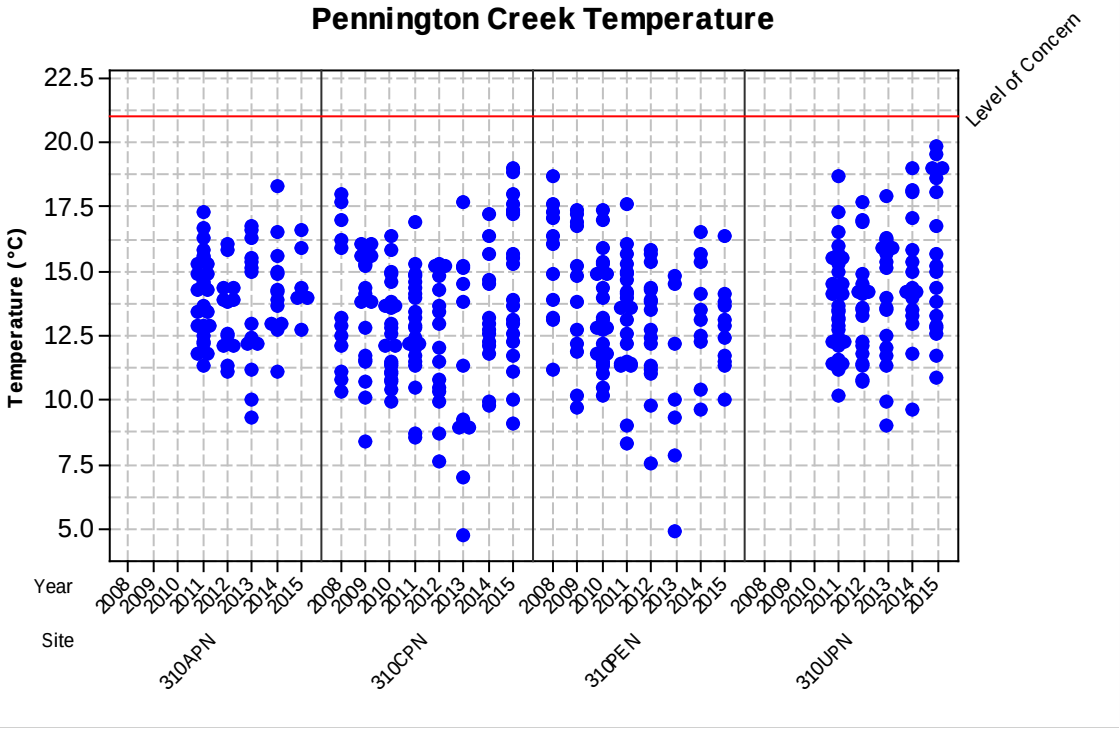
TEMPERATURE

The plot shows the water temperature, with the results grouped by site by year. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk. The 21 °C level of concern for protection of steelhead habitat is a CCRWQCB 303(d) Listing Guidance Value, which is indicated on the graph by a red line.

Although water temperatures typically do not exceed levels of concern in Pennington Creek, the data is of interest due to the water conservation project installed on the nearby Cal Poly Beef Center, located near the UPN site. The rainwater harvesting project consists of piping and tanks to store rainfall from the wet months, to be utilized during the dry months to supply cattle troughs. This replaces pumping of riparian wells during the dry summer months, thus keeping more water in the creek. More water in the creek during dry months could result in lower water temperatures.



The following plot shows the same data in scatter plot format to show the variability of the data.



The following tables provide an overview of the data, following a format recently adopted by the CCRWQCB in their own analysis of impaired waterbodies. In this analysis, the dry season encompasses May to October and the wet season includes November through April.

APN	2011	2012	2013	2014	2015
Annual Average	14.0	13.3	13.6	14.3	14.6
Dry Season Average	15.3	14.7	15.9	15.9	-
Wet Season Average	13.0	12.7	12.0	13.6	14.6
Range	6.0	5.0	7.5	7.2	3.9
n	29	14	14	13	6
# Exceedances for Wet Season	0	0	0	0	0
# Exceedances for Dry Season	0	0	0	0	-
% Exceedances for Entire Year	0	0	0	0	0

UPN	2011	2012	2013	2014	2015
Annual Average	13.7	13.6	13.9	14.7	15.5
Dry Season Average	15.3	15.1	15.9	13.3	17.5
Wet Season Average	12.5	12.3	12.1	16.8	13.1
Range	8.5	7.0	8.9	9.4	9
n	32	18	17	17	18
# Exceedances for Wet Season	0	0	0	0	0
# Exceedances for Dry Season	0	0	0	0	0
% Exceedances for Entire Year	0	0	0	0	0

ALGAE DOCUMENTING

Algae data was analyzed through two data sets generated by 2014 and 2015 assessments at the UPN monitoring site. The percent coverage of macroalgae at the site was determined by calculating algae presence at wetted points located on the transects and inter-transects. This calculated value is used to represent percent algal coverage throughout the 150 m reach. UPN, the only site monitored on Pennington Creek, had a score of 0% coverage by macroalgae in 2013, 9.6% in 2014 and 2.2% in 2015. Additionally, the qualitative spatial coverage of filamentous algae was scored for defined areas 5 m above and 5 m below each of ten transects assessed within each site. Each assessment area (10 m of wetted reach) was assigned a score between 0 to 4, with 0 indicating less than 5% algae coverage, 1 indicating less than 10% coverage, 2 indicating 10 to 40% coverage, 3 indicating 40 to 75% coverage, and 4 indicating greater than 75% coverage. With this metric, UPN scored a 0%, with no scores of 3 or 4 for filamentous algae in 2013, 2014 and 2015.

BACTERIA

The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) is 410 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

The following table contains the number of bacteria samples collected each year at the sites, the number of samples that exceeded the STV criteria of 410 MPN/100 mL and the percent of samples that exceeded.

APN	2008	2009	2010	2011	2012	2013	2014	2015†
n	0	0	0	0	1	10	10	7
> 410 MPN/100 mL	-	-	-	-	0	0	1	2
% exceedance	-	-	-	-	0	0	10.0	28.6

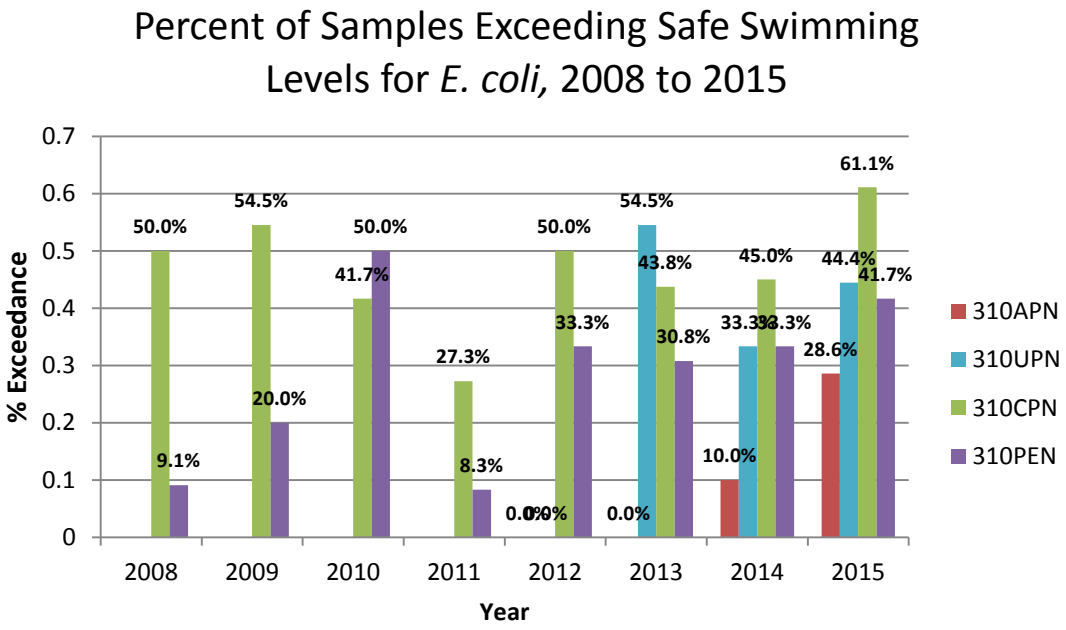
UPN	2008	2009	2010	2011	2012	2013	2014	2015†
n	0	0	0	0	1	11	20	18
> 410 MPN/100 mL	-	-	-	-	0	6	9	11
% exceedance	-	-	-	-	0.0	54.5	45.0	61.1

CPN	2008	2009	2010	2011	2012	2013	2014	2015†
n	12	11	11	11	12	16	12	12
> 410 MPN/100 mL	6	6	5	3	6	7	4	5
% exceedance	50.0	54.5	41.7	27.3	50.0	43.8	33.3	41.7

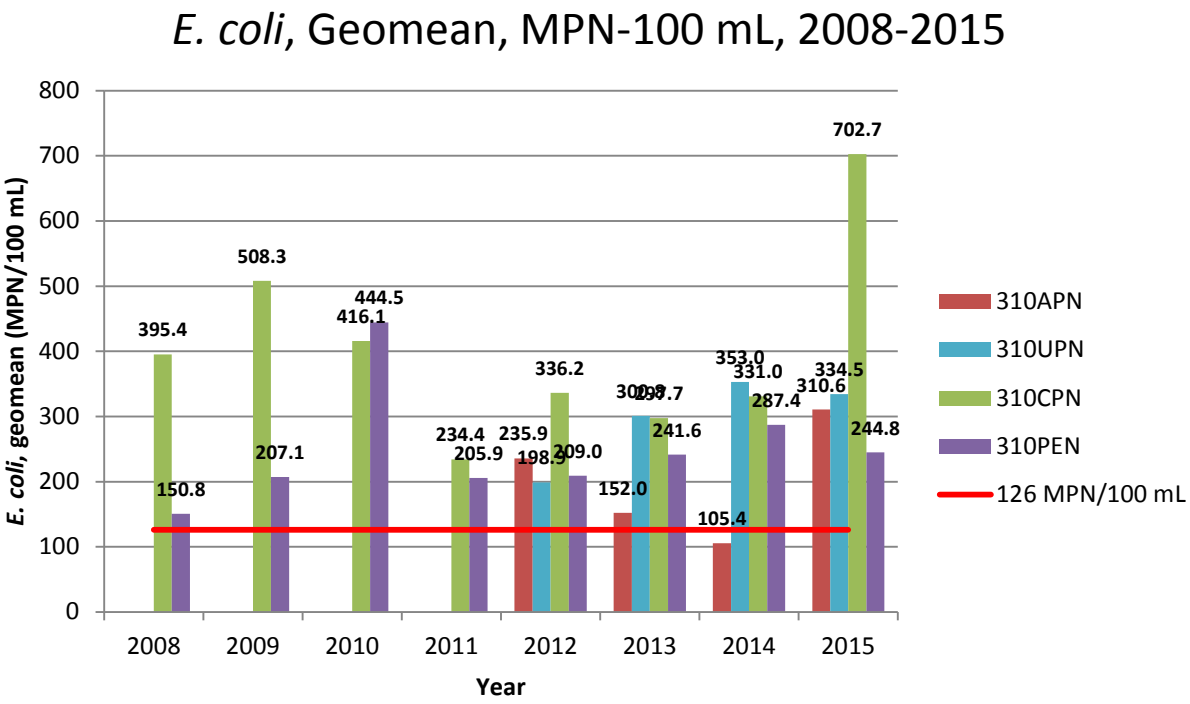
310PEN	2008	2009	2010	2011	2012	2013	2014	2015†
n	11	10	12	12	12	13	17	18
> 410 MPN/100 mL	1	2	6	1	4	4	8	8
% exceedance	9.1	20.0	50.0	8.3	33.3	30.8	47.1	44.4

† 2015 values include January to September 2015.

The following graph illustrates the percent of bacteria samples that exceeded the STV criteria of 410 MPN/100 mL.

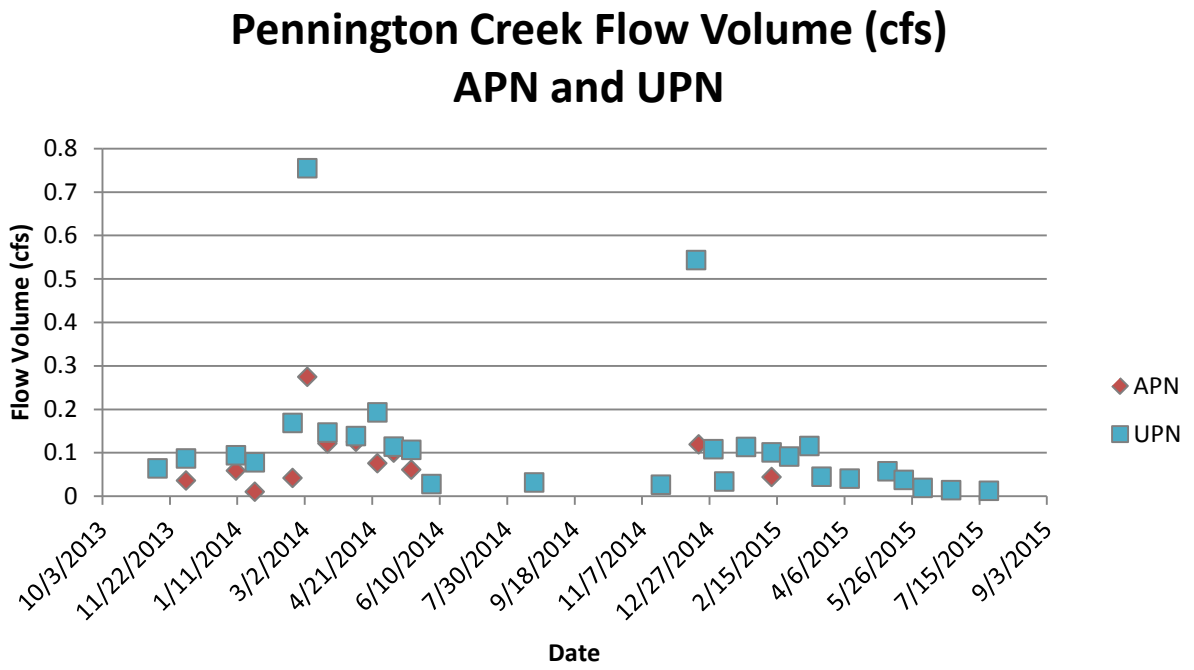


The following graph illustrates the geomean of the *E. coli* data from Pennington Creek from January 2008 through September 2015. The red line represents the regulatory criteria of 126 MPN/100 mL for the geomean of the data.



Flow Volume

The following graph shows flow measurements obtained from the creek at the two upper sites. The graph provides an overview of the range and frequency of flow measurements. Flow volume was infrequently measured at Pennington Creek due to the shallow depth of the water in fast moving habitats. Since paired sites were measured on the same date, the data is displayed in the graphs as pairs of data (APN and UPN) to show the relative differences in flow volume. Inadequate data was available from the two lower sites (CPN and PEN) due to drought conditions.



Macroinvertebrates

The metrics included in this section are taxa richness, EPT richness, EPT% and IBI score. Taxa richness is a measure of the number of different species of organisms in the sample. EPT richness is a measure of the total number of taxa within the sensitive orders of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Taxa richness and EPT richness typically decrease with poor water quality. EPT% is the total number of EPT individuals divided by the total number of individuals in the sample. The Index of Biotic Integrity (IBI) score used in this report is the Southern California Coastal IBI developed by the Aquatic Bioassessment Laboratory of the California Department of Fish & Wildlife. Seven uncorrelated biotic measurements were selected to be included in the calculation. They include collector-gatherer + collector-filterer individuals, percent non-insect taxa, percent tolerant taxa, coleoptera richness, predator richness, percent intolerant individuals and EPT richness. For the IBI, scores of 0 to 19 are considered to be very poor, 20 to 39 are poor, 40 to 59 are fair, 60 to 79 are good, and 80 to 100 are very good. The metrics are displayed below for both Pennington Creek sites.

Upper Pennington Creek (UPN)	*Taxa Richness*	*EPT Richness*	*EPT %*	*IBI Score*
2002	*	*	*	*
2003	*	*	*	*
2004	*	*	*	*
2005	*	*	*	*
2006	49	16	44.0	-
2007	62	21	21.0	-
2008	47	17	18.4	79.0
2009	*	*	*	*
2010	*	*	*	*
2011	59	25	64.4	85.7
2012	56	21	48.5	84.3
2013	70	24	32.63	80.0
2014	73	20	17.6	78.6
2015	53	10	16.1	61.4

** No data collected this year.*

- Metric scores not currently available.

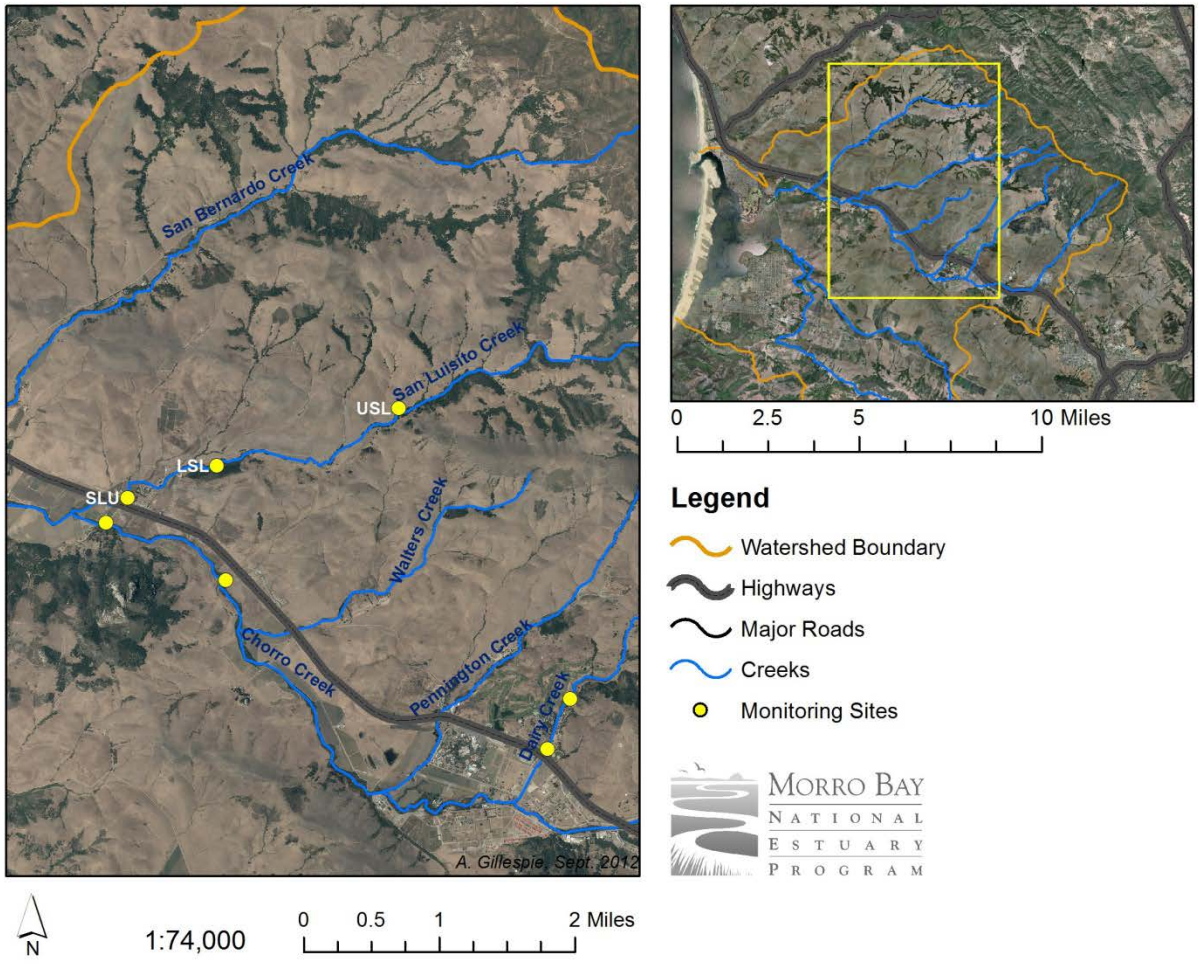
Lower Pennington (PEN)	*Taxa Richness*	*EPT Richness*	*EPT %*	*IBI Score*
2002	*	*	*	*
2003	*	*	*	*
2004	29	11	38.0	66
2005	*	*	*	*
2006	42	17	33.2	70
2007	*	*	*	*
2008	*	*	*	*
2009	*	*	*	*
2010	*	*	*	*
2011	*	*	*	*
2012	*	*	*	*
2013	*	*	*	*

** No data collected this year.*

- Metric scores not currently available.

SAN LUISITO CREEK

SITE MAP AND DESCRIPTION



The San Luisito Creek subwatershed encompasses an area of approximately 8.28 square miles. The watershed is predominately utilized as beef cattle rangeland with a small amount of acreage allocated to row crops and dry farming. There is a cluster of private residences near the Highway 1 crossing and a limited number of rural residences spread throughout the subwatershed. Most of the acreage is privately-owned, with a few holdings by the U.S. Forest Service and the California Department of Fish and Wildlife.

The MBNEP has several monitoring sites on San Luisito Creek. The most downstream site, SLU, was established in the early 1990's as part of the National Monitoring Program (NMP), and data collection was continued by the MBNEP following the conclusion of the NMP in 2001. This site was monitored for water quality and bacteria either monthly or twice monthly depending on volunteer availability.

Three additional monitoring sites, USL, MSL and LSL, were established through cooperative agreement on private property in 2006. A fourth (OSL) was established through cooperative agreement on private property in 2009. These four sites were monitored twice monthly for bacteria only, and no water quality data was collected. Macroinvertebrate data has been collected intermittently at sites LSL and USL since 2008.

Water quality monitoring has taken place monthly or twice monthly at SLU since 2002. San Luisito Creek is a perennial stream, and there are few gaps in the data during the study period. In a few instances, flow data collection was limited by shallow depths in fast water habitats.

ALGAE DOCUMENTING

Algae data was analyzed through two data sets generated by 2014 and 2015 assessments at the USL and LSL sites. The percent coverage of macroalgae at the site was determined by calculating algae presence at wetted points located on the transects and inter-transects. This calculated value is used to represent percent algal coverage throughout the 150 m reach. The upper site on San Luisito Creek, USL, had 22% algal coverage in 2013, 31% in 2014, and 21% in 2015. The lower site on San Luisito Creek, LSL, had 12% algal coverage in 2013, 20% in 2014 and 20% in 2015.

Additionally, the qualitative spatial coverage of filamentous algae was scored for defined areas 5 m above and 5 m below each of ten transects assessed within each site. Each assessment area (10 m of wetted reach) was assigned a score between 0 to 4, with 0 indicating less than 5% algae coverage, 1 indicating less than 10% coverage, 2 indicating 10 to 40% coverage, 3 indicating 40 to 75% coverage, and 4 indicating greater than 75% coverage. With this metric, USL scored 10% of the assessed area scoring a 3 or 4 in 2013, 20% in 2014, and 0% in 2015. LSL scored 10% in 2013, 30% in 2014 and 0% in 2015.

BACTERIA

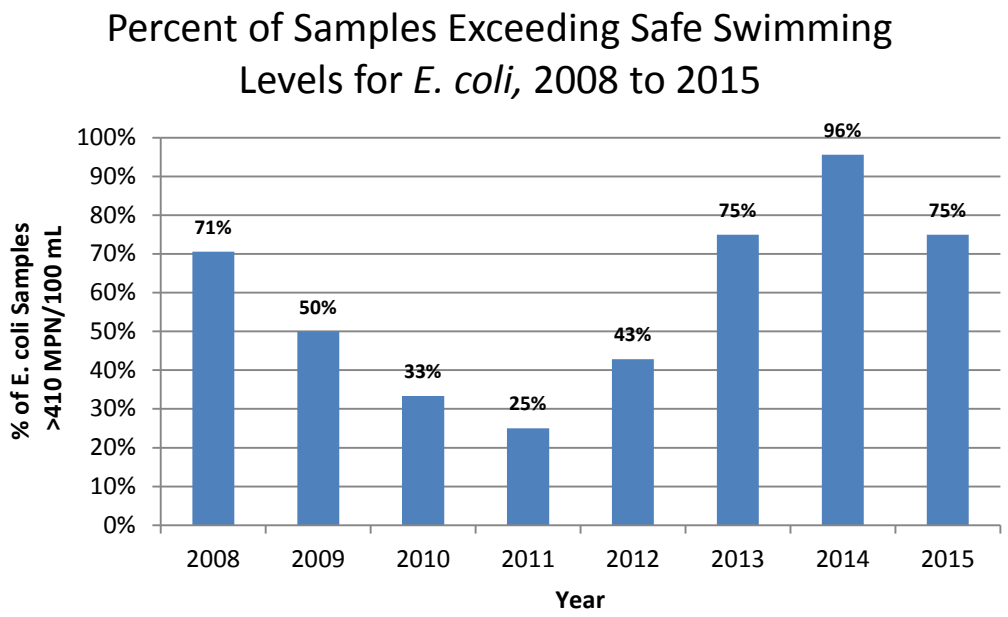
The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) is 410 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

The following table contains the number of bacteria samples collected each year at the sites and the number and percent of samples that exceeded the STV criteria of 410 MPN/100 mL.

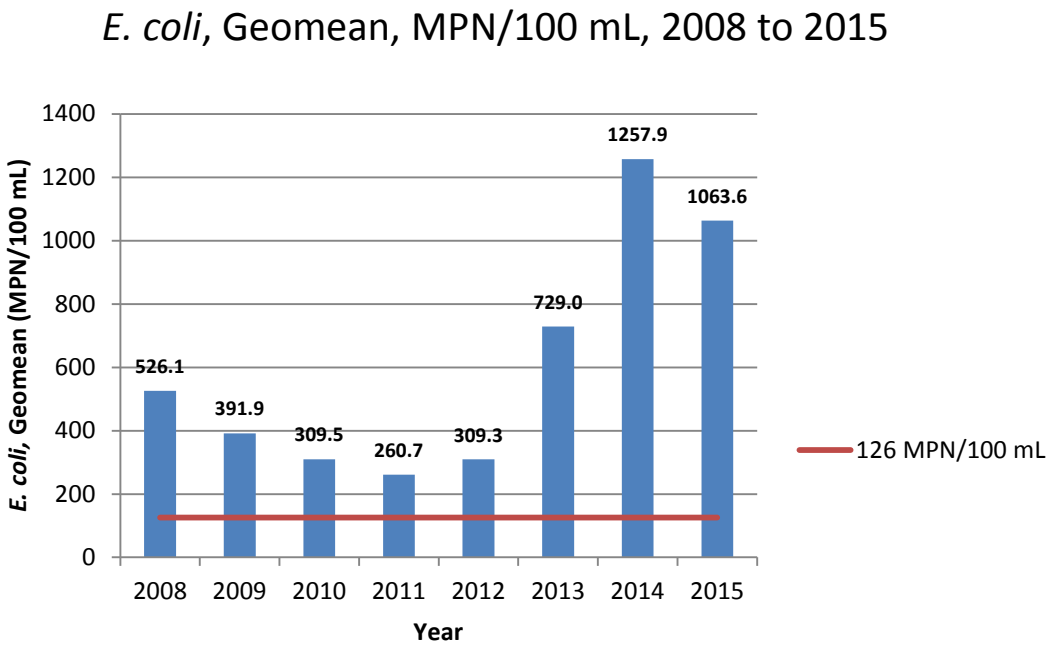
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015†**
SLU n	17	24	24	24	14	24	23	12
>410 MPN/100 mL	12	12	8	6	6	18	22	9
SLU %Exceed	70.6%	50.0%	33.3%	25.0%	42.9%	75.0%	95.7%	75.0%

† 2015 values include January to September 2015.

The following graph illustrates the percent of bacteria samples that exceeded the STV criteria of 410 MPN/100 mL.



The following graph illustrates the geomean of the *E. coli* data from January 2008 through June 2014. The red line represents the regulatory criteria of 126 MPN/100 mL for the geomean of the data.



MACROINVERTEBRATES

The metrics included in this report are taxa richness, EPT richness, EPT% and IBI score. Taxa richness is a measure of the number of different species of organisms in the sample. EPT richness is a measure of the total number of taxa within three sensitive orders: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Taxa richness and EPT richness typically decrease with poor water quality. EPT% is the total number of EPT individuals divided by the total number of individuals in

the sample. The Index of Biotic Integrity (IBI) score used in this report is the Southern California Coastal IBI developed by the Aquatic Bioassessment Laboratory of the California Department of Fish & Wildlife. Seven uncorrelated biotic measurements were selected to be included in the calculation. They include collector-gatherer + collector-filterer individuals, percent non-insect taxa, percent tolerant taxa, coleoptera richness, predator richness, percent intolerant individuals and EPT richness. For the IBI, scores of 0 to 19 are considered to be very poor, 20 to 39 are poor, 40 to 59 are fair, 60 to 79 are good, and 80 to 100 are very good. The metrics are displayed below.

San Luisito Creek, Lower (LSL)	***Taxa Richness***	***EPT Richness***	***EPT %***	***IBI Score***
2002	*	*	*	*
2003	*	*	*	*
2004	*	*	*	*
2005	*	*	*	*
2006	*	*	*	*
2007	*	*	*	*
2008	55	14	25.2	67
2009	49	15	12.4	70.1
2010	48	18	50.6	75.8
2011	45	17	44.5	54.3
2012	61	22	18.3	72.9
2013	39	4	0.94	40.0
2014	44	8	4.3	55.7
2015	54	14	17.8	67.1

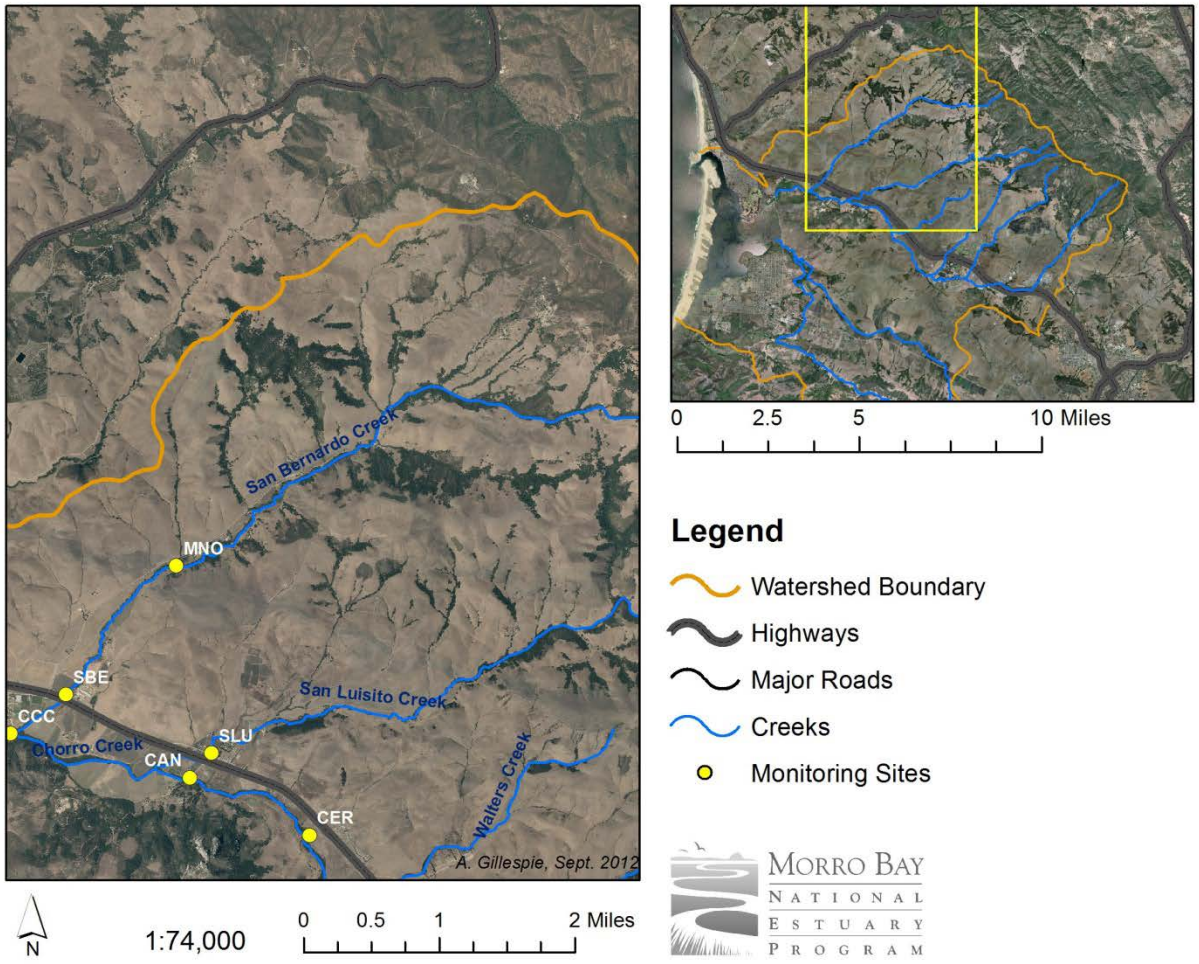
** No data collected this year.*

San Luisito Creek, Upper (USL)	***Taxa Richness***	***EPT Richness***	***EPT %***	***IBI Score***
2010	60	24	35.2	91.5
2011	38	18	76.7	58.6
2012	*	*	*	*
2013	50	16	9.92	60.0
2014	44	16	6.5	65.71
2015	52	19	12.8	68.57

** No data collected this year.*

SAN BERNARDO CREEK

SITE MAP AND DESCRIPTION



The San Bernardo Creek subwatershed encompasses an area of approximately 8.49 square miles. The watershed is predominately utilized as beef cattle rangeland with a small amount of acreage allocated to row crops, small livestock operations, and dry farming. There are a limited number of rural residences spread throughout the subwatershed. Most of the acreage is privately-owned, with a few holdings by the U.S. Forest Service in the upper watershed.

The MBNEP has two monitoring sites on San Bernardo Creek. The most downstream site, SBE, was established in the early 1990s as part of the National Monitoring Program (NMP), and data collection was continued by the MBNEP following the conclusion of the NMP in 2001. Hydrologic conditions at this site have limited the amount of data collection. During many months of the year, the creek goes underground at the lower reach. Monthly water quality and bacteria monitoring are conducted at this site when adequate flows are present. Adequate flows for monitoring were not present in 2014 and 2015.

The limitations of the SBE site prompted staff to seek another upstream site for annual macroinvertebrate monitoring. Site MNO was established with agreement from private landowners on

both sides of the creek. Due to difficult terrain and limited access, this site was not included as part of ongoing water quality or bacteria monitoring efforts. Site MNO was formerly called MSB. The code was changed to coincide with the historical code used by the NMP.

ALGAE DOCUMENTING

Algae data was analyzed through two data sets generated by the 2013 assessment at the site. The percent coverage of macroalgae at the site was determined by calculating algae presence at wetted points located on the transects and inter-transects. This calculated value is used to represent percent algal coverage throughout the 150 m reach. MNO scored 45% algal coverage in 2013, 7% in 2014, and 38% in 2015.

Additionally, the qualitative spatial coverage of filamentous algae was scored for defined areas 5 m above and 5 m below each of 10 transects assessed within each site. Each assessment area (10 m of wetted reach) was assigned a score between 0 to 4, with 0 indicating less than 5% algae coverage, 1 indicating less than 10% coverage, 2 indicating 10 to 40% coverage, 3 indicating 40 to 75% coverage, and 4 indicating greater than 75% coverage. With this metric, MNO scored 70% of the assessed area having scores of 3 or 4 in 2013, 10% in 2014, and 40% in 2015.

BACTERIA

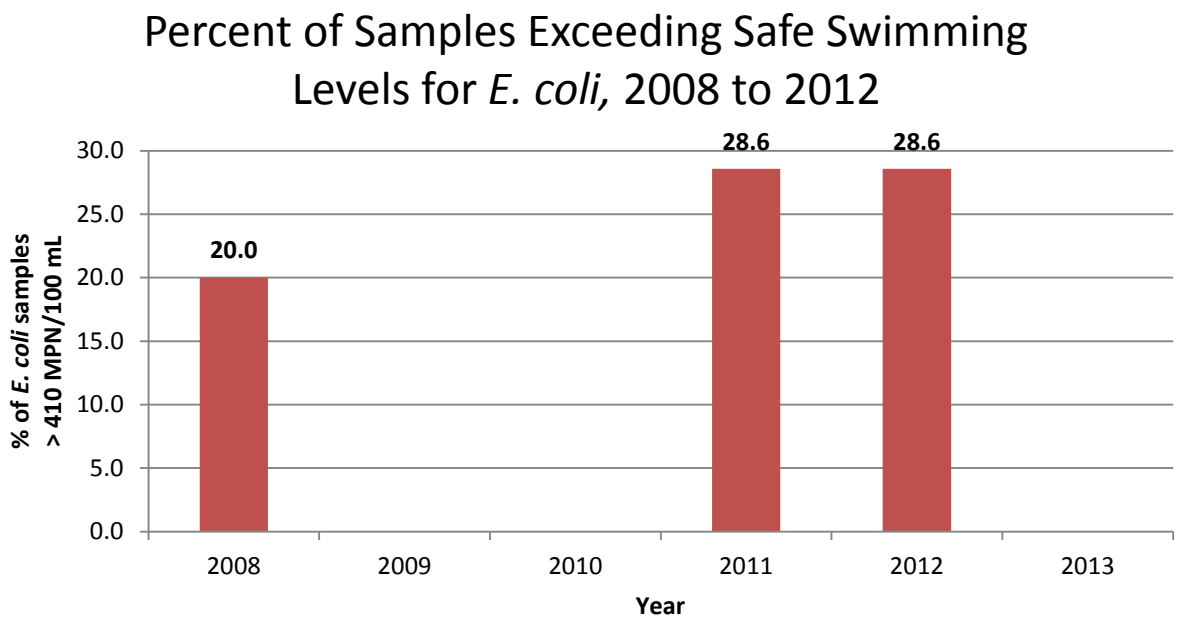
The following table contains the number of bacteria samples collected each year and the number of samples that exceeded the criteria.

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015†**
SBE n	6	2	5	14	7	3	0	0
SBE % Exceed	20	*	*	29	29	*	-	-

**The sample size n < 6 was deemed too small for inclusion in the analysis.*
†2015 values include January to September 2015.

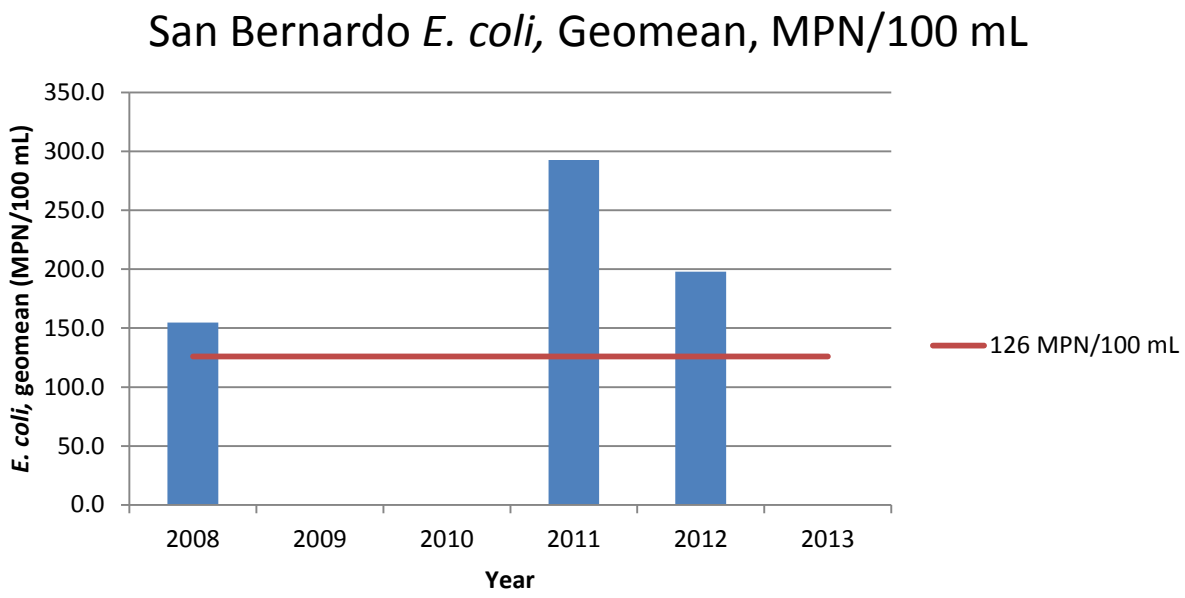
The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) is 410 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

The following graph depicts the % of samples that exceeded the 410 MPN/100 mL STV standard for *E. coli* each year. The blank columns with zeroes in the graphs depict a sample size that was too small for inclusion in the analysis (n < 6), rather than a lack of exceedances of the standard.



Note: The blank columns depict a sample size that was too small for inclusion in the analysis (n < 6), rather than a lack of exceedances of the standard. Inadequate flows were present in 2014 and 2015 for data collection.

The following graph is a plot of the geomean of data from 2008 through 2012 at the SBE site.



MACROINVERTEBRATES

The highly variable hydrology of San Bernardo Creek proved challenging for macroinvertebrate monitoring. Prior to 2008, the monitoring program did not have access to the creek beyond the SBE site. In 2008, landowners on both sides of the creek allowed macroinvertebrate monitoring to take place at site MNO, a location upstream of SBE. Although the creek reach near MNO is also intermittent, the longer hydroperiod allowed sufficient time to conduct bioassessment monitoring.

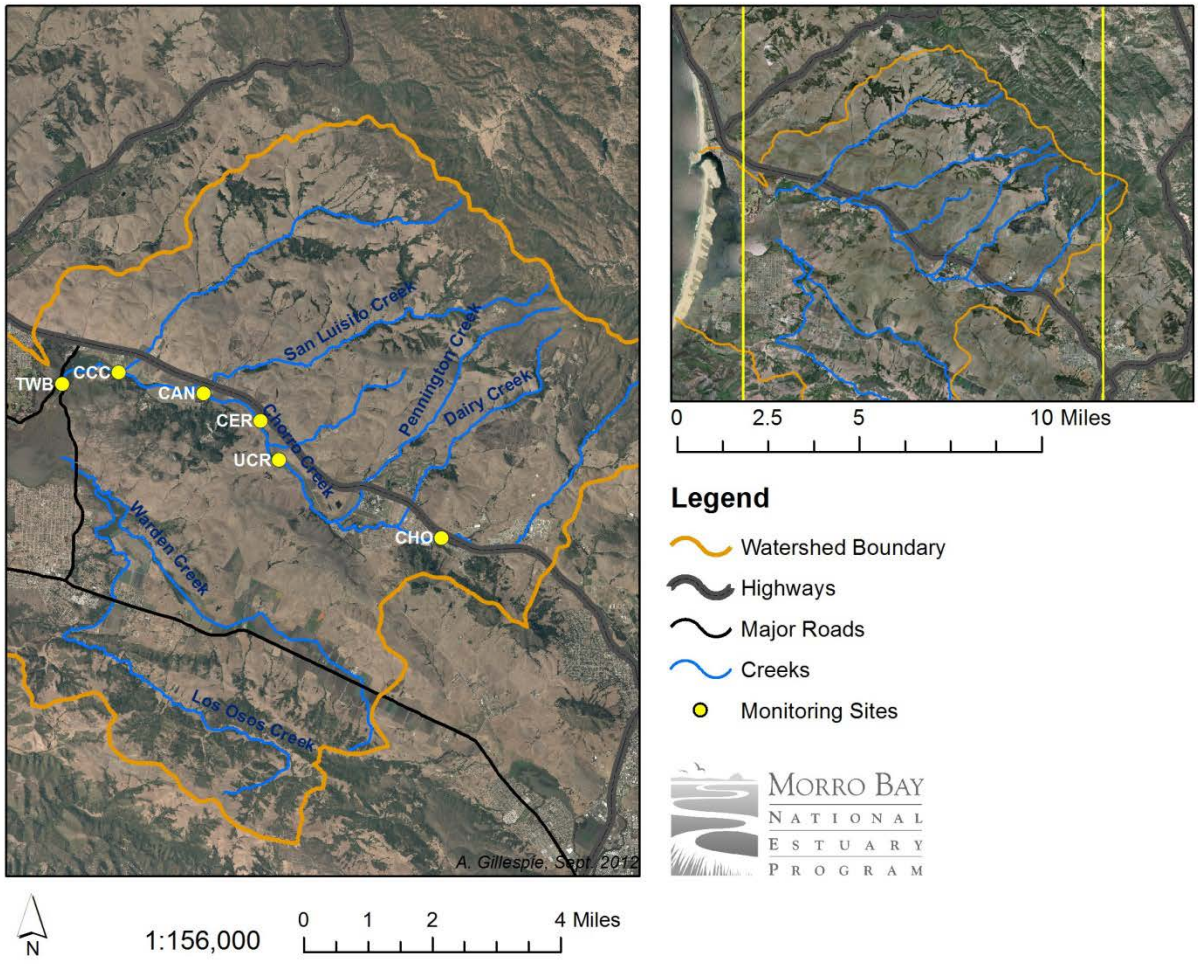
The metrics included in this report are taxa richness, EPT richness, EPT% and IBI score. Taxa richness is a measure of the number of different species of organisms in the sample. EPT richness is a measure of the total number of taxa within three sensitive orders: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Taxa richness and EPT richness typically decrease with poor water quality. EPT% is the total number of EPT individuals divided by the total number of individuals in the sample. The Index of Biotic Integrity (IBI) score used in this report is the Southern California Coastal IBI developed by the Aquatic Bioassessment Laboratory of the California Department of Fish & Wildlife. Seven uncorrelated biotic measurements were selected to be included in the calculation. They include collector-gatherer + collector-filterer individuals, percent non-insect taxa, percent tolerant taxa, coleoptera richness, predator richness, percent intolerant individuals and EPT richness. For the IBI scores, scores of 0 to 19 are considered to be very poor, 20 to 39 are poor, 40 to 59 are fair, 60 to 79 are good, and 80 to 100 are very good. The metrics are displayed below.

Middle San Bernardo Creek (MNO)	Taxa Richness	EPT Richness	EPT %	IBI Score
2002	*	*	*	*
2003	*	*	*	*
2004	*	*	*	*
2005	*	*	*	*
2006	*	*	*	*
2007	*	*	*	*
2008	64	20	50.4	75.8
2009	*	*	*	*
2010	42	14	61.8	67.2
2011	52	17	37.6	62.9
2012	69	22	42.8	74.3
2013	66	18	19.0	80.0
2014	46	3	3.35	44.30
2015	57	5	4.3	48.57

** No data collected this year.*

CHORRO CREEK

SITE MAP AND DESCRIPTIONS



The Chorro Creek watershed encompasses an area of approximately 43 square miles and includes the tributaries Dairy Creek, Pennington Creek, Walters Creek, San Luisito Creek and San Bernardo Creek. The watershed is predominately utilized as beef cattle rangeland with a small amount of acreage allocated to row crops and rural residences. The San Luis Obispo County Operations Center, California Men's Colony and Cuesta College are all located within close proximity to Chorro Creek. Publicly-owned property includes the California Army National Guard Camp San Luis Obispo, the Chorro Creek Ecological Reserve, and rangeland owned by Cal Poly.

The MBNEP has six monitoring sites on the mainstem of Chorro Creek. The most upstream site, CHD, was established below Chorro Dam during the NMP. It is monitored periodically for macroinvertebrates. The site CHO is located on Camp San Luis Obispo property near the Highway 1 overpass. The CMC wastewater treatment plant discharges tertiary treated effluent to Chorro Creek downstream of the CHO monitoring site. CHO is monitored monthly for water quality. The UCR site was established in 2007 with cooperation from Cal Poly. This site is located downstream of the wastewater plant and the confluences of Dairy and Pennington Creeks. It is monitored monthly for water quality and bacteria. Site CER was established in 2003 at the creek crossing on the Chorro Creek Ecological Reserve. This site differs hydologically from UCR in that it includes the confluence of Walters Creek. It is

monitored monthly for water quality and is also a macroinvertebrate site. Site CAN was established in the early 1990s as part of the National Monitoring Program (NMP), and data collection has been continued by the MBNEP following the conclusion of the NMP in 2001. This site has also been the focus of suspended sediment monitoring efforts and is an instrumented gauging station. It is monitored monthly for water quality and bacteria. Site CCC is located at the road crossing of Chorro Creek Road. The MBNEP began monitoring the site in late 2009, and it is monitored monthly for water quality and bacteria. Historical data exists from monitoring during the NMP. The site is also monitored regularly by the Cooperative Monitoring Program of the Central Coast Water Quality Preservation, Inc. The most downstream site, TWB, was also established in the early 1990s as part of the NMP and is a CCAMP Coastal Confluences site. This site has been monitored consistently either monthly or twice monthly by the CCRWQCB since 2002. It is monitored for water quality, bacteria and macroinvertebrates.

Site CCC was formerly called UCF. The code was changed to coincide with the code used for historic monitoring efforts.

WATER QUALITY N VALUE SUMMARY

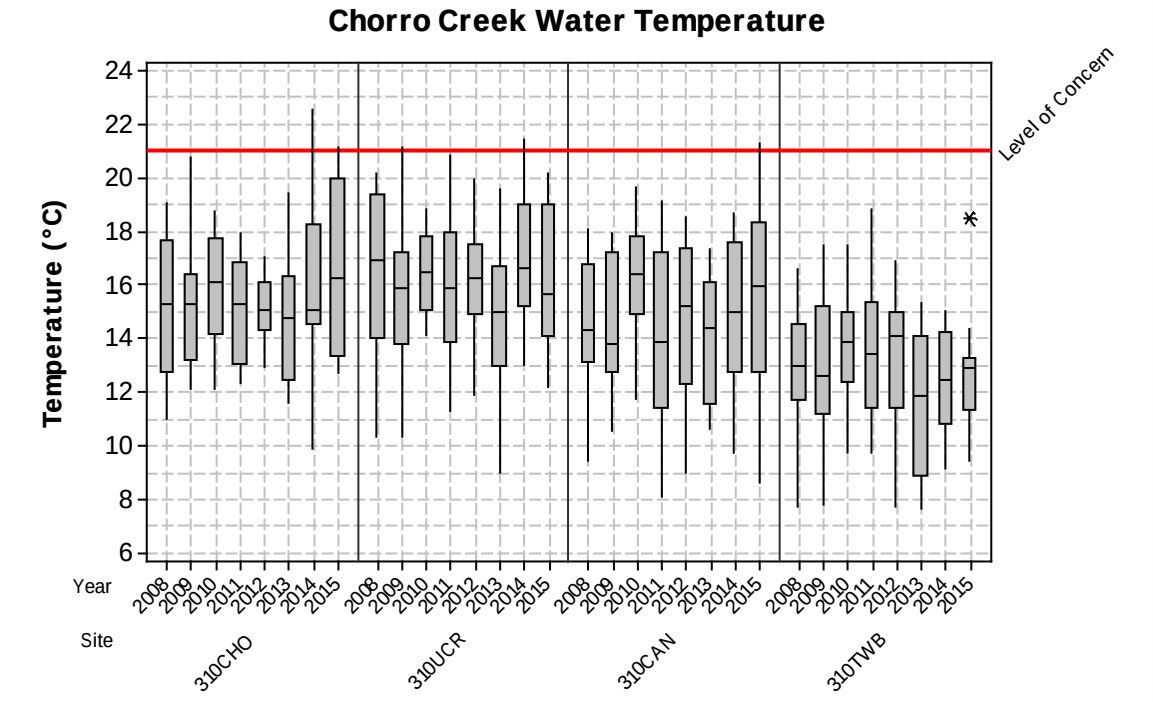
	2008	2009	2010	2011	2012	2013	2014	2015†
CHO	11	11	15	13	9	12	12	9
UCR	17	20	17	17	16	19	24	19
CER	17	28	26	24	23	25	24	18
CAN	13	18	21	21	19	15	23	17
CCC	*	3	8	24	26	21	16	12
TWB	13	18	23	20	20	12	8	14
Sum	**71**	**98**	**111**	**119**	**113**	**104**	**107**	**89**

†2015 values include January to September 2015.

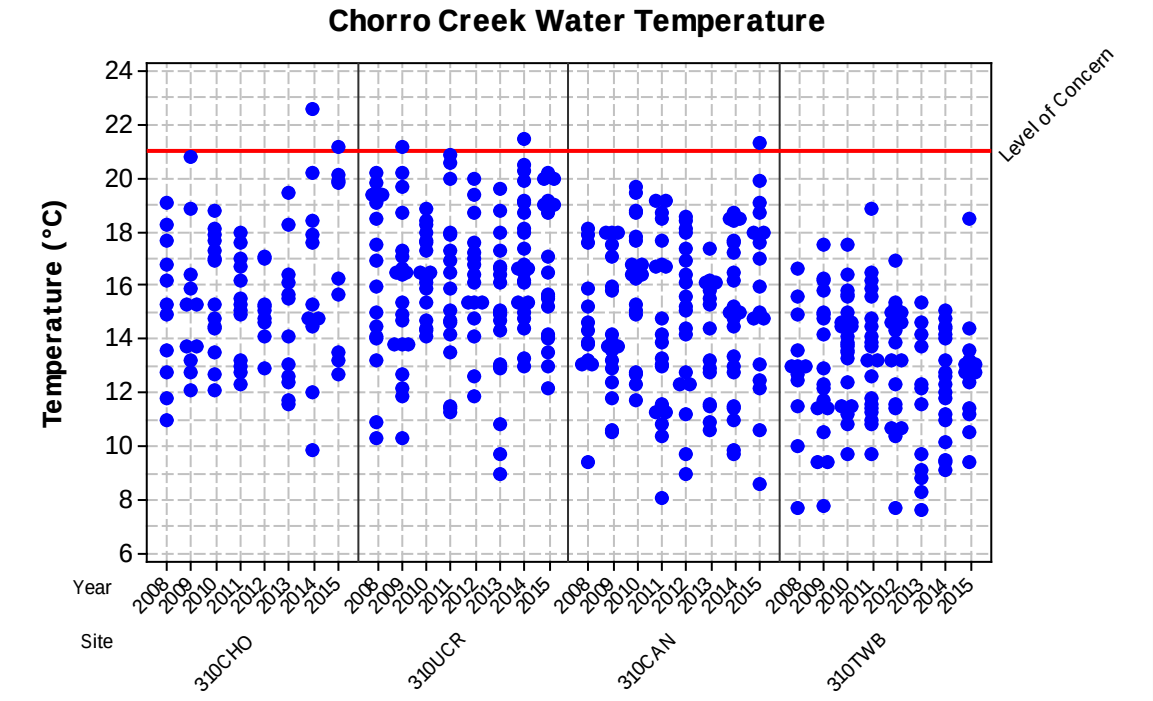
TEMPERATURE

While temperature levels on Chorro Creek have not approached the level of concern for protection of aquatic life, nutrients and therefore DO have been of concern. Due to its link to DO concentrations, an analysis of temperature data on Chorro Creek was conducted. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk.

The 21 °C level of concern for protection of steelhead habitat is a CCRWQCB 303(d) Listing Guidance Value, which is indicated on the graph by a red line.



The data for the same sites is also presented as a scatter plot to show the variability in the data.



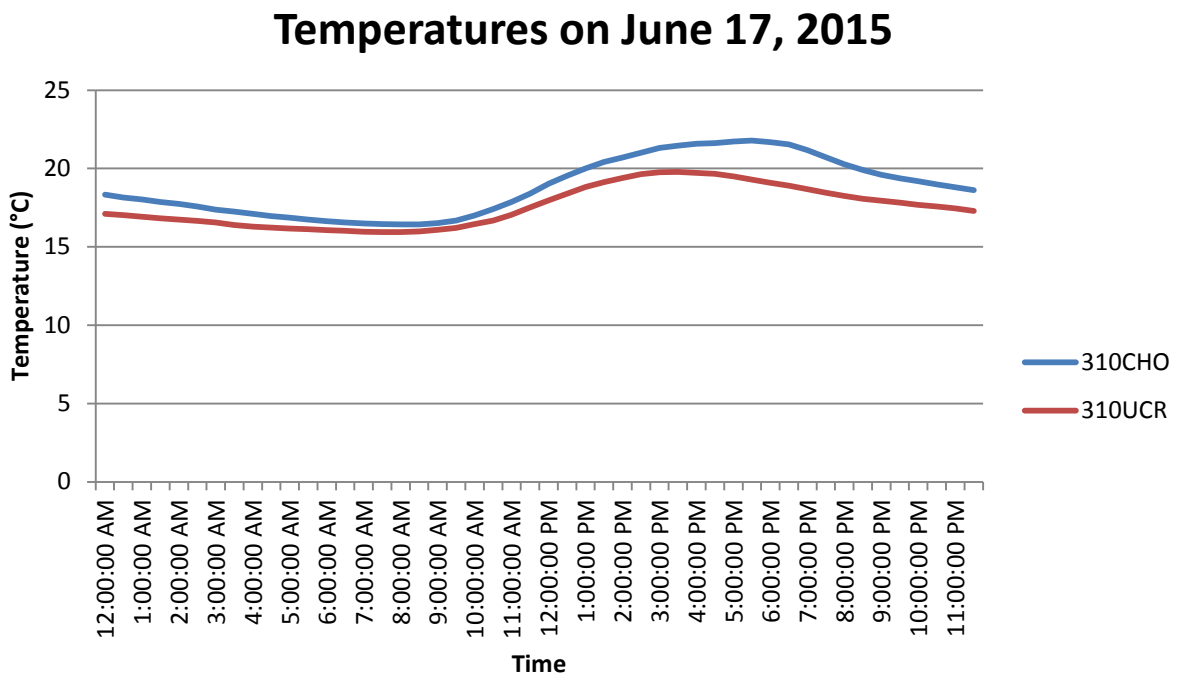
The following tables provide an overview of the data, following a format recently adopted by the CCRWQCB in their own analysis of impaired waterbodies. In this analysis, dry season encompasses May to October and the wet season includes November through April.

CHO	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	15.2	15.3	15.8	15.2	15.1	14.8	16.1	16.9
Dry Season Average	17.4	16.9	17.7	16.6	16.1	16.3	18.6	19.5
Wet Season Average	13.4	13.9	13.9	14.0	14.3	13.3	13.5	13.8
Range	8.1	8.7	6.7	5.7	4.2	7.9	12.7	8.5
n	11	11	14	13	9	12	12	9
# Exceedance for wet season	0	0	0	0	0	0	0	0
# Exceedance for dry season	0	0	0	0	0	0	1	1
% Exceedance for entire year	0	0	0	0	0	0	8.3	11.1

UCR	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	16.4	15.7	16.5	15.9	16.2	14.8	17.0	16.5
Dry Season Average	18.6	18.2	17.3	18.1	17.3	17.0	18.7	18.5
Wet Season Average	13.8	13.6	15.5	13.4	14.7	13.3	15.3	14.1
Range	9.9	10.9	4.8	9.6	8.1	10.6	8.5	8
n	17	20	17	17	16	19	24	19
# Exceedance for wet season	0	0	0	0	0	0	0	0
# Exceedance for dry season	0	1	0	0	0	0	1	0
% Exceedance for entire year	0	5	0	0	0	0	11.8	0

TWB	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	12.8	13.0	13.8	13.5	13.3	11.5	12.3	12.8
Dry Season Average	14.6	15.7	15.1	15.7	14.9	14.0	14.0	15.3
Wet Season Average	11.6	11.3	12.4	12.1	11.7	10.2	12.1	12.1
Range	8.9	9.7	7.8	9.2	9.2	7.8	6	9.1
n	12	18	23	20	20	12	18	14
# Exceedance for wet season	0	0	0	0	0	0	0	0
# Exceedance for dry season	0	0	0	0	0	0	0	0
% Exceedance for entire year	0	0	0	0	0	0	0	0

In addition to monthly monitoring of water quality, continuous monitoring meters are deployed monthly. The following is typical dry season data from June 2015 at CHO and UCR, and a temperature plot was compiled over a 24-hour time period. At this time of year, the elevated temperatures at CHO relative to UCR were potentially related to minimal flows at the CHO site.

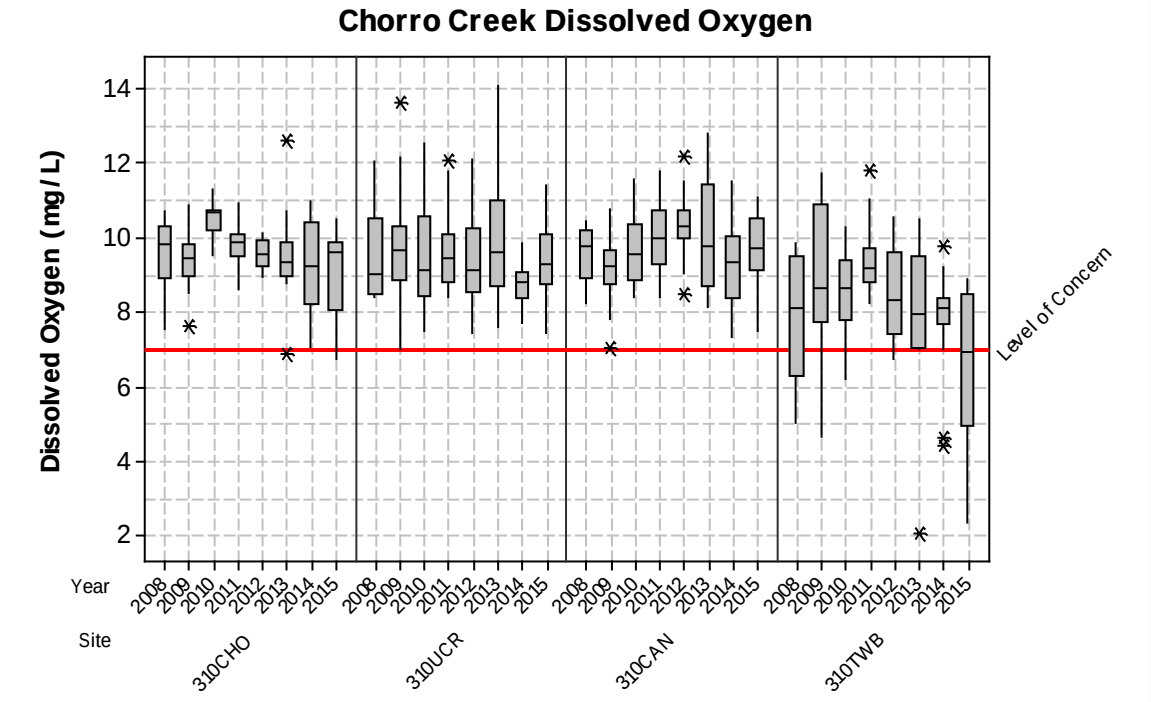


DISSOLVED OXYGEN

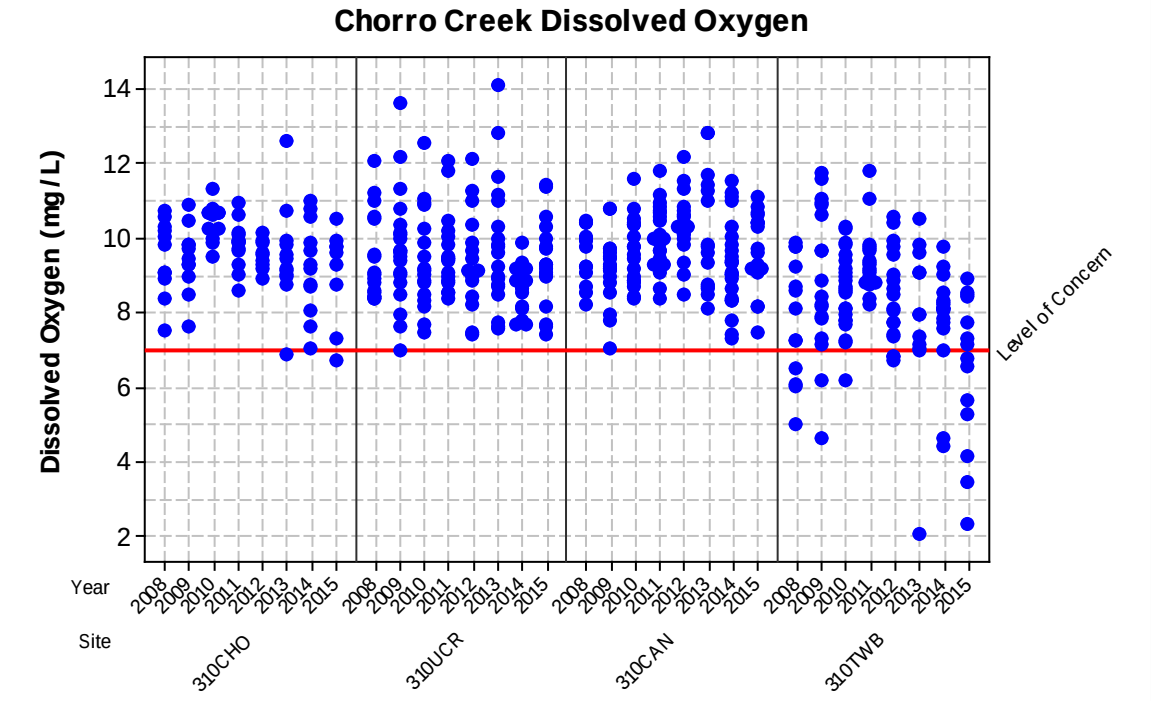
Dissolved oxygen measurements were collected as a concentration in mg/L. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk.

The Central Coast Basin Plan sets a regulatory standard that states that at no time shall DO concentrations fall below 7.0 mg/L.

While DO concentrations on Chorro Creek rarely fell below 7.0 mg/L, nutrient concentrations have been of concern. Due to the link of DO concentrations to elevated nutrient levels and potentially degraded habitat quality, an analysis of DO data on Chorro Creek was conducted.



The data for the same sites is also presented as a scatter plot to show the variability in the data.



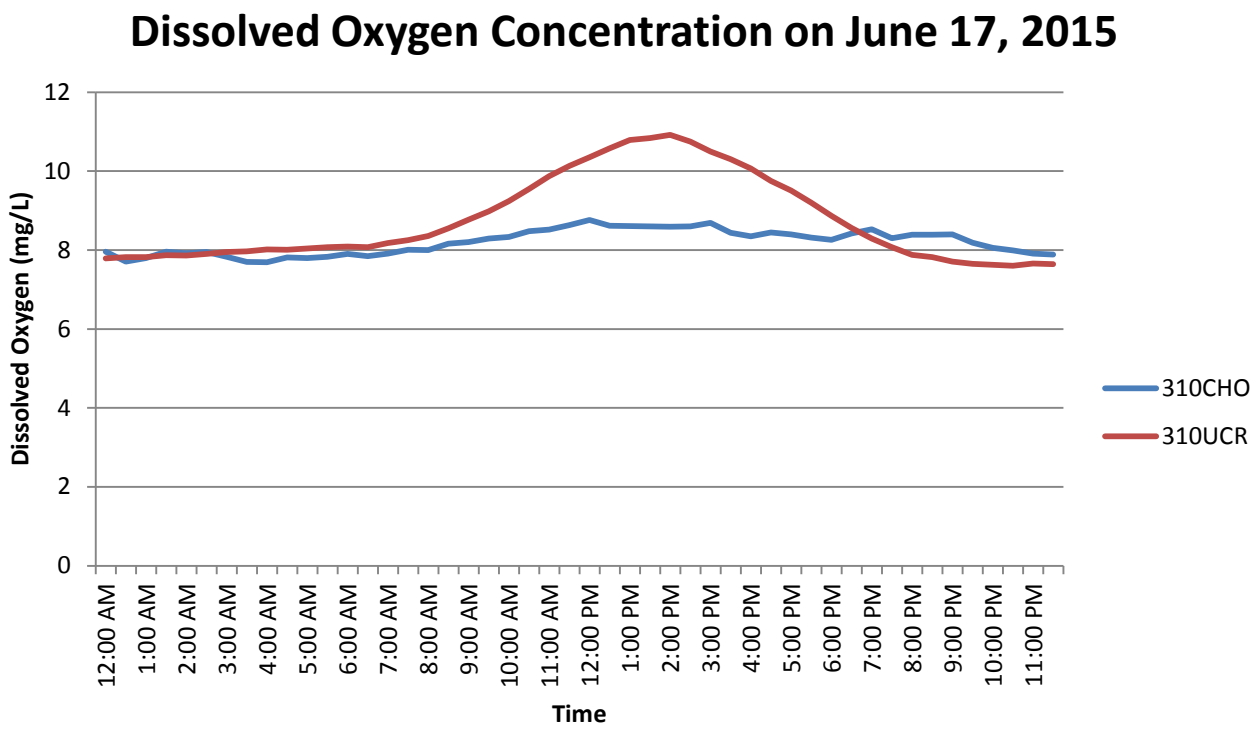
The following tables provide an overview of the data, following a format recently adopted by the CCRWQCB in their own analysis of impaired waterbodies. In this analysis, dry season encompasses May to October and the wet season includes November through April.

CHO	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	9.5	9.5	10.5	9.8	9.6	9.5	9.2	9.1
Dry season average	9.0	9.0	10.4	9.5	9.5	9.3	8.3	8.4
Wet season average	10.0	9.8	10.6	10.1	9.6	9.8	10.2	9.9
Range	3.2	2.8	1.8	2.4	1.3	5.7	4.0	3.8
n	11	11	14	13	9	12	12	9
# exceedance for wet season	0	0	0	0	0	0	0	0
# exceedance for dry season	0	0	0	0	0	0	0	1
% exceedance for entire year	0	0	0	0	0	0	0	11

UCR	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	9.5	9.7	9.4	9.6	9.4	9.8	8.7	9.4
Dry season average	9.0	8.8	9.0	9.2	8.8	8.7	8.7	8.8
Wet season average	10.0	10.5	9.9	10.1	10.2	10.6	8.8	10.1
Range	3.6	6.6	5.1	3.7	4.7	6.5	2.2	4.0
n	16	20	17	17	16	19	21	18
# exceedance for wet season	0	0	0	0	0	0	0	0
# exceedance for dry season	0	0	0	0	0	0	0	0
% exceedance for entire year	0	0	0	0	0	0	0	0

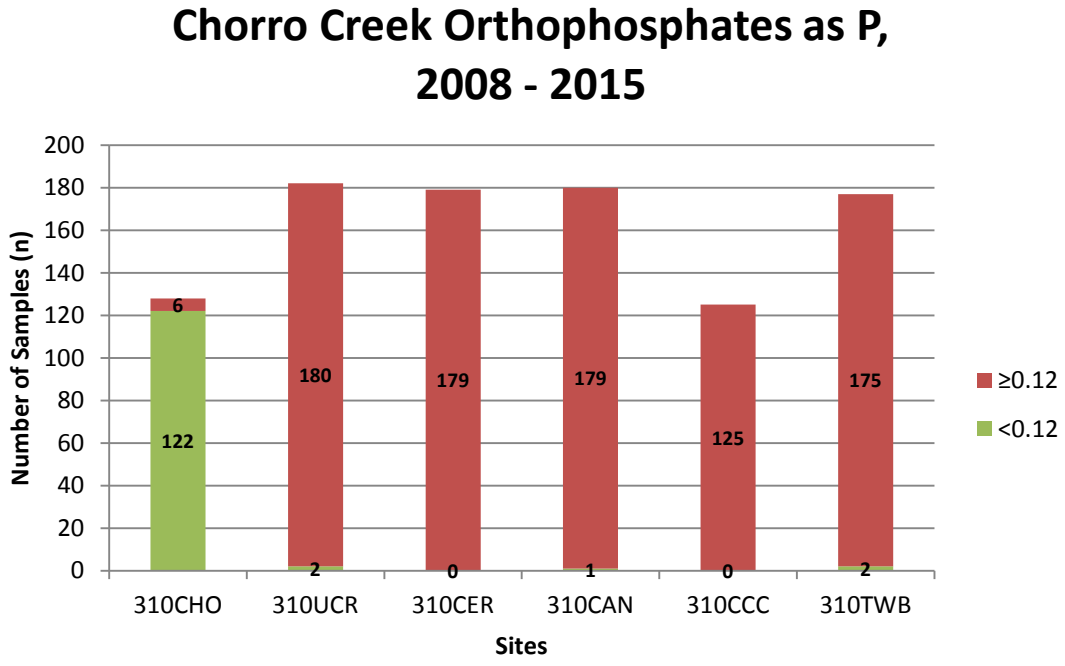
TWB	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	7.9	8.9	8.6	9.4	8.5	7.9	7.8	6.5
Dry season average	6.5	7.5	8.2	8.8	7.4	5.9	7.1	3.3
Wet season average	9.3	9.8	9.1	9.7	9.3	8.9	7.9	7.4
Range	4.9	7.1	4.1	3.6	3.8	8.5	5.4	6.6
n	13	18	23	19	17	12	18	14
# exceedance for wet season	0	0	0	0	0	0	1	3
# exceedance for dry season	4	2	1	0	3	1	1	4
% exceedance for entire year	31	11	4	0	18	8	6	29

In addition to monthly monitoring of water quality, continuous monitoring meters are deployed approximately quarterly. The following is typical dry season data from June 2015 at CHO and UCR, and a so plot was compiled over a 24-hour time period. The DO levels at CHO appeared to be more stable throughout this 24-hour time period, whereas the UCR site experienced swings from 8 to 11 mg/L, with the peak in the mid-afternoon. A likely factor was the presence of algae at UCR.



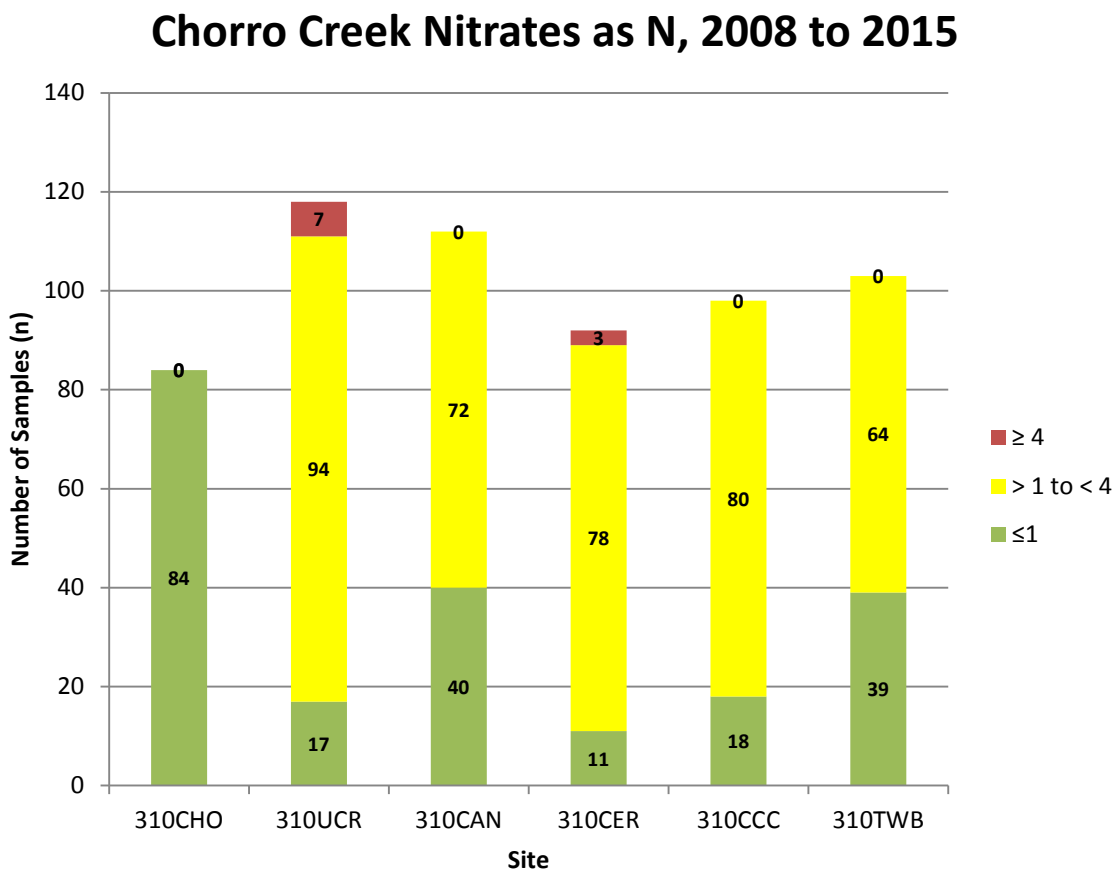
NUTRIENTS

The following bar graph illustrates the number of samples with orthophosphate as P concentrations in two categories: less than 0.12 mg/L (shown in green) and greater than or equal to 0.12 mg/L (shown in red). Site CHO is located above the CMC WWTP outfall on Camp SLO property, while the remaining five sites are located downstream of the WWTP outfall. The data included in the graph is from 2008 through 2015.



The CCRWQCB 303(d) Listing Guidance Value for nitrates as nitrogen is 1.0 mg/L to be protective of aquatic life. The drinking water standard protective of human health is 10.0 mg/L.

The following plot shows the number of nitrate as nitrogen samples in each of three categories: less than or equal to 1 mg/L (shown in green), greater than 1 mg/L and less than 4 mg/L (shown in yellow), and greater than or equal to 4 mg/L (show in red). The plot includes data collected from January 2008 through September 2015.



ALGAE DOCUMENTING

Algae data was analyzed through two data sets generated by 2014 assessments at two monitoring sites, CER and TWB. In 2015, three sites on Chorro Creek, CER, TWB and CHD, were monitored. The percent coverage of macroalgae at each site was determined by calculating algae presence at wetted points located on the transects and inter-transects. This calculated value is used to represent percent algal coverage throughout the 150 m reach. CER had a percent coverage of 29% in 2013, 22% in 2014, and 13% in 2015. TWB had a percent coverage of 33% in 2013, 9% in 2014, and 3% in 2015. CHD had a percent coverage of 16% in 2015.

Additionally, the qualitative spatial coverage of filamentous algae was scored for defined areas 5 m above and 5 m below each of 10 transects assessed within each site. Each assessment area (10 m of wetted reach) was assigned a score between 0 to 4, with 0 indicating less than 5% algae coverage, 1 indicating less than 10% coverage, 2 indicating 10 to 40% coverage, 3 indicating 40 to 75% coverage, and 4 indicating greater than 75% coverage. With this metric, CER scored 20% of the assessed area

having scores of 3 or 4 in 2013, 0% in 2014, and 0% in 2015. TWB scored 20% in 2013, 0% in 2014, and 10% in 2015. CHD scored 20% in 2015.

BACTERIA

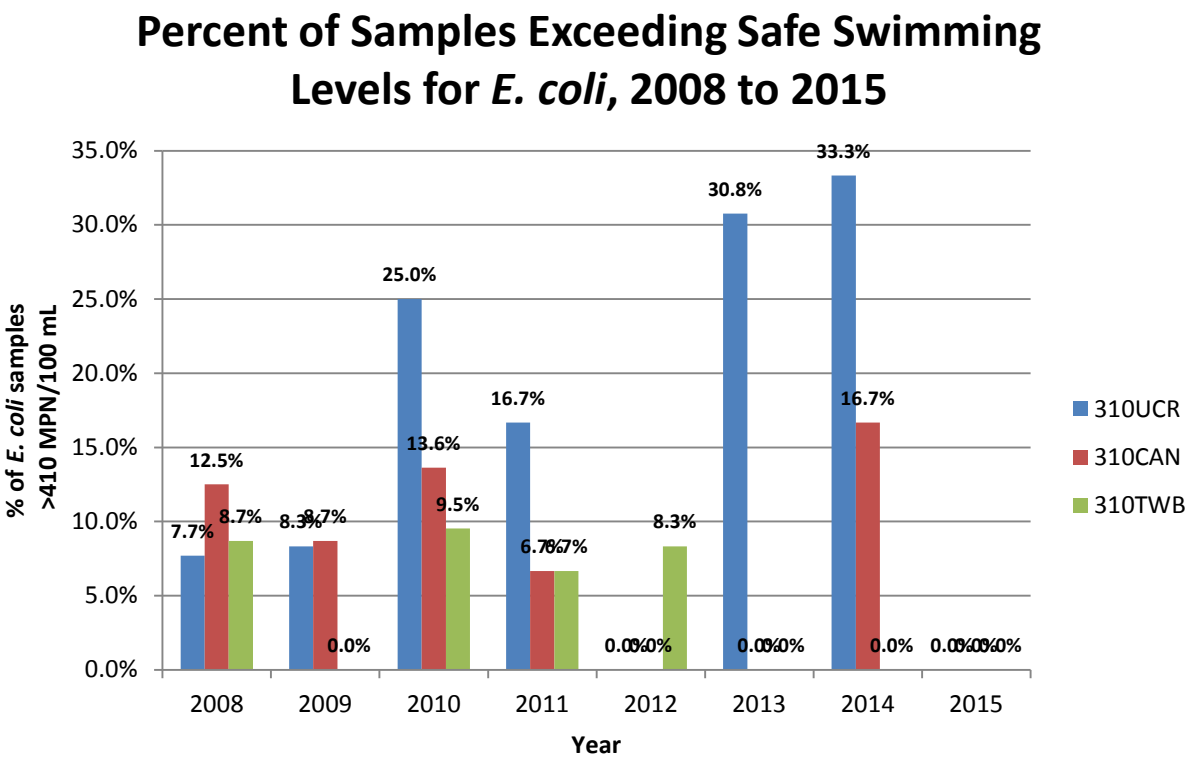
The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) is 410 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

The following table contains the number of bacteria samples collected each year at Chorro Creek sites and the percent of those samples that exceeded the STV value of 410 MPN/100 mL.

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015†**
UCR	13	12	12	12	12	13	12	9
>410 MPN/100 mL	1	1	3	2	0	4	4	0
UCR % Exceed	7.7%	8.3%	25.0%	16.7%	0.0%	30.8%	33.3%	0.0%
CAN n	24	23	22	15	12	12	12	9
>410 MPN/100 mL	3	2	3	1	0	0	2	0
CAN % Exceed	12.5%	8.7%	13.6%	6.7%	0.0%	0.0%	16.7%	0.0%
TWB n	23	19	21	15	12	8	7	7
>410 MPN/100 mL	2	0	2	1	1	0	0	0
TWB % Exceed	8.7%	0.0%	9.5%	6.7%	8.3%	0.0%	0.0%	0.0%

†2015 values include January to September 2015.

The following graphs depict the % of samples that exceeded the 410 MPN/100 mL recreational contact standard for *E. coli* each year.



MACROINVERTEBRATES

The metrics included in this report are taxa richness, EPT richness, EPT% and IBI score. Taxa richness is a measure of the number of different species of organisms in the sample. EPT richness is a measure of the total number of taxa within the sensitive orders of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Taxa richness and EPT richness typically decrease with poor water quality. EPT% is the total number of EPT individuals divided by the total number of individuals in the sample. The Index of Biotic Integrity (IBI) score used in this report is the Southern California Coastal IBI developed by the Aquatic Bioassessment Laboratory of the California Department of Fish & Wildlife. Seven uncorrelated biotic measurements were selected to be included in the calculation. They include collector-gatherer + collector-filterer individuals, percent non-insect taxa, percent tolerant taxa, coleoptera richness, predator richness, percent intolerant individuals and EPT richness. For the IBI scores, scores of 0 to 19 are considered to be very poor, 20 to 39 are poor, 40 to 59 are fair, 60 to 79 are good, and 80 to 100 are very good.

The metrics are displayed below for the three Chorro Creek sites, which are located just below Chorro Dam (CHD), on the Chorro Creek Ecological Reserve (CER) and just below the bridge on South Bay Boulevard and State Park Road (TWB). In recent years, CER and TWB have been monitored by the CCRWQCB. The data are not yet available from the CCRWQCB.

Chorro Creek, Chorro Dam (CHD)	Taxa Richness	EPT Richness	EPT %	IBI Score
2002	*	*	*	*
2003	31	11	35.0	-
2004	42	15	36.0	50

Chorro Creek, Chorro Dam (CHD)	Taxa Richness	EPT Richness	EPT %	IBI Score
2005	*	*	*	*
2006	36	16	19.3	46
2007	59	12	16.4	49
2008	54	13	33.4	44
2009	40	10	11.9	57
2010	*	*	*	*
2011	47	11	52.9	54
2012	*	*	*	*
2013	*	*	*	*
2015	63	14	13.0	50

** No data collected this year.*

- Metric scores not currently available.

Chorro Creek, Ecological Reserve (CER)	Taxa Richness	EPT Richness	EPT %	IBI Score
2002	*	*	*	*
2003	*	*	*	*
2004	27	6	22.0	41
2005	18	4	22.0	31
2006	*	*	*	*
2007	31	4	8.3	30
2008	48	6	14.6	30
2009	-	-	-	-
2010	-	-	-	-
2011	50	14	48.1	34
2012	42	12	35.6	47
2013	26	5	6.32	23
2014	34	6	3.24	30
2015	42	9	11.9	33

** No data collected this year.*

- Metric scores not currently available.

Chorro Creek, South Bay Blvd. (TWB)	Taxa Richness	EPT Richness	EPT %	IBI Score
2002	25	6	24.0	36
2003	23	6	26.0	34
2004	*	*	*	*
2005	*	*	*	*
2006	36	12	20.3	46
2007	37	7	2.9	49

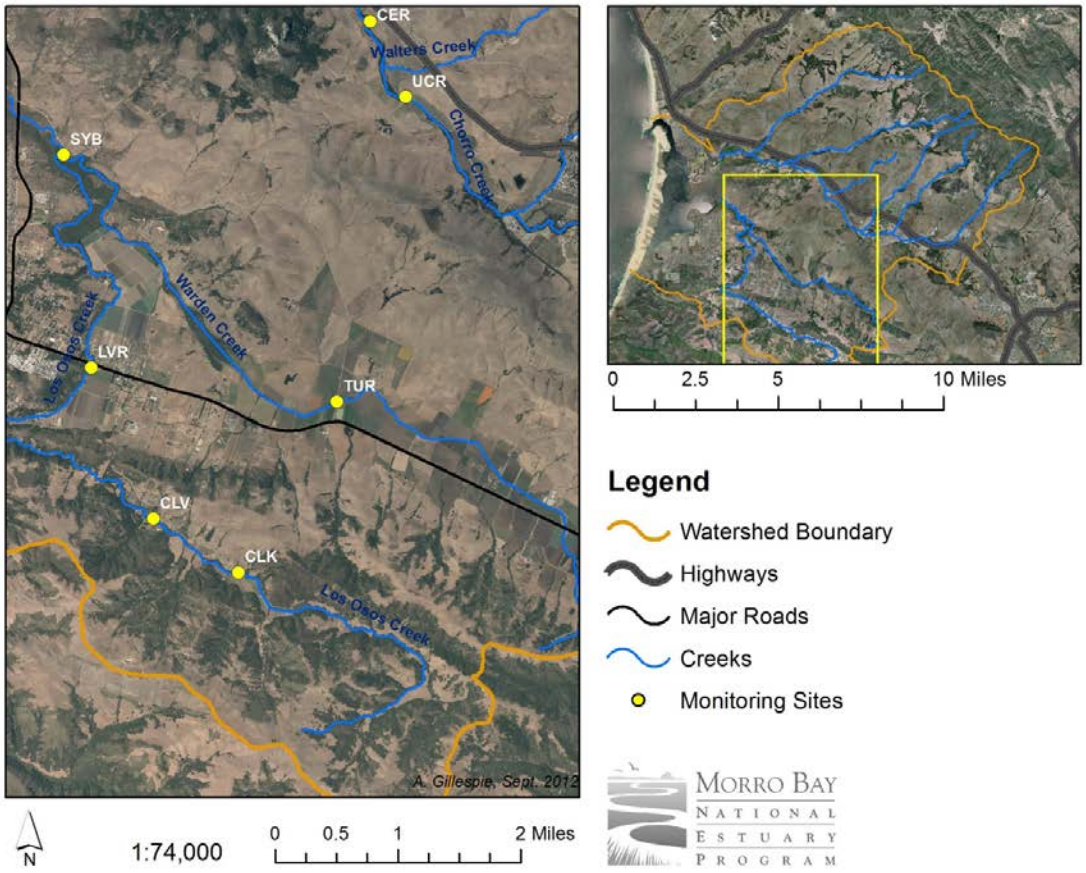
Chorro Creek, South Bay Blvd. (TWB)	Taxa Richness	EPT Richness	EPT %	IBI Score
2008	55	14	27.3	56
2009	-	-	-	37
2010	*	*	*	*
2011	-	-	-	-
2012	46	12	35.6	46
2013	52	9	3.7	54
2014	41	4	6.93	41
2015	31	0	0	24

** No data collected this year.*

- Metric scores not currently available.

LOS OSOS AND WARDEN CREEK

SITE MAP



The Los Osos Creek and Warden Creek watersheds encompass an area of approximately 23 square miles. The program monitored two sites in Clark Valley on Los Osos Creek. Site CLK is located at a private road crossing and is monitored annually for macroinvertebrates. Monthly water quality and bacteria data are not collected at this site. Site CLV was established in 2008 at a private road crossing

on Los Osos Creek and is monitored monthly for water quality and bacteria during times of adequate surface flows. On Los Osos Creek, site LVR is located at the Los Osos Valley Road bridge. This site is monitored infrequently as it contains surface flows only during brief periods of very wet years. When flowing, the site is monitored for water quality. On limited occasions when adequate water is present, site LVR is monitored for macroinvertebrates. Site SYB on Los Osos Creek is downstream of the Warden Creek confluence. The site is tidally-influenced by Morro Bay, and the CCRWQCB is currently reclassifying the site as estuarine. Site GS1 is downstream of SYB on Los Osos Creek. It is also tidally-influenced. The site was added to the monitoring effort because a site was needed that could be safely accessed during low tide conditions.

On Warden Creek, site TUR is located at the bridge crossing on Turri Road. Although there is typically water present at the TUR site year-round, extremely low flow volumes and velocities often prevent monitoring during the dry season.

In 2011, the Coastal San Luis Resource Conservation District (CSLRCD) began a grant to implement agricultural water quality enhancement projects, including on-farm audits of irrigation and fertilizer use to reduce the impacts of run-off. Riparian fencing was installed to help ranches minimize the impacts of cattle on fragile streambanks and to improve water quality. As a partner in this project, the MBNEP was responsible for ambient monitoring of nutrients in the Los Osos Creek subwatershed. Monitoring began in December 2010 and concluded in spring of 2015, and data was submitted quarterly to the CCRWQCB. At the end of the project, the data underwent statistical analysis and a monitoring report will be compiled and submitted to the CCRWQCB. Some brief summary analyses are included in this report.

Water Quality n value summary

The table below indicates the frequency of water quality monitoring at Los Osos and Warden Creeks.

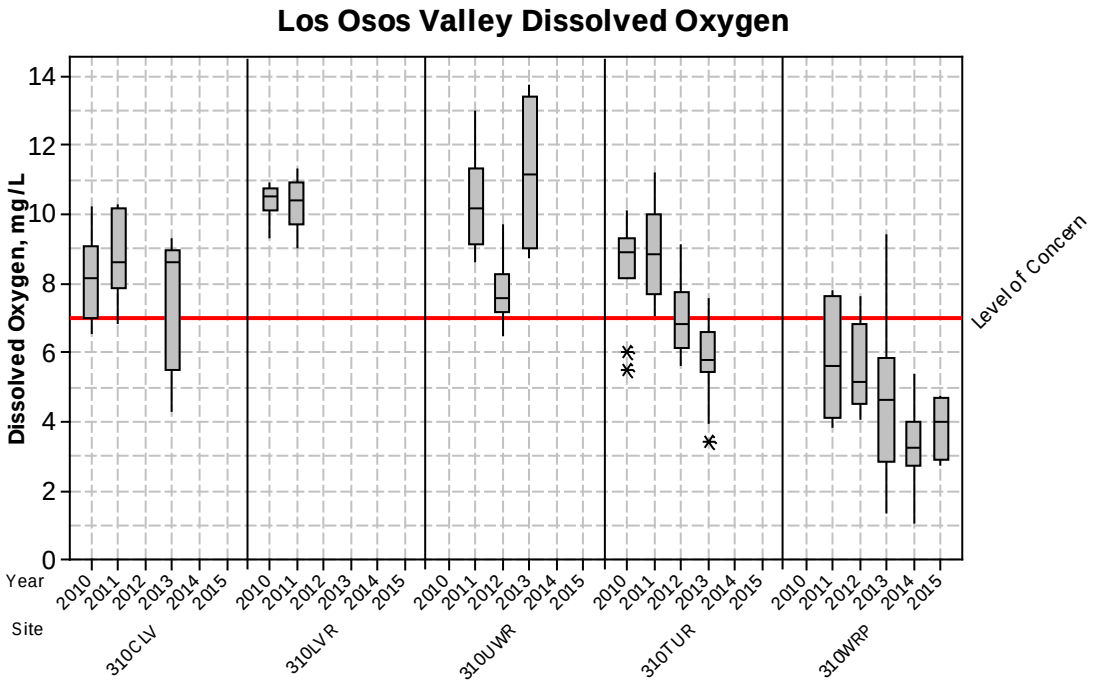
	2008	2009	2010	2011	2012	2013	2014	2015*
CLV	7	8	12	10	0	7	0	0
LVR	0	0	7	9	0	0	0	0
UWR	-	-	-	-	15	4	0	0
TUR	8	4	13	13	14	20	0	0
WRP	-	-	-	11	16	33	17	5
SYB	12	13	13	12	12	12	10	9

**2015 data represents January through September.*

Dissolved Oxygen

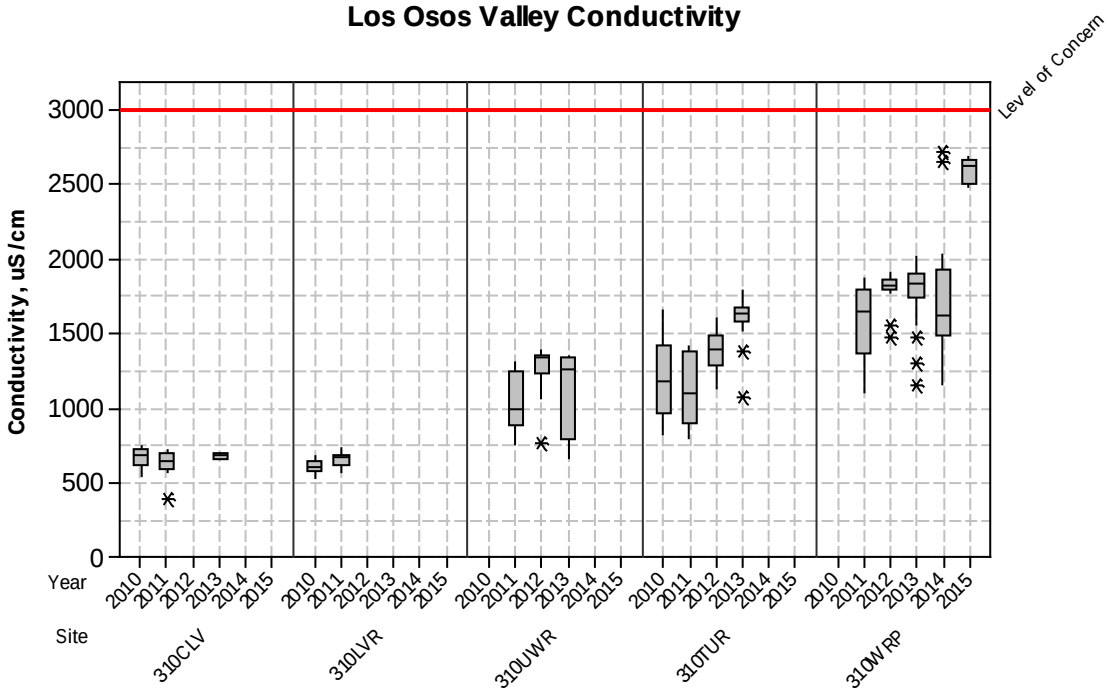
The following graph shows the DO concentration data at three sites on Warden Creek (UWR, TUR and WRP) and CLV on Los Osos Creek. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk. The Central Coast Basin Plan set a regulatory standard that states that at no time shall DO concentrations fall below 7.0 mg/L.

Time of day has a significant impact on DO levels. Monitoring at the three Warden Creek sites consistently occurred on the same day, i.e., the monitoring team would visit all three sites within a two-hour period.



CONDUCTIVITY

The following graph illustrates the mean conductivity levels by year at UWR, TUR and WRP (on Warden Creek) and at CLV (on Los Osos Creek) from 2008 through June 2014. Average conductivity levels at all three sites on Warden Creek are consistently in the "Increasing Problems" range listed in the Basin Plan standards (750 to 3,000 uS/cm), but do not exceed 3,000 uS/cm where the problem would be considered “Severe."

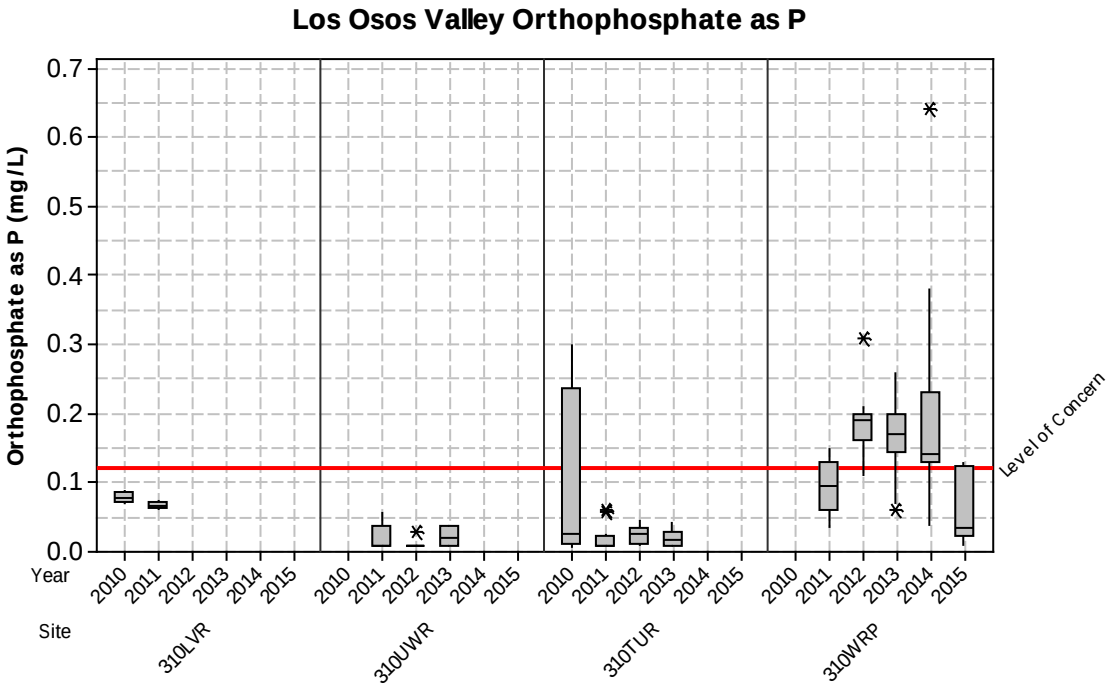


NUTRIENTS

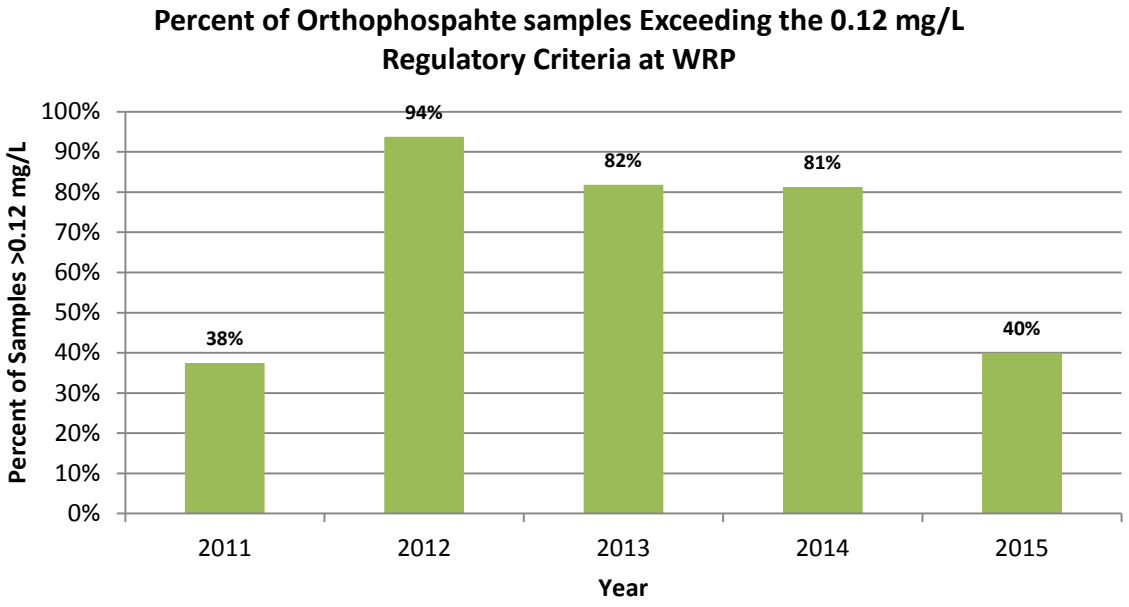
The MBNEP measured orthophosphates as phosphorus and nitrates as nitrogen during each water quality field visit. Samples were collected by staff and trained volunteers, and analysis was conducted at the MBNEP office using chemical test kits or colorimeters.

The MBNEP also collected samples which were sent to a certified laboratory for nutrient analysis. The following graphs contain the lab-generated nutrient data for sites UWR, WRP, TUR and LVR from 2010 through 2015. Due to lower than average annual rainfall, LVR did not have measurable surface flows during 2012, 2013, 2014 or 2015. UWR and TUR did not have measurable flows in 2014 or 2015.

For orthophosphates, the following bar graph contains lab-generated orthophosphate as P results for TUR, UWR and WRP on Warden Creek and LVR on Los Osos Creek.



The orthophosphate data was also analyzed by comparing it to the 0.12 mg/L level of concern intended to be protective of aquatic life. The site from Los Osos Creek (LVR) did not have any exceedances of the criteria. As TUR and UWR had minimal issues with this analyte, an analysis was conducted for WRP only.

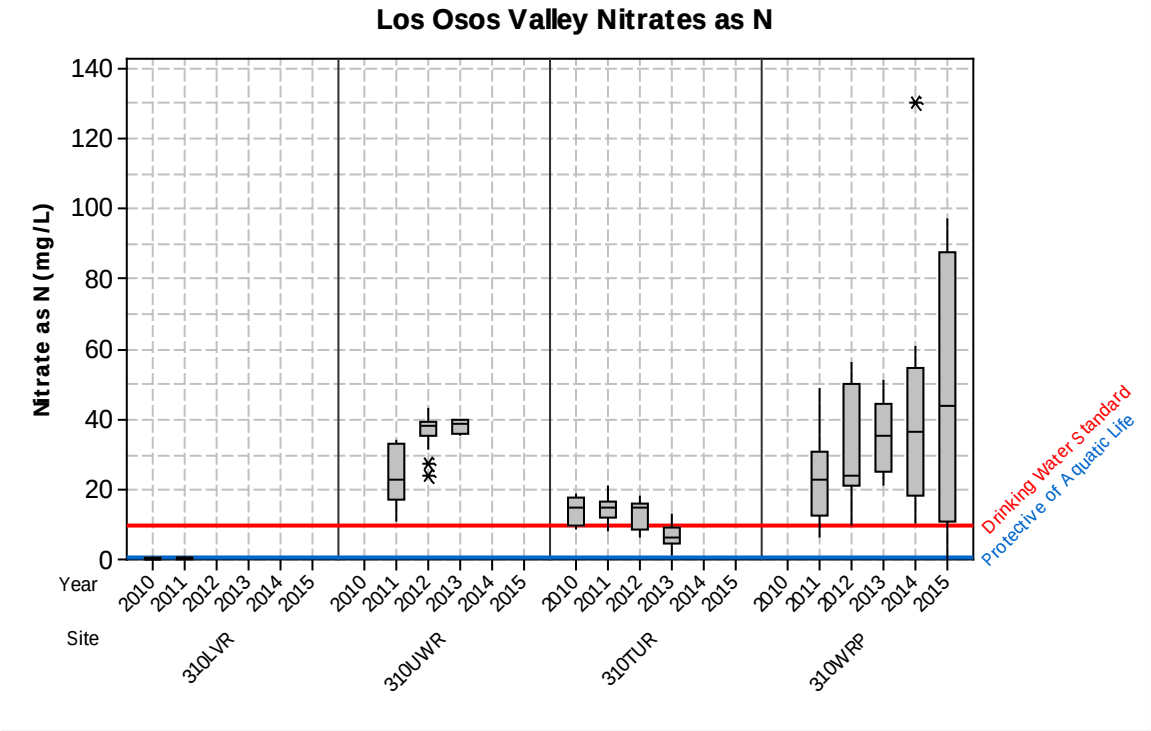


As the orthophosphate results indicate that this parameter has frequent exceedances at WRP, an additional method of analysis was included in this report. The following table is modeled after methods utilized by the CCRWQCB in their own analysis of impaired waterbodies. For this analysis, dry season encompasses May to October and wet season includes November through April.

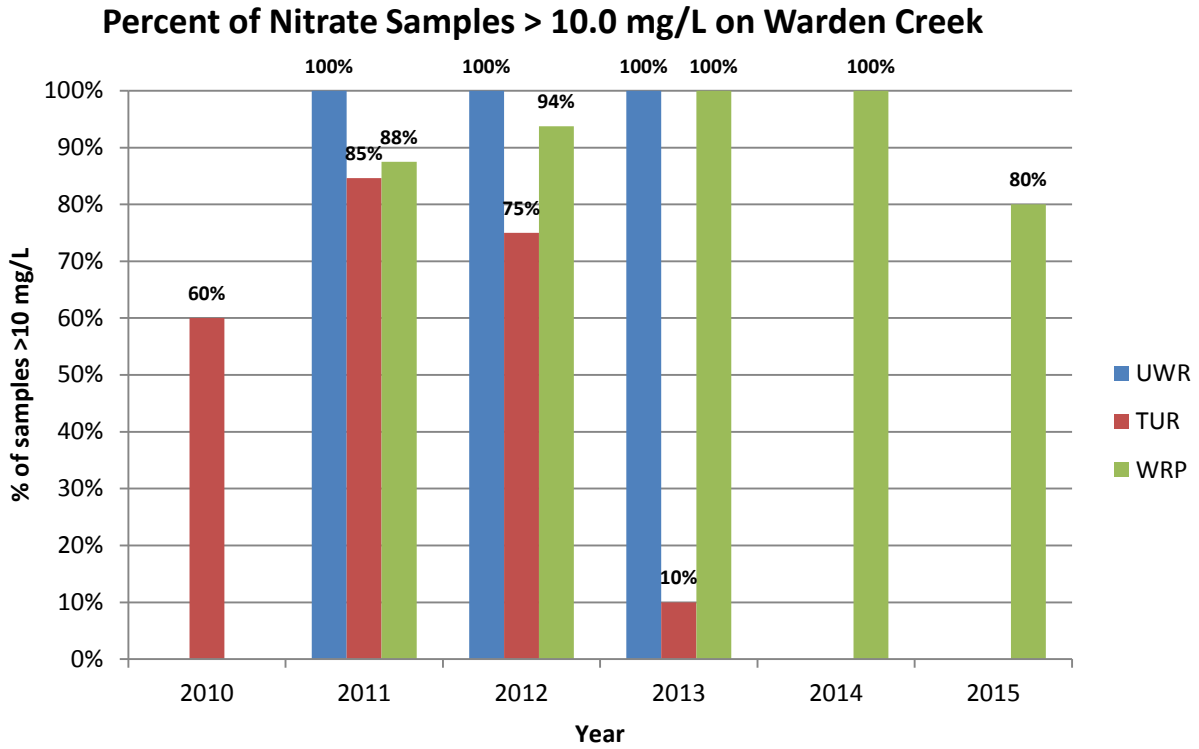
WRP	2011	2012	2013	2014	2015
Annual Average	0.1	0.2	0.2	0.2	0.1
Dry Season Average	0.1	0.2	0.2	0.3	-
Wet Season Average	0.1	0.2	0.2	0.2	0.1
Range	0.1	0.2	0.2	0.6	0.1
n	8	16	33	16	5
# exceedences for wet season	1	7	14	4	-
# exceedences for dry season	2	8	13	9	2
% exceedences for entire year	37.5%	93.8%	81.8%	81.3%	40.0%

The CCRWQCB 303(d) Listing Guidance Value for nitrates as nitrogen is 1.0 mg/L to be protective of aquatic life and 10.0 mg/L to be protective of human health.

The following graph is lab-generated data anazlyed for UWR, TUR and WRP on Warden Creek and LVR on Los Osos Creek. Lab-generated nitrate data was not available for CLV, however results from screening methods from 2010 through 2013 indicated no issues with nitrate concentrations. While this data should be considered as screening level data and was not included in the following graph, it indicates a long-running trend of minimal nitrates at the site.



The following graph shows the percent of samples with nitrate concentrations greater than 10 mg/L, the drinking water standard, on three Warden Creek sites from 2010 through 2015. All data used in this analysis was from analysis by a certified laboratory.



Note: TUR and UWR were not monitored in 2014 and 2015 due to lack of water. In 2010, the only site monitored was TUR.

As the nitrate analysis indicates that this parameter has frequent exceedances, an additional method of analysis was included in this report. The following tables are modeled after methods utilized by the CCRWQCB in their own analysis of impaired waterbodies. For this analysis, dry season encompasses May to October and wet season includes November through April.

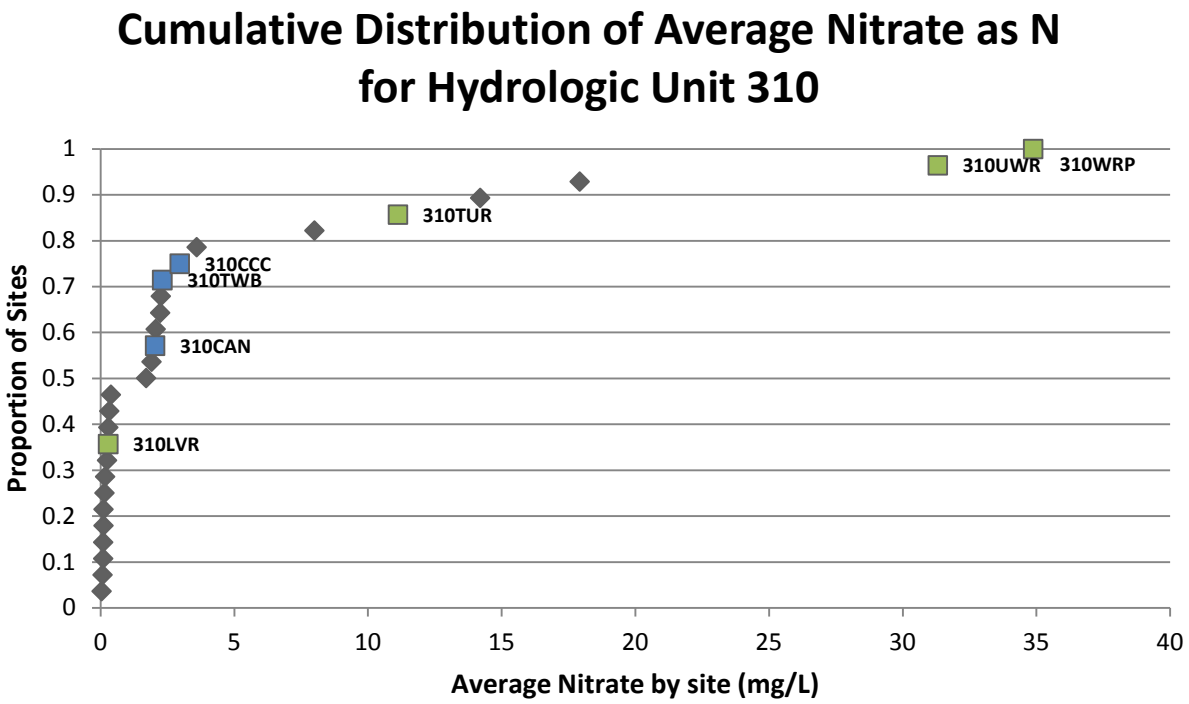
LVR	2010	2011	2012	2013	2014	2015
Annual Average	0.17	0.35	-	-	-	-
Dry Season Average	-	0.08	-	-	-	-
Wet Season Average	0.17	0.42	-	-	-	-
Range	0.35	0.73	-	-	-	-
n	3	9	-	-	-	-
# exceedences for wet season	0	0	-	-	-	-
# exceedences for dry season	0	0	-	-	-	-
% exceedences for entire year	0%	0%	-	-	-	-

UWR	2010	2011	2012	2013	2014	2015
Annual Average	-	23.7	36.1	38.0	-	-
Dry Season Average	-	31.0	40.0	-	-	-
Wet Season Average	-	20.4	33.6	38.0	-	-
Range	-	23.0	19.0	5.0	-	-
n	-	13	15	4	-	-
# exceedences for wet season	-	4	6	-	-	-
# exceedences for dry season	-	9	9	4	-	-
% exceedences for entire year	-	100%	100%	100%	-	-

TUR	2010	2011	2012	2013	2014	2015
Annual Average	13.7	14.2	12.8	6.4	-	-
Dry Season Average	13.8	18.3	9.3	3.5	-	-
Wet Season Average	13.7	12.4	15.6	8.4	-	-
Range	10.4	13.2	11.6	11.6	-	-
n	10	13	16	20	-	-
# exceedences for wet season	3	4	3	0	-	-
# exceedences for dry season	3	7	9	2	-	-
% exceedences for entire year	60%	85%	75%	10%	-	-

WRP	2010	2011	2012	2013	2014	2015
Annual Average	-	23.3	32.0	34.8	39.6	48.1
Dry Season Average	-	30.8	47.9	41.2	58.3	-
Wet Season Average	-	15.8	19.7	29.4	33.4	48.1
Range	-	42.7	46.4	30.0	120.0	96.8
n	-	8	16	33	16	5
# exceedences for wet season	-	4	7	15	4	-
# exceedences for dry season	-	3	8	18	12	4
% exceedences for entire year	-	88%	94%	100%	100%	80%

The following graph is a cumulative distribution of nitrate data for sites within hydrologic unit 310. The graph contains the average nitrate data for 28 creeks in the Estero Bay Hydrologic Unit. The sites from the Morro Bay watershed are highlighted on the plot. The sites are from the following creeks: Arroyo de la Cruz, San Simeon, Santa Rosa, Villa, Cayucos, Morro, Chorro, San Bernardo, San Luisito, Los Osos, Warden, Coon, San Luis Obispo, Pismo and Arroyo Grande. These sites were selected to represent varying levels of impacts from human activities. The Warden Creek sites stand out as having some of the highest nitrate concentrations among the sites selected for analysis.



ALGAE DOCUMENTING

Due to inadequate water at CLK and LVR in 2014 and 2015, algae documenting could not be conducted during those years.

MACROINVERTEBRATES

The metrics included in this report are taxa richness, EPT richness, EPT% and IBI score. Taxa richness is a measure of the number of different species of organisms in the sample. EPT richness is a measure of the total number of taxa within the sensitive orders of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Taxa richness and EPT richness typically decrease with poor water quality. EPT% is the total number of EPT individuals divided by the total number of individuals in the sample. The Index of Biotic Integrity (IBI) score used in this report is the Southern California Coastal IBI developed by the Aquatic Bioassessment Laboratory of the California Department of Fish & Wildlife. Seven uncorrelated biotic measurements were selected to be included in the calculation. They include collector-gatherer + collector-filterer individuals, percent non-insect taxa, percent tolerant taxa, coleoptera richness, predator richness, percent intolerant individuals and EPT richness. For the IBI scores, scores of 0 to 19 are considered to be very poor, 20 to 39 are poor, 40 to 59 are fair, 60 to 79 are good, and 80 to 100 are very good.

Bioassessment monitoring did not take place at CLK and LVR in 2014 and 2015 due to lack of water.

Los Osos Creek, Clark Valley (CLK)	Taxa Richness	EPT Richness	EPT %	IBI Score
2002	30	9	30	70
2003	35	14	40	81
2004	35	17	49	79
2005	25	12	48.0	60
2006	33	13	51.0	51
2007	*	*	*	*
2008	29	13	17.9	58.6
2009	*	*	*	*
2010	39	13	31.7	65.8
2011	41	15	58.7	52.9
2012	51	14	63.5	70.0
2013	*	*	*	*

** No data collected this year.*

Los Osos Creek, Los Osos Valley Road (LVR)	Taxa Richness	EPT Richness	EPT %	IBI Score
2002	*	*	*	*
2003	*	*	*	*
2004	*	*	*	*
2005	15	6	40.0	46
2006	*	*	*	*
2007	*	*	*	*
2008	*	*	*	*
2009	*	*	*	*
2010	18	3	25.1	41.5
2011	46	13	53.0	48.6
2012	*	*	*	*
2013	*	*	*	*

** No data collected this year*

3.0 BAY DATA ANALYSIS

The following analysis addresses data collected from the bay, including bacteria, dissolved oxygen, shorebirds and phytoplankton.

MORRO BAY BACTERIA

SITE MAP AND DESCRIPTION

The Morro Bay estuary is a 2,300-acre semi-enclosed body of water which supports recreational activities for residents and visitors alike. Kayaking, sailing, windsurfing, swimming and wading are common activities in the bay. Recreational use is frequent year-round at various designated access points around the bay. The MBNEP monitors eight commonly used bay access points on a monthly basis for *E. coli* and *Enterococcus* spp. concentrations. These sites were established between 2002 and 2004.

Monthly samples were collected by staff and volunteers in the field and then analyzed with the IDEXX method using Colilert-18 reagent to obtain *E. coli* results and Enterolert reagent to obtain *Enterococcus*

spp. results. Samples were analyzed by MBNEP staff and volunteers using lab facilities in the Morro Bay-Cayucos Wastewater Treatment Plant Laboratory.

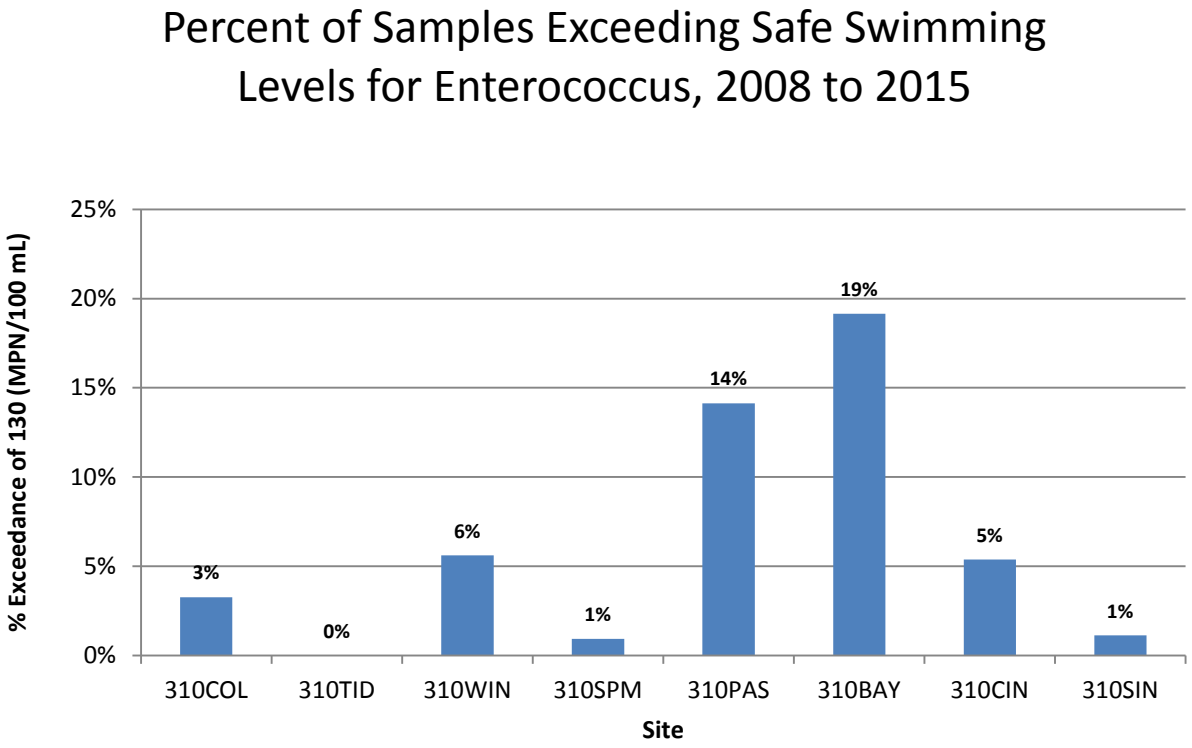
The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. The geomean of the enterococcus data should be less than 35 MPN/100 mL and the statistical threshold value (STV) of 130 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

Based on typical sample dilutions, the range of detection for the *Enterococcus* spp. testing is from < 10 MPN/100 mL to 24,196 MPN/100 mL.

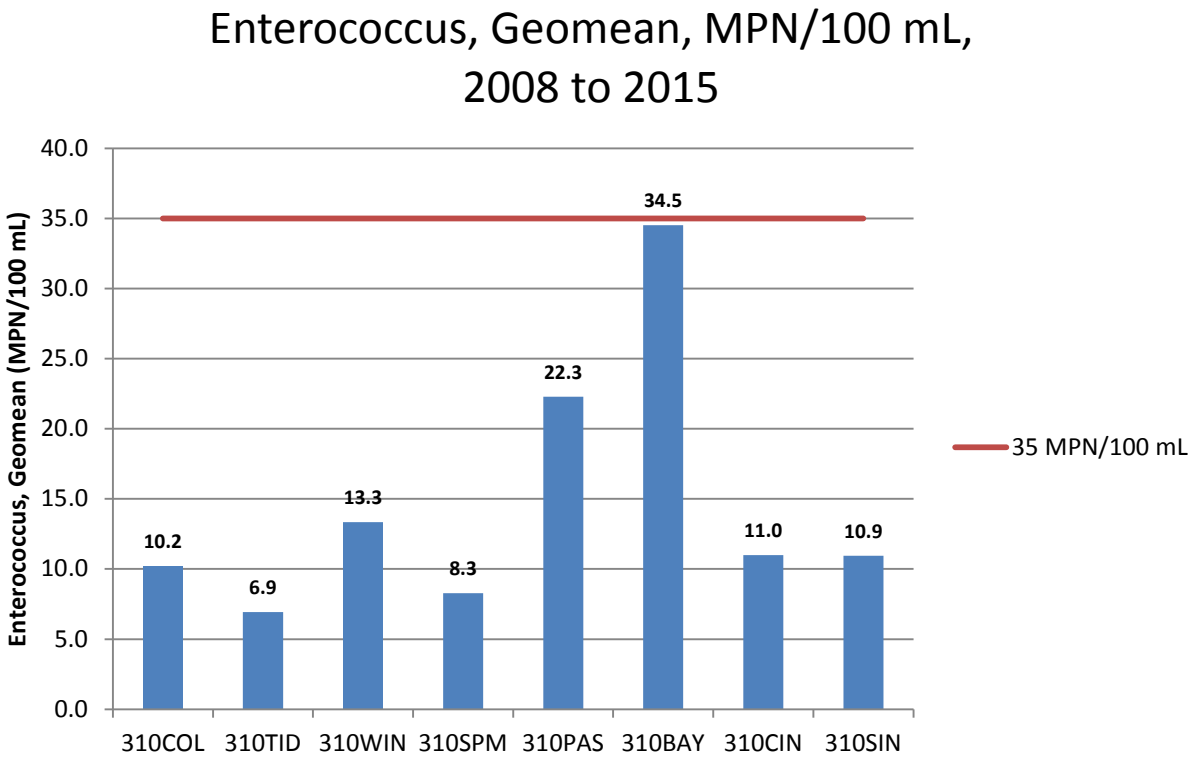
The following table contains the number of *Enterococcus* spp. samples collected at the sites from January 2008 through September 2015.

Site Code	Site Description	Number of Samples (n)	Number of Exceedances of 130 MPN/100 mL	Percent of Samples Exceeding
COL	Coleman Beach	92	3	3%
TID	Tidelands Park	93	0	0%
WIN	Windy Cove	107	6	6%
SPM	State Park Marina	107	1	1%
PAS	Pasadena Point	92	13	14%
BAY	Baywood Pier	94	18	19%
CIN	Cuesta Inlet	93	5	5%
SIN	Sharks Inlet	89	1	1%

The following graph shows the percent of samples that exceeded the 130 MPN/100 mL regulatory standard for safe recreational contact for *Enterococcus* spp. in marine waters. This analysis is for data from January 2008 through September 2015.



The following graph illustrates the geomean of the *Enterococcus* spp. data from January 2008 through September 2015 for each site.



DAWN PATROL

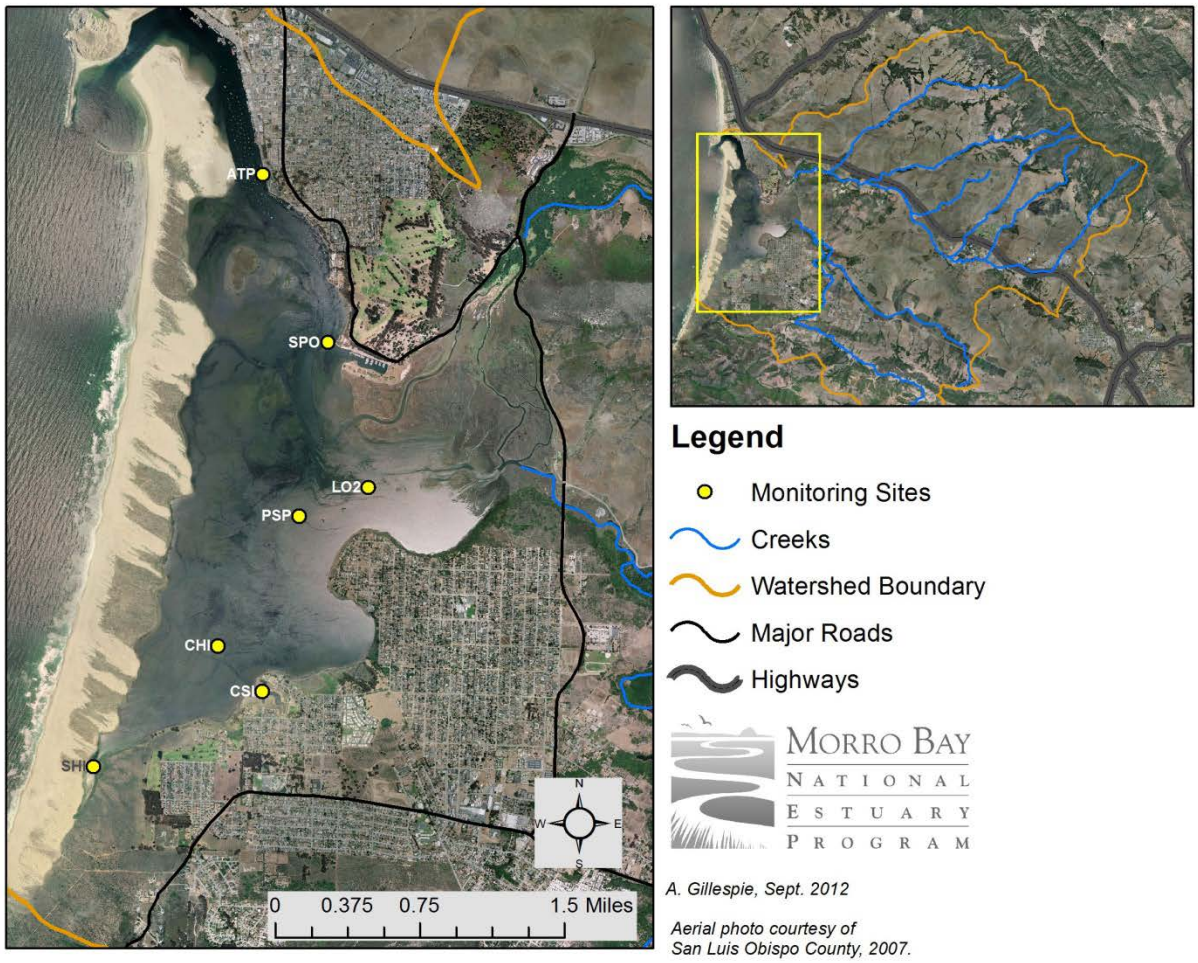
SITE MAP AND DESCRIPTION

Early morning dissolved oxygen (DO) readings in the bay were monitored starting in 2002. Seven sites are monitored on a monthly basis in the early morning hours. Volunteers kayak to the sites and take surface measurements of temperature, salinity, and DO percent saturation and concentration. Measurements collected with continuous monitoring equipment demonstrated that depressed DO levels continued until approximately two hours after sunrise. Volunteers collect readings within two hours of sunrise to capture the lowest DO levels of the day.

The Central Coast Region Basin Plan states that bay DO concentrations must remain above 7.0 mg/L to be protective of marine aquatic life.

The monitoring sites were selected to provide a wide spatial distribution throughout the bay. The sites are divided into two regions which are covered by two separate monitoring teams each month. The front bay sites include Tidelands Park (ATP), State Park Marina (SPO), near the Los Osos Creek tributary in the mudflat area (LO2), and Pasadena Point (PSP) in the channel. The back bay sites include the main channel off of Cuesta Inlet (CHI), Cuesta Inlet (CSI), and Sharks Inlet (SHI). The two sets of sites are not necessarily monitored on the same day.

The State Park Marina site was formerly listed under code SPM. To differentiate this site from the shoreline bacteria monitoring site, the Dawn Patrol site was re-coded as SPO.



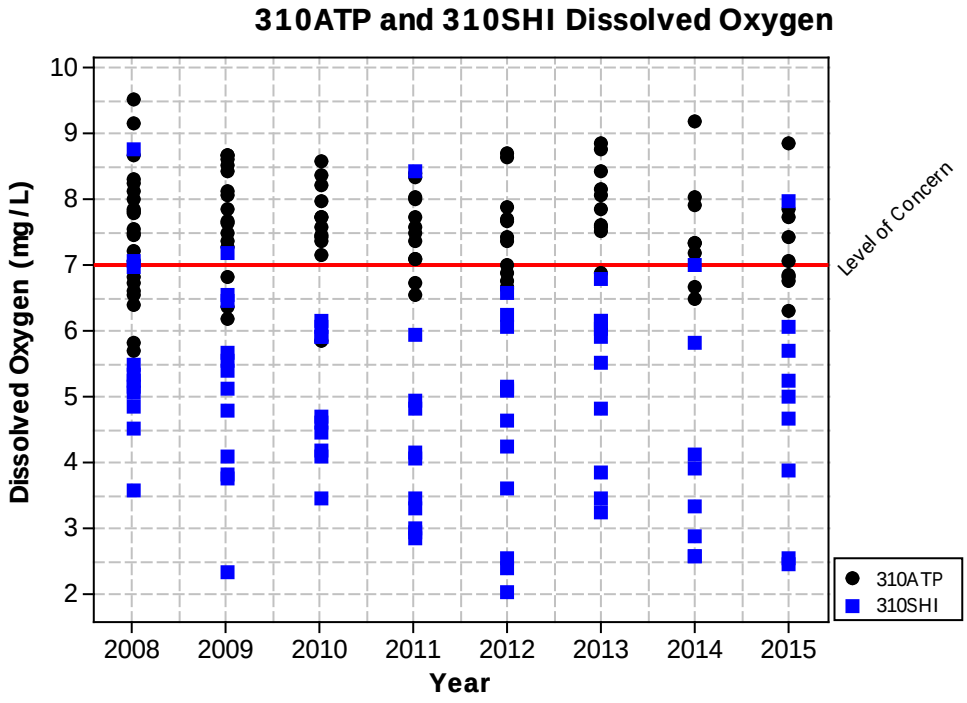
The following table shows the number of readings taken at each site by year. The table also shows the number and percent of samples that fell below the 7.0 mg/L regulatory standard that is protective of marine habitat.

Site	2008	2009	2010	2011	2012	2013	2014	2015	Sample Size	# of exceed-ances of 7 mg/L	% of Exceedances
ATP	22	15	12	12	12	11	8	9	101	26	26%
SPO	13	12	12	12	12	11	8	9	89	32	36%
LO2	13	12	12	12	12	11	8	8	88	29	33%
PSP	13	12	12	12	12	11	8	9	89	29	33%
CHI	11	12	10	11	12	10	9	9	84	67	80%
CSI	11	12	10	11	12	10	9	9	84	79	94%
SHI	11	12	10	11	12	10	8	9	83	77	93%

**2015 data includes January through September.*

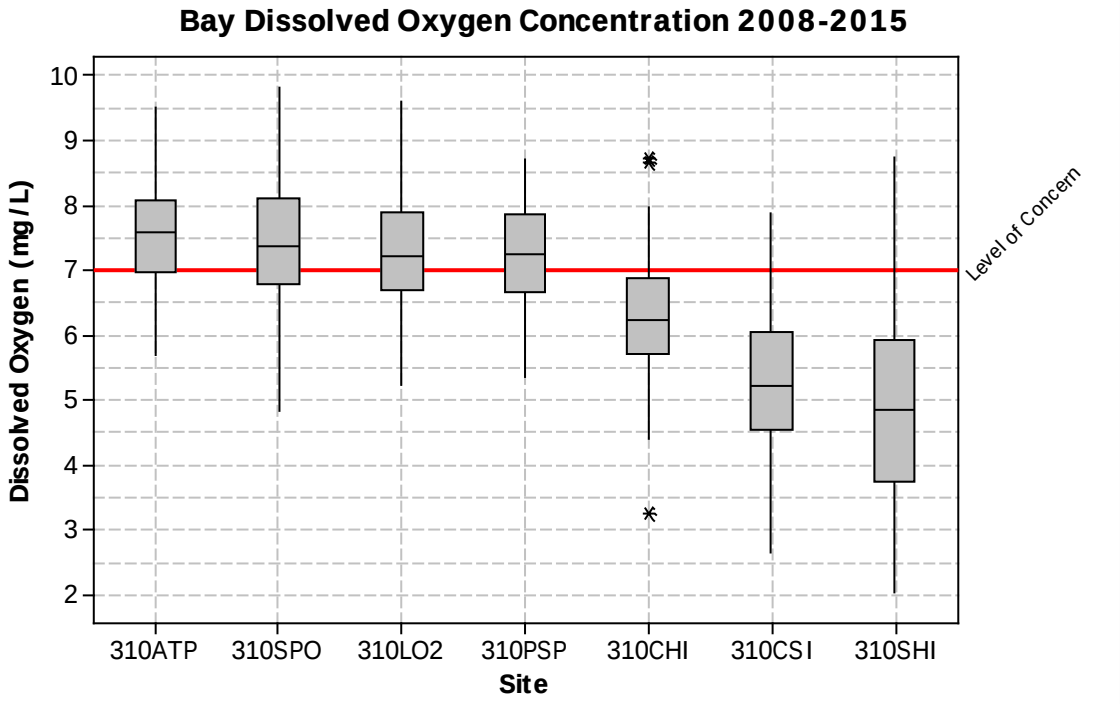
The following figure is a scatter plot of surface DO levels at two sites, Tidelands Park (ATP) and Sharks Inlet (SHI). The red line indicates the Basin Plan DO standard of 7.0 mg/L that is protective of marine life. The southernmost site of Sharks Inlet (shown in blue) exhibits DO levels that tended to remain in

the 5 to 6 mg/L range. In comparison, the front bay site at Tidelands Park (shown in black) consistently had levels above 7.0 mg/L.

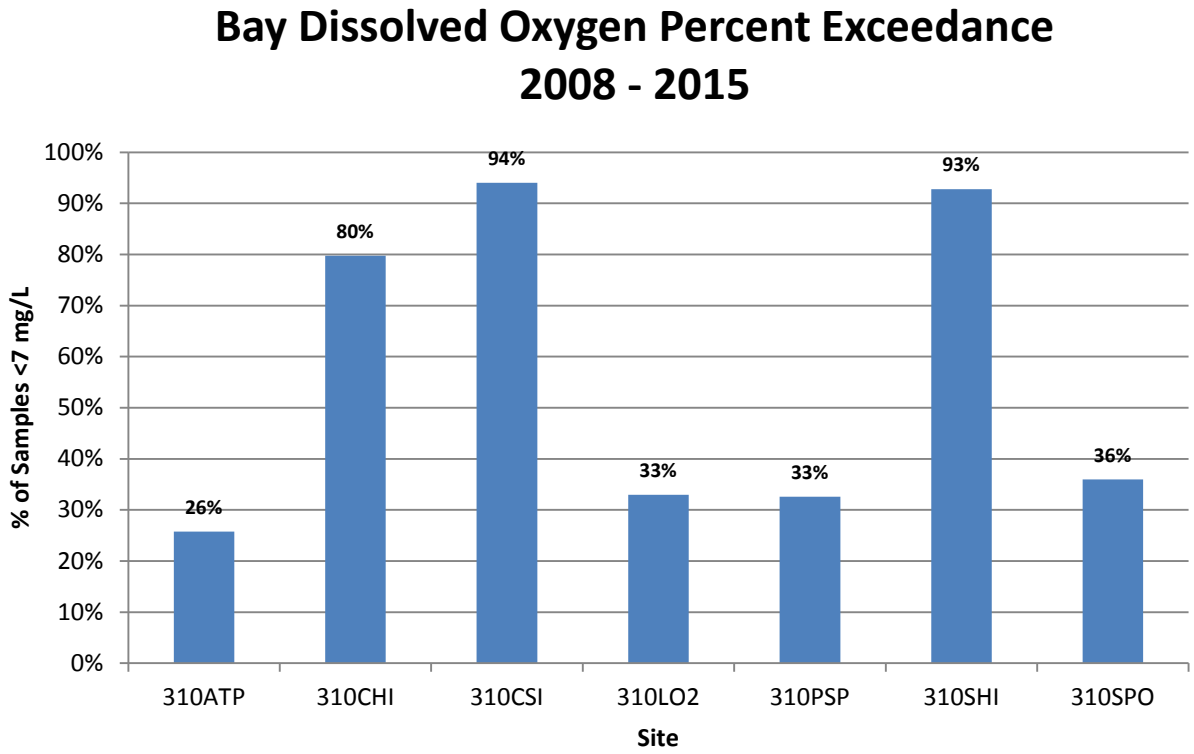


The next figure indicates the median DO levels at each of the sites. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk.

The red line indicates the Basin Plan DO standard of 7.0 mg/L that is protective of marine life. The data show the expected trend of higher DO levels along the main channel where more tidal flushing occurs (sites ATP, SPO, LO2 and PSP) and lower DO levels in the shallow back bay areas (sites CHI, CSI, SHI). Concentrations below 7.0 mg/L were regularly observed in the summer time in the front bay sites and year-round in the back bay sites. The low DO levels in the back bay could be a naturally-occurring phenomenon due to a lack of tidal flushing.



The following bar graph shows the percent of monitoring events where the DO concentration was below 7.0 mg/L for each site.



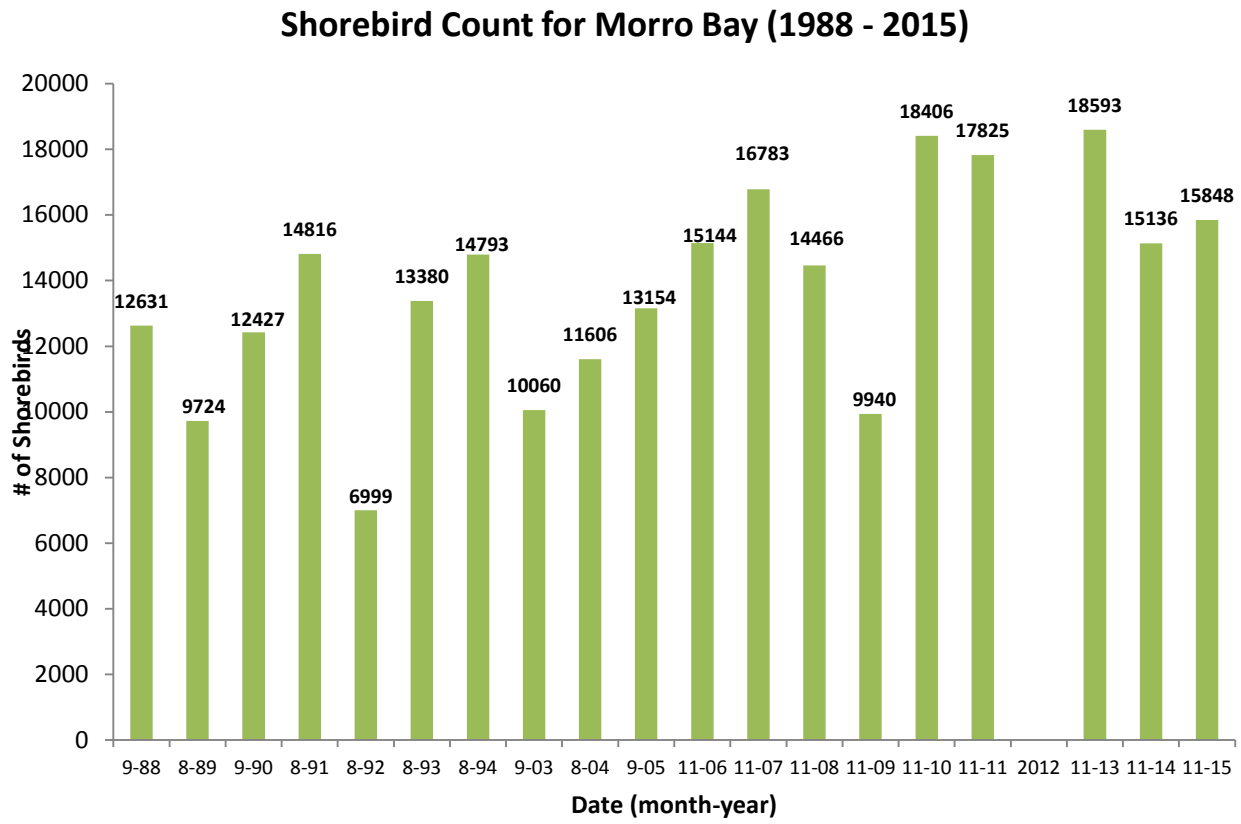
SHOREBIRD MONITORING

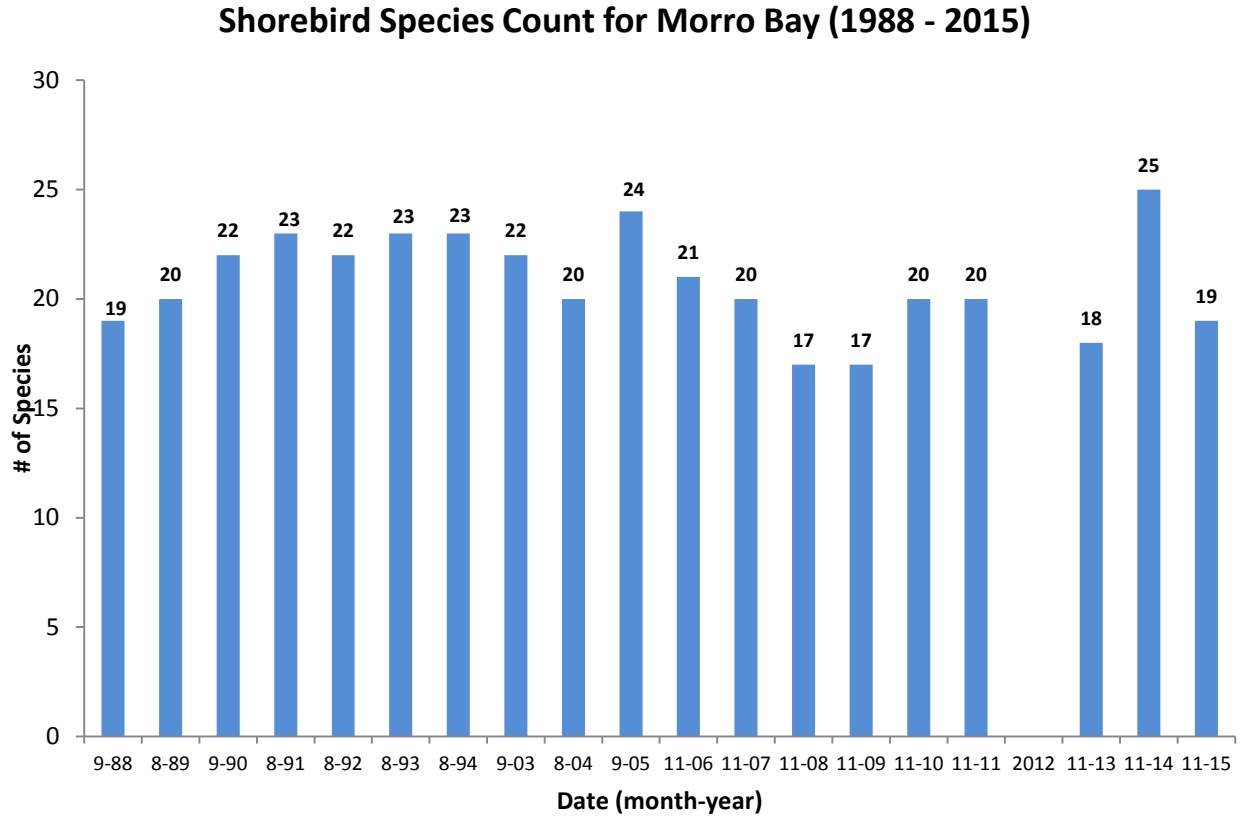
A Morro Bay shorebird survey has been conducted each fall since the late 1990s. The bay, sand spit and Morro strand beach are divided into 15 distinct regions. One to two birders occupy each region and conduct a count during a two-hour period. Depending on the conditions of the region, birders conduct counts from boats or at specified lookouts on land. They conduct species counts of shorebirds in their region while trying not to double count birds leaving one region and traveling to another. The protocol was developed by the Pt. Reyes Bird Observatory (PRBO) to monitor activity along the Pacific Flyway, and surveys were coordinated for Morro Bay by local birder Marlin Harms from the mid-1980s through the mid-1990s. When the MBNEP restarted this monitoring effort in 2003, the PRBO methodologies were adopted so that the recent trends could be compared with the historical data.

The following maps show the areas covered by the survey and the 15 regions.

In the fall of 2006, PRBO restarted its flyway monitoring effort. Volunteers in San Francisco, Humboldt, San Diego, Bolsa Chica, Newport Beach, Elkhorn Slough and a few other pockets in the Santa Barbara and San Diego areas conducted their counts during a one-week period. A longer survey period was allowed due to the varying tidal conditions required by each individual survey area.

The following figure shows the shorebird count and number of species counted for Morro Bay.


Shorebird Count for Morro Bay (1988 - 2015)
# of Shorebirds
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
12631
9724
12427
14816
6999
13380
14793
10060
11606
13154
15144
16783
14466
9940
18406
17825
18593
15136
15848
9-88
8-89
9-90
8-91
8-92
8-93
8-94
9-03
8-04
9-05
11-06
11-07
11-08
11-09
11-10
11-11
2012
11-13
11-14
11-15
Date (month-year)


Shorebird Species Count for Morro Bay (1988 - 2015)
# of Species
30
25
20
15
10
5
0
19
20
22
23
22
23
23
22
20
24
21
20
17
17
20
20
18
25
19
9-88
8-89
9-90
8-91
8-92
8-93
8-94
9-03
8-04
9-05
11-06
11-07
11-08
11-09
11-10
11-11
2012
11-13
11-14
11-15
Date (month-year)

The average number of shorebirds for fall surveys was 13,775 birds, and the average number of species counted was 21.

The reason for the elevated fall counts in 2006 and 2007 was likely a shifting of the survey date. While fall surveys had historically been conducted in August or September, the survey date was shifted back to November when coordination began with PRBO.

No survey took place in 2012 due to poor weather conditions.

PHYTOPLANKTON

MBNEP volunteers collect samples once a month throughout the year. Samples are collected by lowering a 20 µm net into the water to collect a sample at the north T-Pier near the Coast Guard/Harbor Patrol station in Morro Bay. Volunteers then conduct counts under the microscope and identify plankton down to the genus level. The datasheet and a preserved sample are sent to the California Department of Public Health (CDPH) to assist with biotoxin monitoring to ensure the safety of farmed and sport harvested shellfish for human consumption. This effort was started in conjunction with CDPH in 2002.

Since the data is not used as a bioindicator for the watershed, it will not be summarized in this report. As far as toxic organisms present, monitoring since May 2002 has yielded 189 pulls containing species known to produce domoic acid and 24 pulls with species potentially containing paralytic shellfish poison toxins, out of a total of 301 pulls.

4.0 IMPLEMENTATION EFFECTIVENESS ANALYSIS

The MBNEP is focused on conducting implementation effectiveness monitoring, in addition to continuing the ambient monitoring efforts that have been underway in the Morro Bay watershed for many years. This monitoring effort is referred to as the implementation effectiveness program (IEP) and consists of targeted monitoring and analysis designed to evaluate water quality and habitat benefits resulting from specific restoration actions and projects. It also provides analysis for assessment of TMDLs and 303(d) status.

To better determine the significance of these projects, the program consulted with Dr. Andrew Schaffner, a professor in the Department of Statistics at Cal Poly.

In some cases, pre-project data was collected by an agency other than the MBNEP.

The following table contains an overview of the projects analyzed for effectiveness.

Project Type	Parameters Monitored	Monitoring Frequency	Notes
Riparian Fencing on San Luisito Creek	Total coliform, *E. coli*, SWAMP Bioassessment, dissolved oxygen, temperature	Annually for SWAMP Bioassessment; twice monthly for bacteria; continuous monitoring monthly	
Riparian Fencing on Dairy Creek	Total coliform, *E. coli*, dissolved oxygen, temperature, SWAMP Bioassessment	Annually for SWAMP Bioassessment; monthly for all others; continuous monitoring twice annually for DO, temperature	
Walters Creek, Phase I Restoration and Riparian Fencing	Suspended sediment concentration, flow	Wet season monitoring, frequency varies depending on rainfall	
Pennington Creek, Rainwater Catchment Project	Dissolved oxygen, temperature, flow, SWAMP Bioassessment, water depth	Annually for SWAMP Bioassessment; bimonthly for DO, temperature and flow, monthly on two lower sites; continuous for water depth	
Riparian Fencing on San Bernardo Creek	Total coliform, *E. coli*, dissolved oxygen, temperature, SWAMP Bioassessment	Annually for SWAMP Bioassessment; monthly for all others	
Walters Creek, Phase II Restoration	SWAMP Bioassessment, CRAM	Annually for SWAMP Bioassessment; once for CRAM	
TMDL Assessment for Sediment, Pathogens and Nutrients	Total coliform, *E. coli*, fecal coliform, *Enterococcus* spp., dissolved oxygen, temperature, nutrients, SWAMP Bioassessment, algae, suspended sediment concentration	Annually for SWAMP Bioassessment and algae; wet season for suspended sediment; monthly for all others; continuous monitoring monthly for DO, temperature	Long-term data collected from sites throughout the watershed which the Region 3 RWQCB requires for triennial assessment of TMDL progress.

Project Type	Parameters Monitored	Monitoring Frequency	Notes
303(d) Assessment	Total coliform, *E. coli*, fecal coliform, *Enterococcus* spp., dissolved oxygen, temperature, nutrients, SWAMP Bioassessment, algae, suspended sediment concentration	Annually for SWAMP Bioassessment and algae; wet season for suspended sediment; monthly for all others; continuous monitoring monthly for DO, temperature	Long-term data collected from sites throughout the watershed which the Region 3 RWQCB requires for biennial assessment of 303(d) status.
Stormwater Management Efforts for the City of Morro Bay, the Community of Los Osos, and San Luis Obispo County	Total coliform (creek site only), *E. coli, Enterococcus* spp. (bay sites only)	Monthly	Our monitoring supplements the monitoring conducted by these agencies to demonstrate implementation of their stormwater management plans.
Chorro Flow Study	Flow, water depth	Continuous for depth; monthly for all others	This project, a partnership with Trout Unlimited, involves assessing the water balance for the valley and working with landowners to implement conservation projects. Monitoring data supplies the information to develop the water balance.
Los Osos Wastewater Project	Nitrate concentrations in bay shoreline freshwater seeps	Monthly	The Los Osos Wastewater Project is expected to come on line in the spring of 2016. Our monitoring before and after project implementation will track changes in nitrate concentrations in freshwater seeps along the bay shoreline.

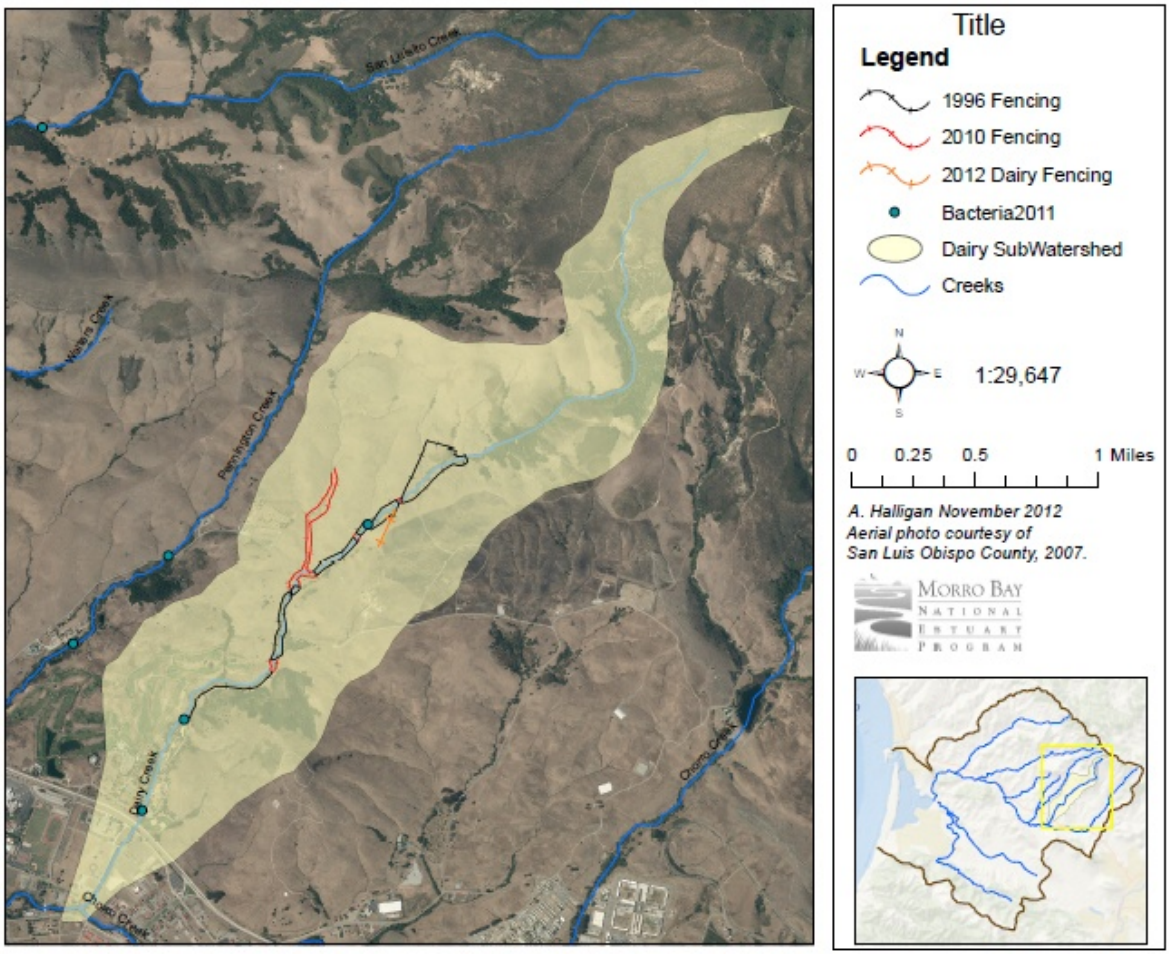
DAIRY CREEK BEST MANAGEMENT PRACTICES IMPLEMENTATION

Project background: As part of the National Monitoring Program (NMP), barbed wire fencing was installed on both banks of Dairy Creek to control cattle access to the creek. Unfenced gaps were incorporated to provide cattle limited access to a water source. The riparian corridor was re-vegetated in fenced areas. Work was completed on the lower mile of the creek in the summer of 1994 and on the upper half mile of creek fenced during the summer of 1995. In August 2010, an additional 2,028 feet of fencing were installed to close gaps in the riparian fencing, and an off-creek water system was installed. Another 5,097 feet of fencing were installed on a seasonal tributary in the upper portion of the project area. In June 2012, additional fencing was added to the upper portion of the project area to replace a fence which was in disrepair. Cattle are now completely excluded from the creek throughout the entire project area with the exception of periodic limited access for weed abatement.

Expected project benefits: The primary goal of the project was to reduce bacterial loading concentrations through exclusion of cattle from the creek. The secondary goals were increased riparian vegetation, improved bank stability and improved in-stream habitat value resulting from increased dissolved oxygen levels and decreased water temperatures.

Existing data: Pre-project NMP data spanned from June 1993 to June 1996. Post-project NMP monitoring took place between July 1996 and June 2001. Three sites were monitored weekly in the wet season and twice monthly during the dry season from December 1993 until fall 2000 at Dairy lower, and until spring 2001 for the middle and upper sites. Sites were analyzed for total and fecal coliform. Sites were also monitored for water quality parameters including dissolved oxygen, temperature, pH, turbidity, conductivity, flow, nitrates as N and orthophosphates as P during the same time period. The upper Dairy Creek site (DAU) was directly upstream of the BMP implementation area and the middle site (DAM) was directly below the implementation area. The lower Dairy Creek site (DAL) was the most downstream monitoring site and was below both the project area and the El Chorro Regional Park open space.

Starting in 2002, DAL was monitored by the MBNEP on a monthly basis for total coliform and *E. coli*. Monitoring began at DAM in 2003 and at DAU in 2005. Beginning during the same timeframe, similar water quality constituents were analyzed on a monthly basis. However, different instruments or methodologies were used for the two data collection efforts. The following map shows the monitoring sites, as well as the locations of the fencing installed in the mid-1990s, in 2010, and in 2012.



Bioassessment was conducted prior to fencing installation in the mid-1990s at DAU, DAM and DAL. Following implementation, bioassessment was conducted by the NMP at all three sites. Historically, the MBNEP bioassessment monitoring was conducted only at DAL. Beginning in 2008, the program also began monitoring at DAM and DAU for comparison with NMP data.

IEP activities: Bacteria monitoring was continued for total coliform and *E. coli* at the three sites on a monthly basis. Because all NMP data was analyzed for fecal coliform using the multiple tube fermentation method, a study was conducted in 2008 to determine whether a useful predictive relationship existed between *E. coli* and fecal coliform data.

Samples were split, with a portion analyzed for *E.coli* using the IDEXX method and a portion analyzed for fecal coliform using the multiple tube fermentation method. These sets of values were compared to determine if a predictive relationship could be determined. The conclusion was that a useful predictive relationship did not exist between these two data sets. Thus, NMP fecal coliform data and MBNEP *E. coli* data could not be combined into a single data set for analysis. Instead, the project statistician conducted an analysis using temporal sorting, which analyzed data from sites upstream and downstream of the project that were collected during the same time period to help understand the effectiveness of the project.

Bioassessment was conducted annually, which includes assessment of substrate diversity, in-stream habitat, canopy cover, and erosion. In 2011, an algae assessment protocol was added to the habitat assessment to track algal coverage.

Monthly water quality monitoring was conducted at the three sites for dissolved oxygen, temperature, pH, turbidity, conductivity, flow, nitrates as N and orthophosphates as P.

IEP data analysis: Historical data underwent a statistical analysis using temporal grouping. This means that even if pre and post-project data were not available for a particular analyte or site, that the effectiveness of the project could still be assessed because the upstream and downstream data were collected in the same time period.

Throughout the analysis, the 'pre-project' period refers to the time before any fencing was installed on the creek (1995 and earlier). 'Phase I' refers to the time period between mid-1996 (when the initial fencing was installed in the mid-1990s as part of the NMP) through July 2010. 'Phase II' refers to after August 2010, when the remaining gaps in the fence were closed, a seasonal tributary was fenced, an off-creek water system was installed, and repairs were made to existing fences.

Bacteria

The NMP effort analyzed for fecal coliform concentration, while the MBNEP effort analyzed for *E. coli* concentration. A study was conducted which determined that there was no clear predictive model for converting this data from one analyte to the other, therefore a direct comparison could not be made between these two analytes. Thus, two individual statistical assessments were conducted for the two indicator species.

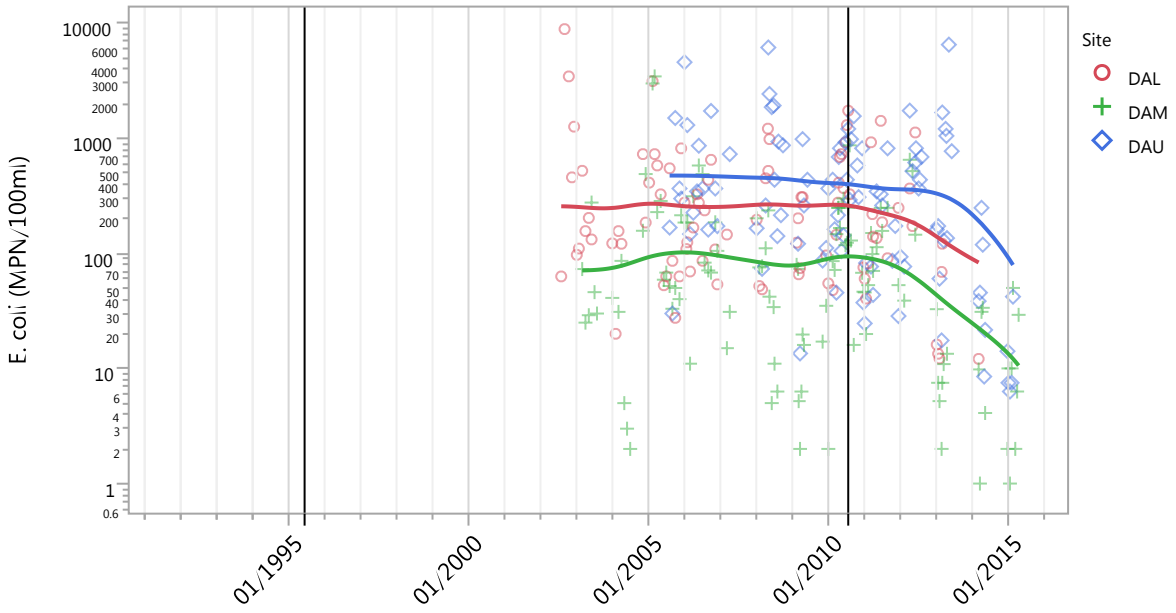
The *E. coli* data were analyzed with a model that can be described with the following linear expression: Log(*E. coli*) = lag(log(*E. coli*),1) + date + month + site + phase + site:phase + date:phase

This model adjusts for seasonal (monthly) variation and allows explicit modelling of unique temporal trends for sites and study phases. It contains an expression to address 'lag', which is the concept that if two samples were collected too close together in time, technically they are not independent observations.

The following figure shows the LOESS smoothed temporal trends of *E. coli* at the three sites. All data was collected by the MBNEP from 2002 to 2015. In both Phase I and Phase II, there was a statistically significant decrease in the counts (p-value = 0.0007). The counts at the three sites differed significantly (p-value < 0.0001). The mean counts at DAM were significantly lower than those at DAU and DAL (p-value < 0.0001 and 0.0007, respectively). During Phase II, the temporal trends across the sites shifted downwards (p-value = 0.0006) compared to Phase I. The magnitude of this shift did not differ significantly across the sites (p-value = 0.7697).

The red line represents 410 MPN/100 mL, the STV value for the indicator. No more than 10% of results should exceed this value. The vertical line on the graph in the mid-1990s represents the time of Phase I fencing implemented during the NMP. The vertical line in 2010 represents Phase II fencing project.

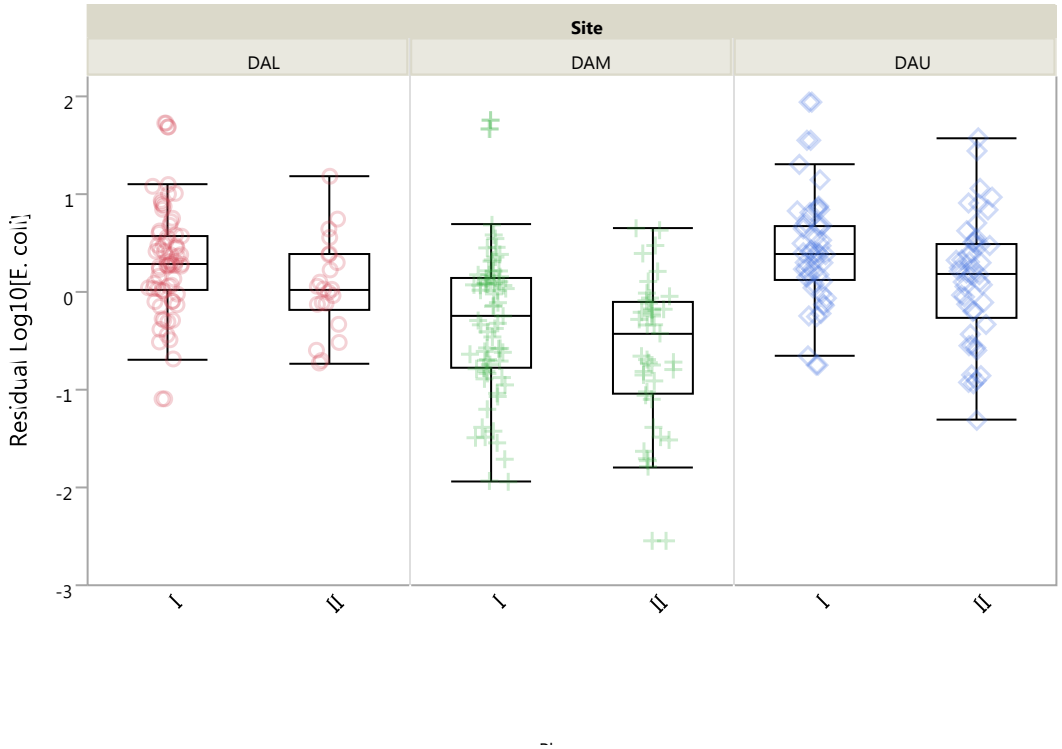
On average, regardless of phase, bacteria concentrations are improving on Dairy Creek.



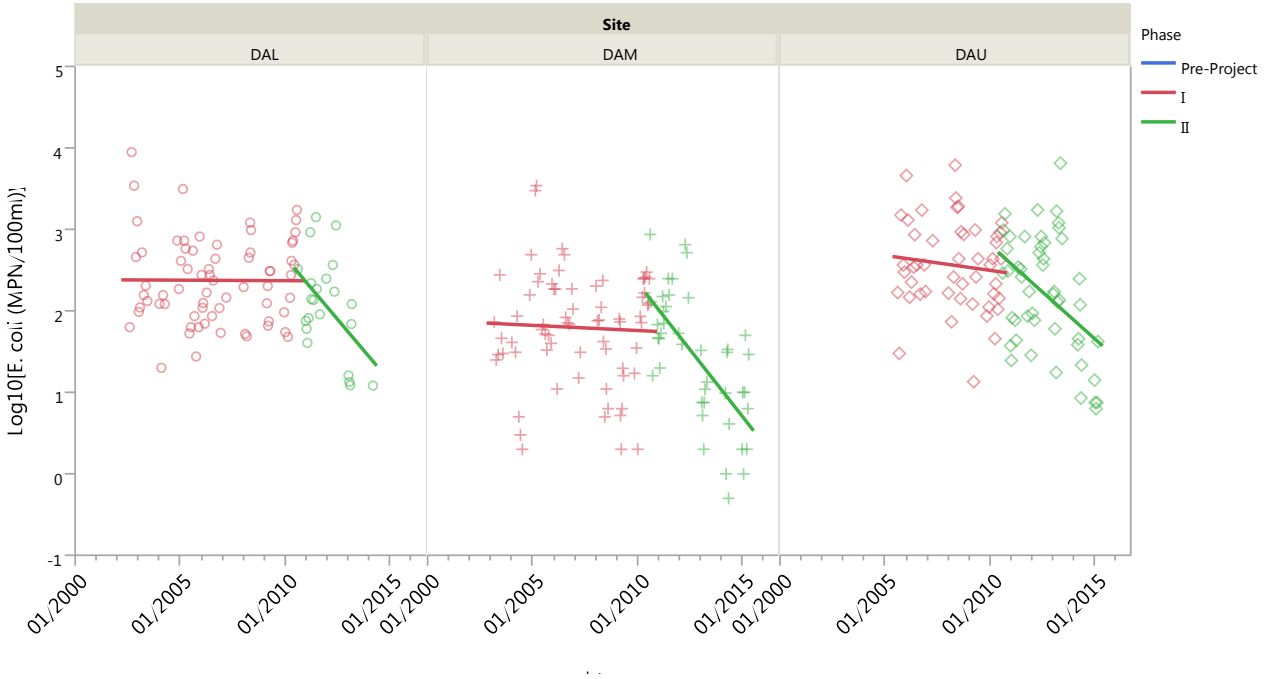
The following figure shows the residuals from the seasonally detrended data on a log scale as box plots. All data shown was collected post-project, since a different bacterial indicator was used for the pre-project data collection. The boxes labeled 'I' represent data from Phase I, following the first phase of fencing installation in the mid-1990s. The boxes labeled 'II' represent data from Phase II, following the fencing installation in 2010. The bottom and top of the box represents 25th and 75th percentiles (the lower and upper quartiles). The dark horizontal line in each box shows the median value of the data set. A drop in *E. coli* from Phase I to Phase II is apparent at all three sites.

The highest median *E. coli* values in both Phase I and II were at DAU, which is the site above the project, while the lowest values were at DAM, which is the site immediately below the project. The model used for the analysis took into effect seasonal trends and removed their effect in order to focus on the effect of the project. Currently there is no significant evidence that the mean log counts differ between Phase I and Phase II, although preliminary results indicate a decrease in *E. coli* concentrations following project installation.

In general, bacteria concentrations decreased as water moved through the project area (between DAU and DAM). Below the project area (between DAM and DAL), the bacteria concentration increased, although not to levels as high as the concentrations at DAU.



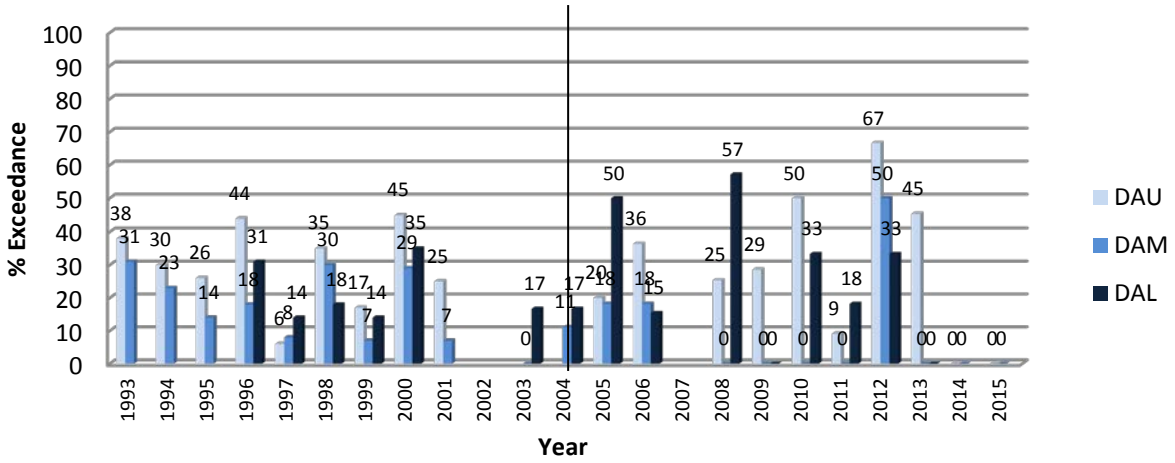
The analysis indicated that the rate of *E. coli* drop was much greater after implementation of Phase II. In the following plots, the red line indicates the trend after Phase I implementation and the green line indicates the trend after Phase II implementation. The slopes of the red lines at all three sites were relatively flat, but following Phase II implementation, the changes in the slope from Phase I to Phase II were statistically significant.



The following graph is a simple analysis of the percent exceedances of bacteria data relative to the relevant regulatory criteria. For the NMP-collected fecal coliform data, the data were compared to

the 400 MPN/100 mL regulatory limit for safe recreational contact. The percent exceedance of this standard by year for each site was plotted. For the MBNEP-collected *E. coli* data, the data were compared to the 410 MPN/100 mL STV regulatory limit for safe recreational contact. A cursory review of this analysis indicates that the exceedances were worse following implementation. This could be an artifact of the indicator species, rather than a real measure of change following implementation.

Fecal Coliform (1993 to 2001) % Exceedances of 400 MPN/100 mL and *E. coli* (2002 to 2014) % Exceedances of 410 MPN/100 mL

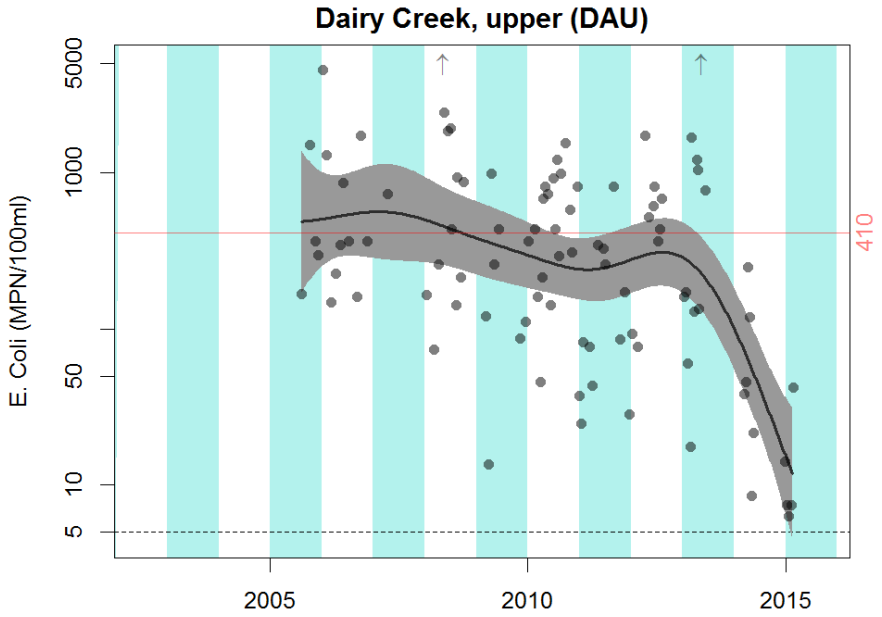


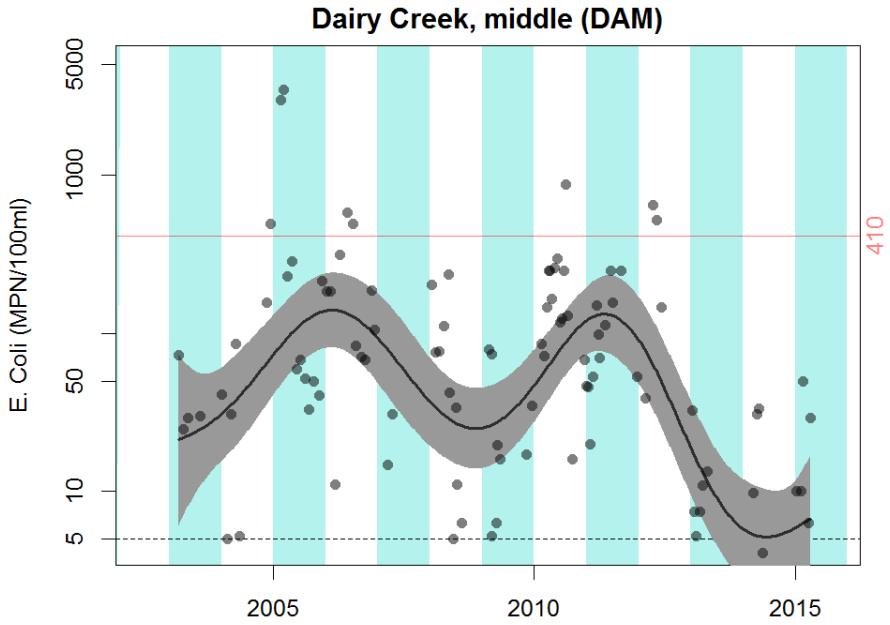
Note: Inadequate data was available in 2007 for inclusion in this analysis.

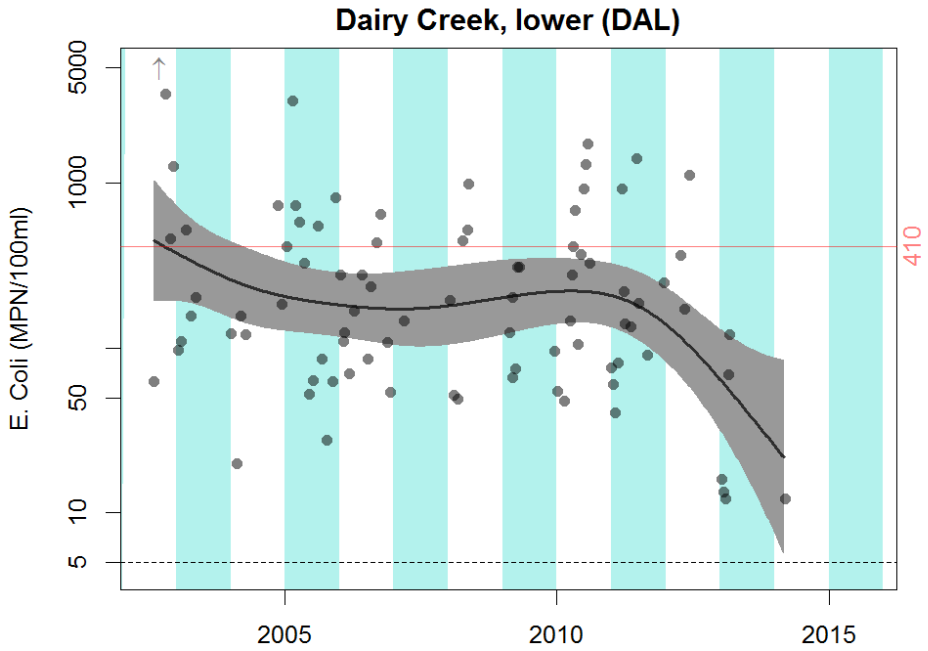
From pre-project to Phase I, the conclusion of the IEP analysis was that there was weak evidence for a difference between pre and post-project results at the site above and the site below the BMP implementation when fecal coliform was the indicator. In the analysis for the NMP conducted by Cal Poly and the CCRWQCB, the final report concluded that the statistical analysis showed fecal coliform levels at DAM remained the same before and after BMP implementation while fecal coliform levels at DAU improved.

However, when *E. coli* was the indicator species during a later time period, the analysis detected a significant decrease in bacteria concentrations between DAU and DAM when comparing pre-project and Phase I data. However between DAM and DAL, an increase in *E. coli* was detected for data collected during the same time period. The time period for the *E. coli* data was completely different than the time period for fecal coliform analysis, and the effects of varying water years, cattle activity and other factors were not included in this analysis.

The following plots show the long-term trends of *E. coli* data at the three sites. The smooth curve is a spline smooth with degrees of freedom (df $\approx$ 7.8) chosen by cross-validation. The grayed area is the error band for the data. The up arrows represent values that were greater than 5,000 MPN/100 mL. The smooth line summarizes the mean bacteria level while the gray band is an error band that reflects the certainty of this trend (average) estimate. They may be considered as a 95% confidence interval for the mean bacteria level at any point in time. At all three sites, the data shows a decreasing trend that falls within the 95% confidence interval represented by the error band.


Dairy Creek, upper (DAU)
E. Coli (MPN/100ml)
5000
1000
50
10
5
410
2005
2010
2015


Dairy Creek, middle (DAM)
E. Coli (MPN/100ml)
5000
1000
50
10
5
410
2005
2010
2015



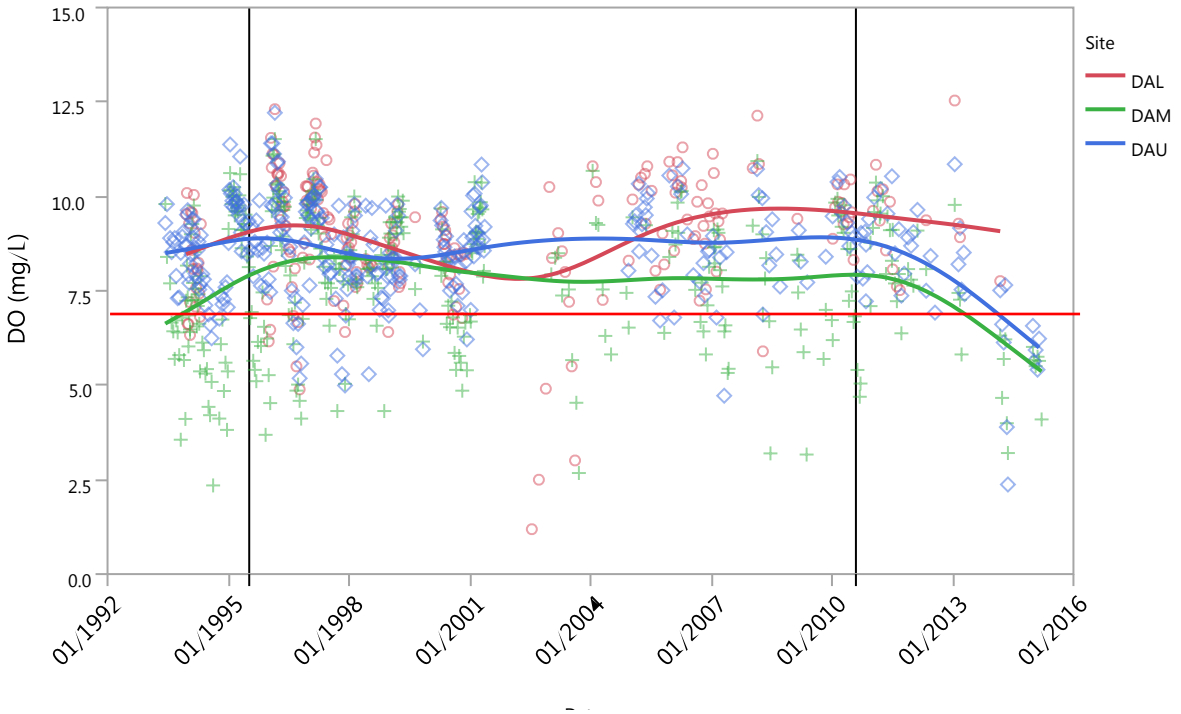
In general, the analysis showed lower bacteria levels at DAM relative to DAU post-project, indicating the efficacy of fencing. However the increase *in E. coli* at DAL relative to DAM indicated that the beneficial effect of the fencing on bacteria was localized.

Dissolved Oxygen

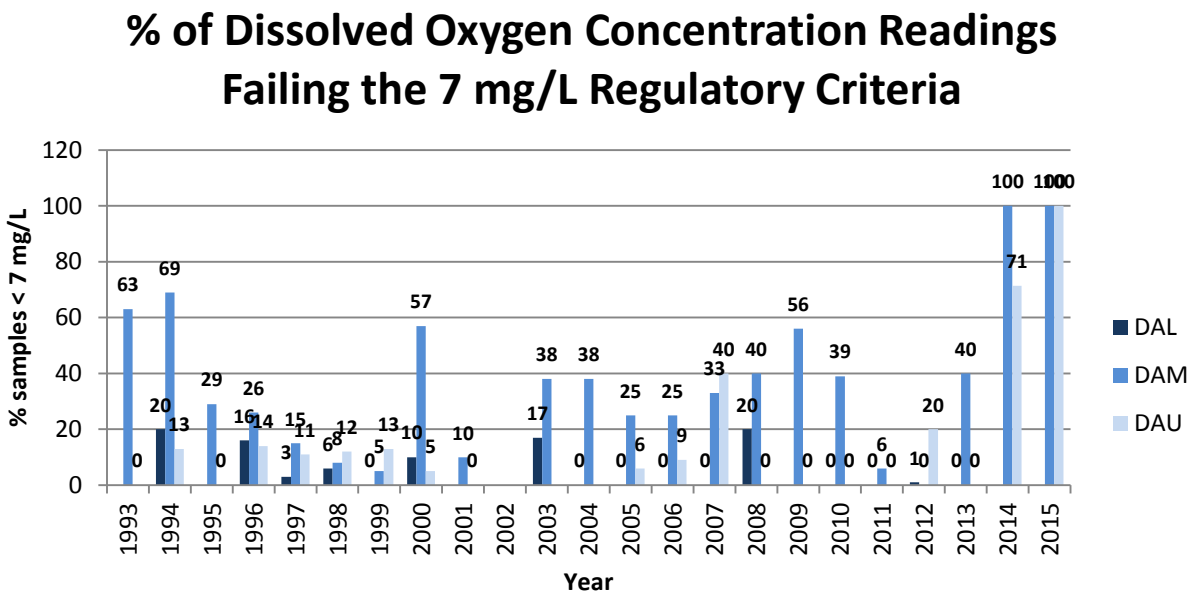
Dissolved oxygen (DO) monitoring was challenging at Dairy Creek due to the intermittent nature of the surface flows. Most years, the creek was completely dry by late summer and did not flow again until well into winter. A temporal analysis was conducted where data collected during the same monitoring event were grouped for analysis. The NMP and the MBNEP data sets were combined, despite the difference in equipment used to collect the data. The NMP staff used a Hydrolab, and the MBNEP used a YSI Model 85 unit.

The following figure shows the range and general trend in the DO data collected over time. The plot shows the data in mg/L. The red line at 7.0 mg/L indicates the Basin Plan standard protective of aquatic life. To avoid impairment of the water body, DO levels must remain above 7.0 mg/L.

While there is no overall general trend in DO over time (p-value = 0.2058), there trends are not the same within all phases (p-value < 0.0001). In particular, the DO levels were generally increasing in the pre-project phase, stable in Phase I, and decreasing in Phase II. There are significant differences in DO levels across the sites (p-value < 0.0001) with DO levels at DAM being generally lower than DAL and DAU across the study period (p-value = 0.0065 and < 0.0001, respectively). The mean DO differs across the phase (p-value < 0.0001) with levels that are generally higher than expected in Phase II given the temporal trend in the same period. This may be due to some confounding since DAL is not observed through the entire phase, and there are generally more observations at the start of the phase where DO levels were generally higher.



The following graph is a plot which illustrates the percent of measurements recorded each year that were below 7.0 mg/L, which is the Central Coast Region Basin Plan water quality objective protective of cold water habitat. The previous graph indicates that DO at DAM was typically below levels at DAL and DAU. Likewise, the following graph shows DAM as the site with the most frequent violations of the water quality objective.



In the 2014 data summary report, the analysis also looked at the effect of rainfall on DO concentrations. Rain gauge data from the California Irrigation Management Information System (CIMIS) network was gathered going back to 1993. The data came from station 52 (Elevation: 330,

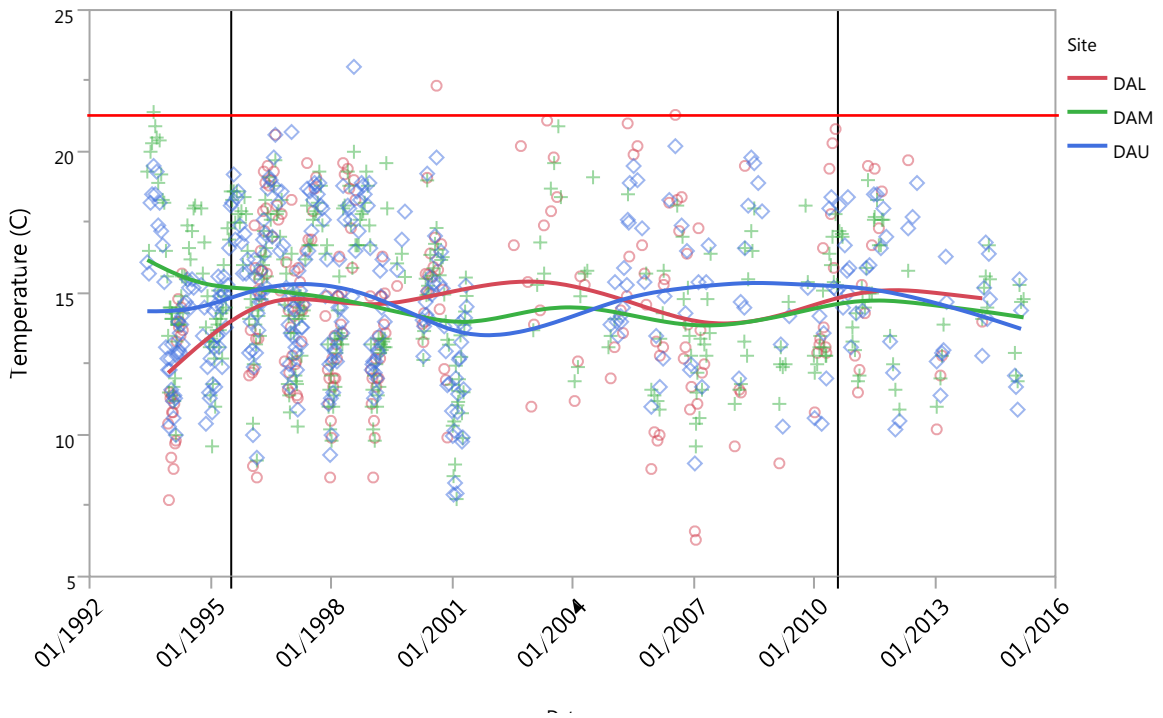
Latitude: 35º18'20N / 35.305442, Longitude: -120º39'42W / -120.661780) which is located near the Cal Poly Botanical Garden. DO was found to be positively associated with rainfall (p-value < 0.00001), meaning DO levels were higher with higher rainfall totals. The association was not the same across all the sites (p-value = 0.0287), with the primary differences at DAM where the positive association was stronger than the average (p-value = 0.0017) and at DAU with weaker than the average (p-value = 0.0121). This analysis was not repeated with additional data, but assuming the conclusion still holds, the effect of the drought and low rainfalls most strongly impacts the DAM site.

Overall, the analysis indicated a general downward trend in DO, regardless of the implementation phase. Although additional data would have strengthened the analysis following Phase II implementation, lower than normal rainfalls resulted in shorter than usual monitoring seasons since 2012.

Temperature

Following BMP implementation, the expected result was a decrease in water temperatures through the project area since riparian fencing should lead to increased density of canopy cover and improved shading of the creek. All data was reported in degrees Celsius. NMP data was collected with a Hydrolab, and MBNEP data was collected with a YSI Model 85.

The figure shows the range and general trend in the temperature data from the three monitoring sites. Temperatures should remain below 21 °C to be protective of cold water habitats, represented by the red line.



Over the observed period, there is a slight (not statistically significant) decreasing trend in temperature (p-value = 0.0640). There are no statistically significant overall mean temperature differences across the sites. However, the differences between phases are not the same across sites (p-value = 0.0104). At DAL there is a statistically significant increase in temperature from pre-project

to Phase I (p-value = 0.0175), but not from Phase I to II (p-value = 0.8433). At DAM there are no statistically significant changes across the phases. At DAU there is a significant increase in temperature in Phase I compared to pre-project (p-value = 0.0252), but not between Phases I and II. During the pre-project period DAM had higher temperatures than DAL (p-value = 0.0036) and DAU (p-value = 0.0085). There were no significant differences between pairs of sites during Phase I or II. As with the bacteria analysis, the model include a lag term to account for the fact that measurements collected too close together could not be considered to be independent observations.

The conclusion of this analysis was that while temperatures at DAM remained the same, temperatures at DAU underwent a significant increase in temperature from pre-project to Phase I but not between Phase I and II. Prior to the project, DAM had higher temperatures than DAU. Thus, the fencing could have resulted in temperature improvements since water coming into the site (at DAU) has become warmer while temperatures at the bottom of the site (at DAM) have remained the same.

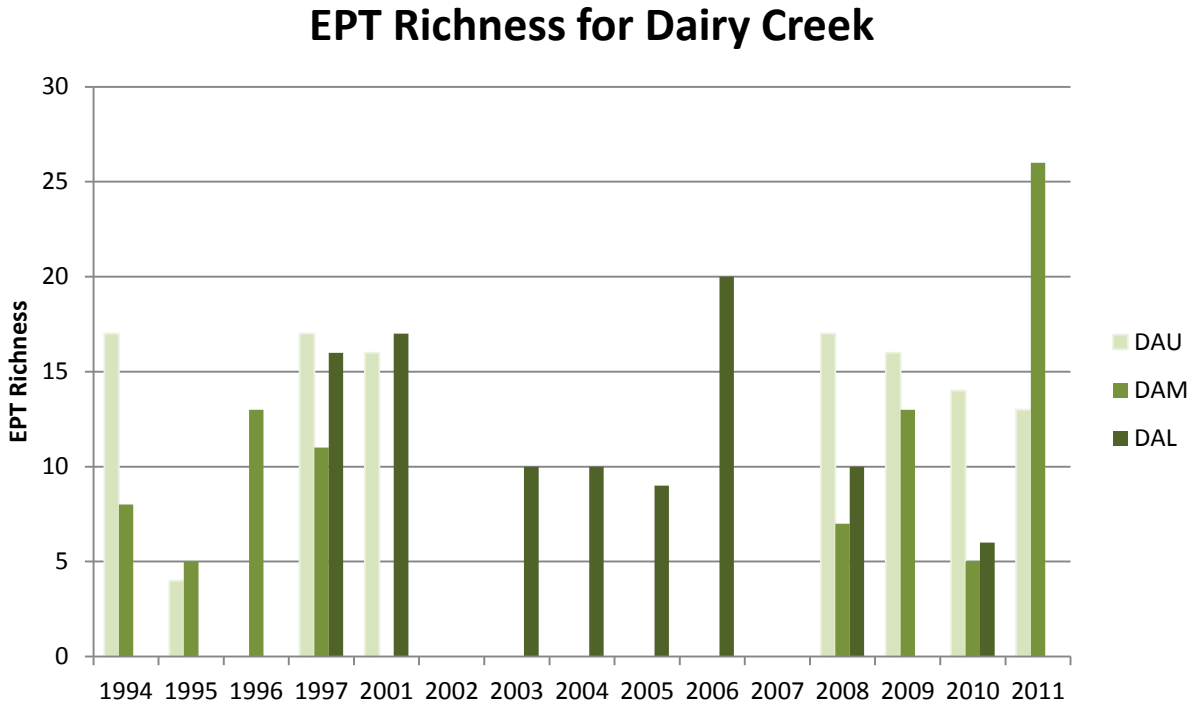
Macroinvertebrates

Data collected since 2007 utilized the SWAMP bioassessment procedures titled *Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California*, which was updated in spring 2007. The MBNEP monitored a 150 m reach at each creek site using the reach-wide benthos procedure. Measurements and observations on substrate, water depth, canopy cover, bank stability and other physical parameters were taken at each of 11 equidistant transects and 10 inter-transects. Macroinvertebrate samples were collected from each transect, following the reach-wide benthos protocol option. Macroinvertebrates were composited into a single sample, which was sent to a lab for sorting and counting until 600 randomly selected organisms were identified. The lab provided a count of the individual taxa as well as some calculated metrics.

Data collected prior to 2007 was generated using prior approved methods. The data from previous surveys was standardized by a Monte Carlo analysis and was included for comparison.

The following graph displays the changes in EPT richness over time at each Dairy Creek site. EPT richness is a count of the total number of taxa within the sensitive orders of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Taxa richness typically decreases with poor water quality. As a comparison, Coon Creek, the control site, averaged an EPT richness score of 20 over six years of monitoring.

Due to low flow conditions, bioassessment analysis could not be conducted on Dairy Creek in 2012, 2013, 2014 and 2015.

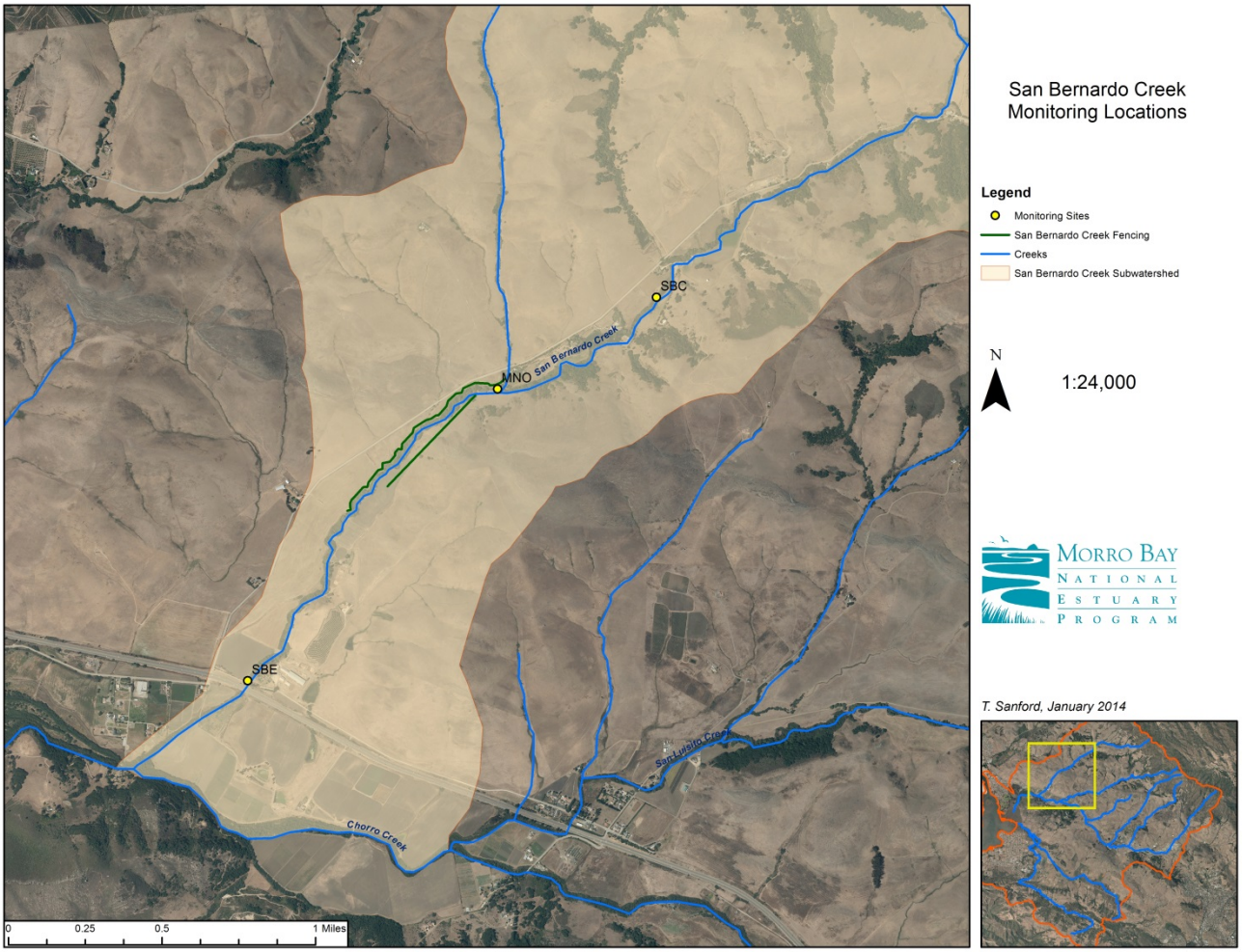


Conclusions: In general, the analysis showed lower bacteria levels at DAM relative to DAU, indicating the efficacy of fencing. However the increase *in E. coli* at DAL relative to DAM indicated that the effect of the fencing is localized. The analysis indicated a general downward trend in DO, although additional information would strengthen the analysis following Phase II implementation. There was a significant increase in temperatures at DAU, while DAM held steady, potentially demonstrating the efficacy of the project at reducing water temperatures.

Due to the intermittent nature of Dairy Creek, bioassessment data was not collected consistently enough for statistical analysis.

SAN BERNARDO RIPARIAN FENCING

Project background: The MBNEP has worked with landowners throughout the Morro Bay Watershed to install riparian fencing that limits direct cattle access to creeks. Approximately 5,000 feet of fencing was installed on both sides of San Bernardo Creek. Fencing installation was completed for the landowner on the eastern bank of the creek in late summer of 2006. Fencing installation for the landowner on the western bank of the creek was completed in early 2007. Cattle were fenced out from areas where they previously had free access to the creek.



Expected project benefits: The primary goal of the project was to reduce bacteria levels through exclusion of cattle from the creek. Secondary goals were increased riparian vegetation and shading of the creek, improved bank stability, reduced erosion, and improved habitat value for fish and wildlife.

Existing data: A site downstream of the fenced area was monitored monthly by the MBNEP beginning in May 2002 for total coliform and *E. coli.* Monthly analysis was also conducted for basic water quality parameters including dissolved oxygen, temperature, pH, turbidity, conductivity, flow, nitrates as N and orthophosphates as P. Even-interval data was also collected at the same downstream site during the NMP study. Between June 1993 and May 2001, approximately 150 samples were collected for fecal and total coliform on a weekly basis during the wet season and twice monthly during the dry season.

IEP activities: Annual bioassessment monitoring (including substrate diversity, in-stream habitat, canopy cover, and erosion) were conducted starting in spring 2008 at a site within the fenced project area.

Monthly water quality monitoring was conducted at the historical site (SBE), which is downstream of the project location. Dissolved oxygen, temperature, pH, turbidity, conductivity, flow, nitrates as N and orthophosphates as P were monitored monthly for comparison to pre-project data.

IEP data analysis: To date, extensive post-project data could not be collected due to the highly intermittent nature of the creek. The site typically flowed only during the wet season (approximately six months of the year from January through June) and was dry for the remainder of the year. In especially dry years such the 2014 and 2015 rain year, no surface flows were observed at the site during the year. Although flows occurred, their intermittent nature was such that they could not be monitored.

Bacteria

The following table summarizes the bacteria indicator measured, the number of samples collected during the water year, the number of samples that exceeded the appropriate regulatory criteria, and the entity that conducted the monitoring.

The fecal coliform data collected by the NMP was compared to the REC-1 standard from the Basin Plan that states that no more than 10% of total samples during a period of 30-days can exceed 400 MPN/100 mL. Given the volume of data, a comparison was made to this standard on a yearly basis rather than a monthly basis. For *E. coli* data collected by the MBNEP since 2003, the regulatory criteria for comparison was the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) of 410 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

Water Year	Indicator	Standard for Single Sample (MPN/ 100 mL)	# Samples Exceeding Criteria for Single Sample	Total # of Samples	% Samples Exceeding Single Sample Standard	Geomean (MPN/100 mL)	Data Source
1995	Fecal coliform	400	9	23	39%	409.0	NMP
1996	Fecal coliform	400	21	33	63%	528.5	NMP
1997	Fecal coliform	400	12	27	44%	359.7	NMP
1998	Fecal coliform	400	9	25	36%	371.4	NMP
1999	Fecal coliform	400	8	22	36%	199.6	NMP
2000	Fecal coliform	400	12	24	50%	512.6	NMP
2001	Fecal coliform	400	1	2	50%	294.8	NMP
2003	*E. coli*	410	2	5	40%	325.2	MBNEP
2004	*E. coli*	410	0	5	0%	56.6	MBNEP
2005	*E. coli*	410	1	9	11%	133.8	MBNEP
2006	*E. coli*	410	6	12	50%	399.6	MBNEP

Water Year	Indicator	Standard for Single Sample (MPN/ 100 mL)	# Samples Exceeding Criteria for Single Sample	Total # of Samples	% Samples Exceeding Single Sample Standard	Geomean (MPN/100 mL)	Data Source
2007	*E. coli*	410	3	8	38%	208.1	MBNEP
2008	*E. coli*	410	6	6	100%	1581.0	MBNEP
2009	*E. coli*	410	0	2	0%	47.1	MBNEP
2010	*E. coli*	410	1	4	25%	224.0	MBNEP
2011	*E. coli*	410	3	11	27%	272.8	MBNEP
2012	*E. coli*	410	3	10	30%	240.3	MBNEP
2013	*E. coli*	410	3	3	100%	636.7	MBNEP
2014	*E. coli*	410	-	-	-	-	MBNEP
2015	*E. coli*	410	-	-	-	-	MBNEP

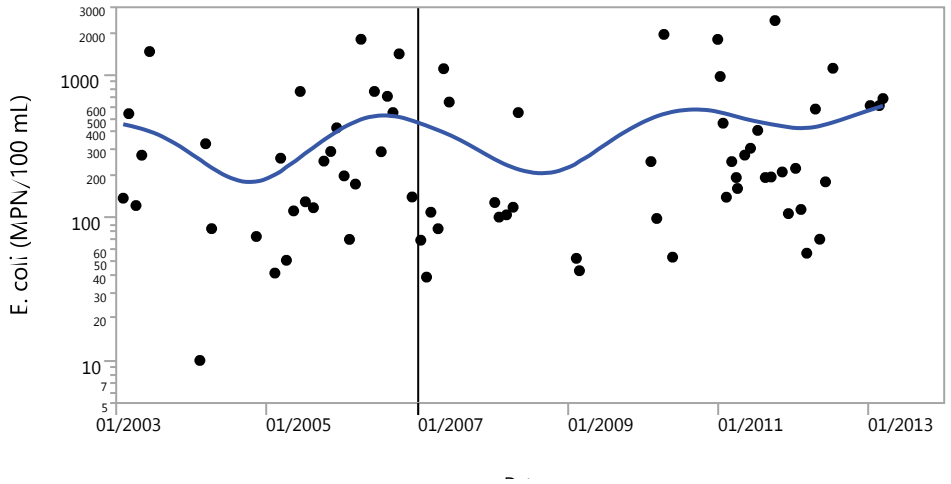
**Flows were inadequate for monitoring during the 2014 and 2015 water years.*

Modeling was conducted on the *E. coli* data. The graph below shows LOESS smoothed temporal trends of *E. coli* over the observation period (2/4/2003 through 3/10/2013). There is no evidence of any project impact either as mean difference pre/post project or in general trend (p-value = 0.5969). There is also no evidence of any general temporal trend (p-value = 0.2898)

The above results are based on a general linear expressed generally as

Log(*E. coli*) = date + month + phase + date:phase

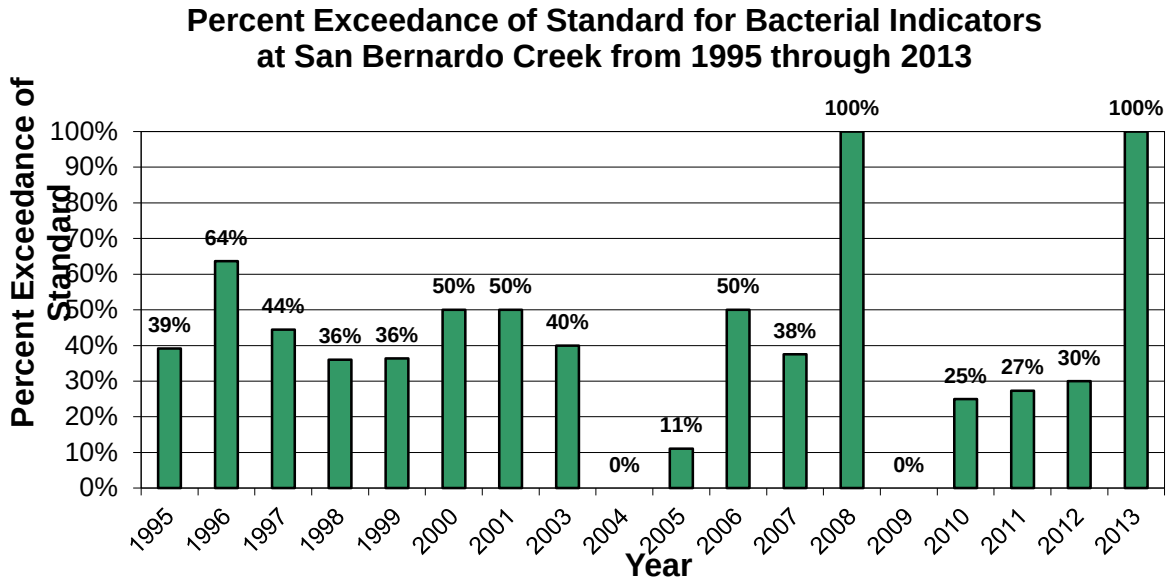
This model adjusts for seasonal (monthly) variation and allows explicit modelling of unique temporal trends for study phases. A lag term was considered, but not included in the above model as there was no evidence of serial correlation (Durbin-Watson p-value = 0.6361).



The following plot facilitates comparison across phases. The values plotted are the residuals from the seasonally detrended data. After adjusting for seasonal (monthly) patterns, empirically the post-project counts are a bit higher, though this difference is not significant and does not account for the slight overall (non-significant) upward temporal trend. The Least Square Means plot shows that the

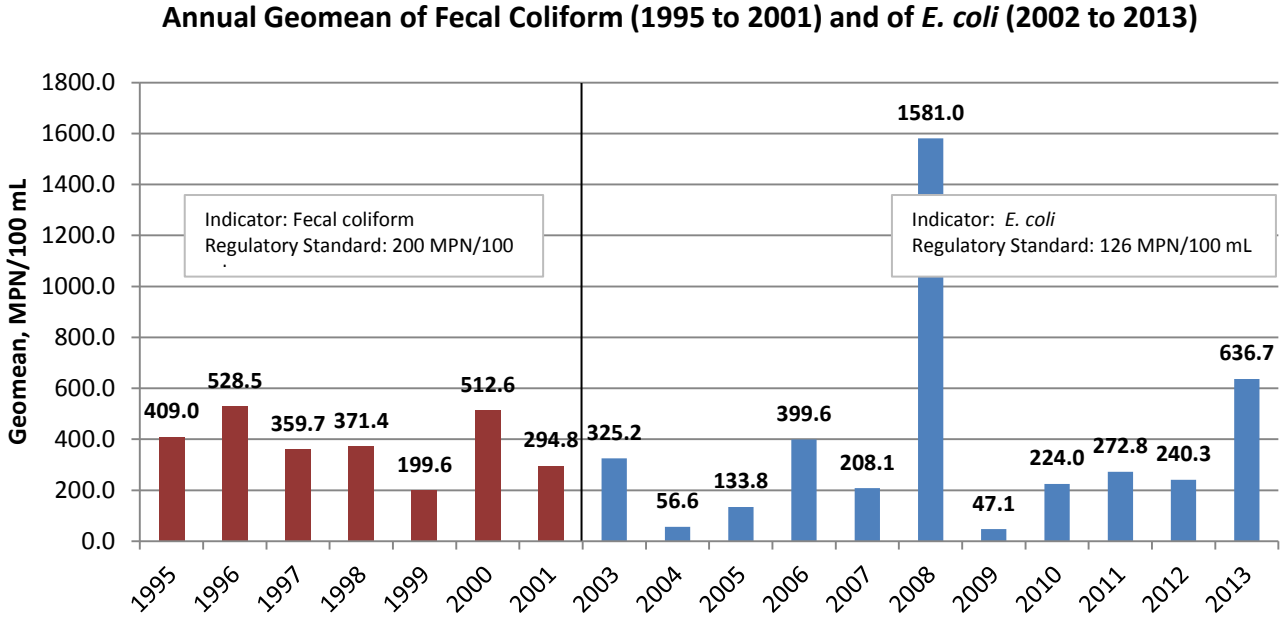
mean post-project counts are between 81% lower to as much as 183% greater than the pre-project mean counts with 95% confidence. This interval is wide because of the paucity and variability in the data.

The following figure summarizes the pre and post-project data from the monitoring site downstream from the project, by water year.



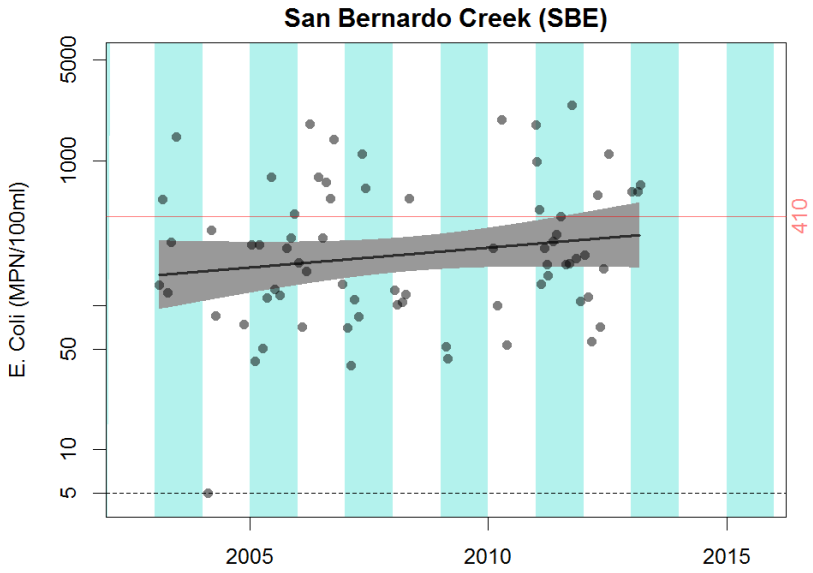
Note: In 2009, only two samples were collected due to lack of flow. Data for 2013 includes data through March 2013. Data could not be collected in 2014 and 2015 due to lack of surface flows.

The following graph plots the geomean of the data by year.



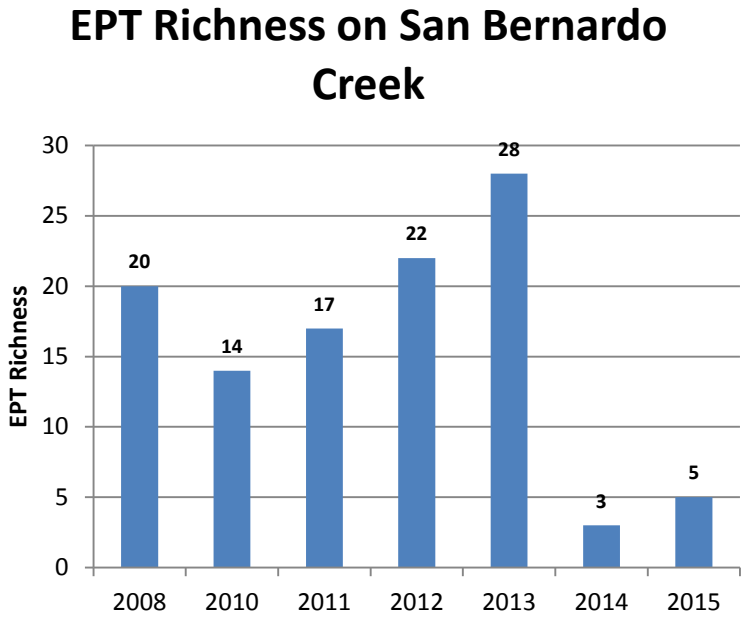
Ideally, fecal coliform and *E. coli* data could be directly compared. A study to determine a predictive relationship between the two parameters was not successful. Thus, a more sophisticated analysis was not possible for the bacteria data because the two different indicator species cannot be combined.

The following plot shows the long-term trends of *E. coli* data at SBE. The smooth curve is a spline smooth with degrees of freedom (df ≈ 7.8) chosen by cross-validation. The grayed area is the error band for the data and represents the 95% confidence interval. The data shows a trend that is relatively flat and stable just below 410 MPN/100 mL.



Macroinvertebrates

Prior to 2008, the MBNEP had access only to the downstream site (SBE) which has limited above ground flows, thus precluding macroinvertebrate monitoring on that creek. In 2008, landowners on both sides of the creek allowed macroinvertebrate monitoring to take place at a location upstream of SBE. Although this reach (site MNO) also experiences intermittent surface flows, the longer hydroperiod allowed sufficient time to conduct bioassessment monitoring. Monitoring was conducted at MNO each spring between 2008 and 2015. The samples were collected according to the most recent SWAMP protocol over a 150 m reach with a composite sample collected from ten transects. A habitat assessment was also conducted.



While limited macroinvertebrate and habitat assessment data were available, the results were of interest in the context of other sites in the watershed. The EPT richness metric indicates the number of different species identified in the sample, and a higher score indicates that the habitat is healthy enough to support a wide range of macroinvertebrates. During most years, San Bernardo Creek had some of the highest EPT richness scores of all of the sites. Lower than normal rainfall in 2014 and 2015 likely had a negative impact on the biota, thus impacting EPT and other metrics.

Conclusions: The hydrologic conditions at the lower monitoring site limited the data that could be collected each year. Due to the intermittent nature of the flow and the limited years since the project was installed, adequate bacteria data could not be collected to conduct an analysis of project effectiveness. The macroinvertebrate data has shown promise, with some of the higher metric scores measured among all sites in the watershed.

WALTERS CREEK RESTORATION, PHASE II

Project background: The Phase II of the Walters Creek Restoration Project was implemented along a 2,000-foot long reach that is surrounded by grassland pastures and an active private gun range. Formerly a military firing range, the property still operates as a shooting range, owned by the Department of Fish and Wildlife and operated by a private entity. The creek channel was altered by the military during WWII. The channel was straightened and earthen berms with undersized culverts were constructed. By the early 2000s, the channel morphology consisted of an incised, u-shaped channel that was dominated by non-native vegetation. The Phase II restoration project removed all berms, re-established a creek meander, and connected the channel to its floodplain. Construction was completed in April 2008 and included substantial planting of native riparian vegetation.

Expected project benefits: Upon completion of the project, the expectation was to see an improvement in vegetation, riparian habitat, and topography based on the habitat assessment component of the California Department of Fish and Wildlife Bioassessment protocol.

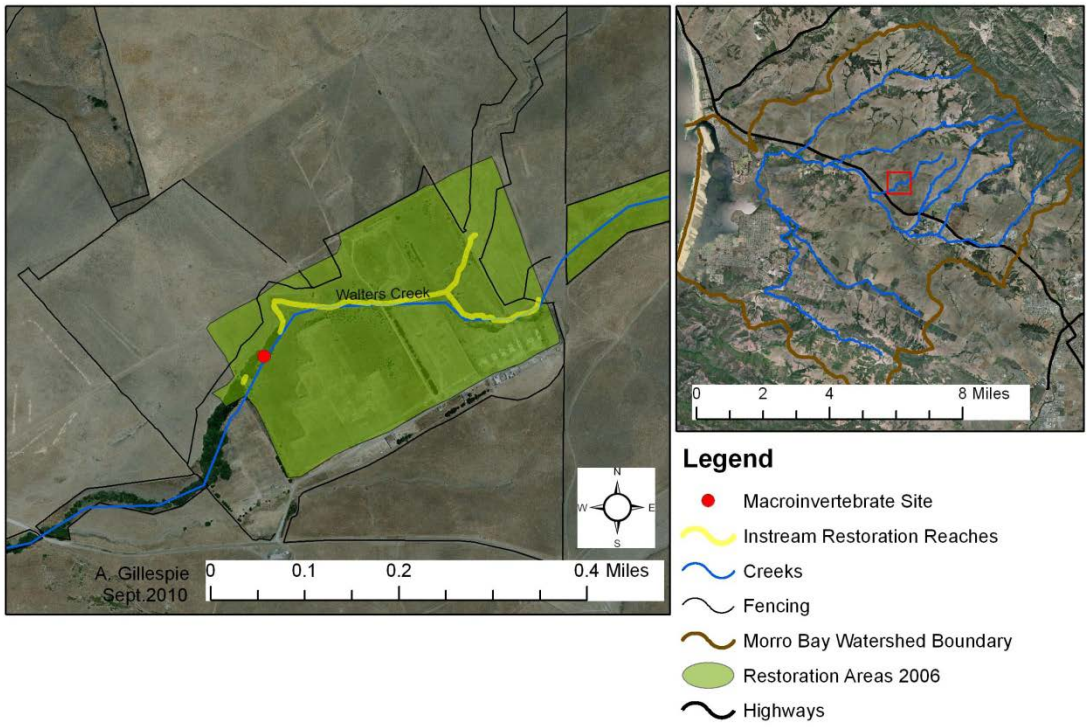
Existing data: A bioassessment habitat assessment was conducted in 2007 prior to construction. Macroinvertebrates could not be sampled at that time, due to lack of flow.

IEP activities: In 2008 and 2010, a bioassessment habitat assessment (including substrate diversity, in-stream habitat, canopy cover, and erosion) was conducted, and macroinvertebrate samples were collected and analyzed. During the spring of 2008, post-project cross-sectional profiles were conducted for comparison with pre-project profiles. Riparian point count bird surveys were begun in June of 2008 and were conducted on a monthly basis. Vegetation within the replanted project area has been monitored annually. Bioassessment monitoring could not be conducted from 2011 through 2015 due to lack of surface flows. Immediately following project implementation, the site was assessed in 2008 using the California Rapid Assesssment Method (CRAM), which is a protocol developed by the San Francisco Estuary Institute, the Southern California Coastal Water Research Project, the California Coastal Commission, and Moss Landing Marine Laboratories (MLML). It is used state-wide for assessment of wetlands, estuaries and riverine systems. The assessment was conducted by MLML staff who were CRAM certified.

IEP data analysis: The relatively recent completion date of the project and lower than normal rainfall totals limited the amount of post-project data that could be collected. At this point, preliminary data does not allow for an in-depth analysis of project benefits. Monitoring will continue at this site over the long term to track project benefits. However, with the data collected to date, some observations can be made.

Macroinvertebrates

In 2007, a habitat assessment was conducted prior to construction. Due to lack of water, benthic macroinvertebrate samples could not be collected. In 2008 and 2010, adequate water was present for sample collection. In 2011, the site was not monitored due to lack of staff resources. The monitoring site is located immediately downstream of the Phase II restoration project. Historically, macroinvertebrate sampling took place near the flume site, which is higher up in the watershed. The monitoring sites are illustrated on the following map.



The metric scores are presented in the following table.

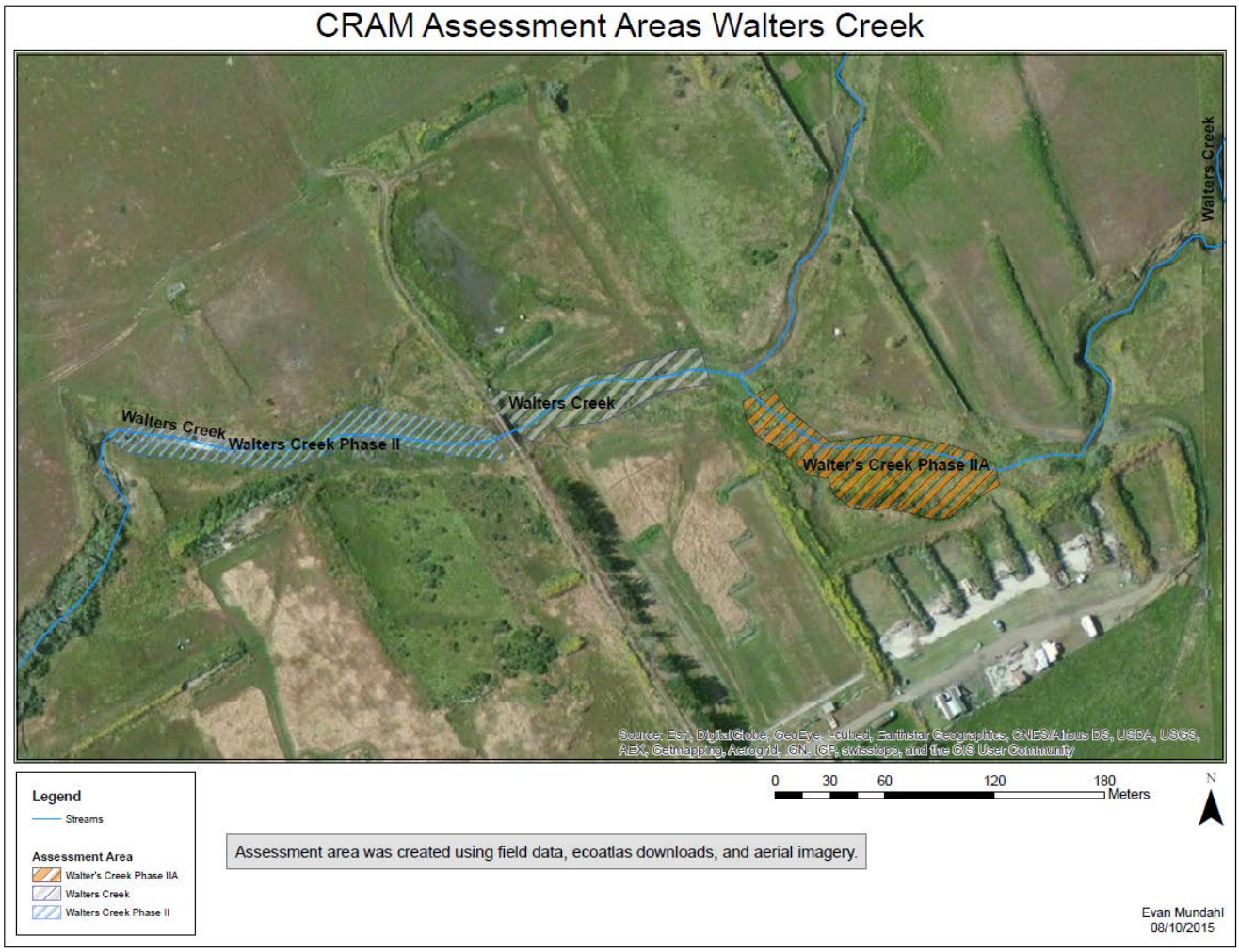
Walters Creek (WAL)	*Taxa Richness*	*EPT Richness*	*EPT %*	*IBI Score*
2008	39	2	1.0	38.6
2009	*	*	*	*
2010	44	4	1.8	28.6

** No data collected this year*

To provide context for this data, Walters Creek had EPT richness scores on the order of those from Los Osos Creek (LVR site) with a score of 3 and at Dairy Creek (6 at DAL and 5 at DAM) in 2010. For comparison, upper San Luisito Creek (USL) had a 24, the highest score of all of the sites in 2010. Walters Creek had the lowest EPT % scores of all of the Morro Bay sites in 2010 with a value of 1.8%. (For comparison, upper San Luisito Creek, which is considered to be relatively unimpaired, had an EPT % score of 35.2% in 2010.)

California Rapid Assessment Method

In the summer of 2015, the project site was re-assessed with CRAM to determine any changes following project implementation. Three areas of the project were assessed, as illustrated in the following map.



In comparing the 2015 scores to the 2008 scores immediately following construction, some conclusions could be drawn at each of the three sites.

Walters Creek Phase II:

- The overall assessment area score improved from 57 to 63. Most notable changes were to the average buffer width, channel stability, and structural patch richness submetrics.
- The buffer width score changed from an A in 2007 to a D in 2015. This is most likely due to differences in opinions of those conducting the assessment on which land covers are excluded. Most of the area southwest of the creek includes parking lots and an active shooting range. To the north of the creek, a fence has been installed that may prohibit wildlife movement.
- Channel stability improved from a C to a B. This is likely a result of the riprap installations from 2007.
- The structural patch richness submetric decreased significantly from the 2007 score. The score changed from a B to a D. This is most likely due to the lack of hydrologic influence on the channel morphology during the recent drought. Little habitat complexity was present in the stream reach at the time of assessment.

Walters Creek

- The overall assessment area score improved from 56 to 62. Only one submetric, channel stability, showed a significant change. Other areas of assessment showed small improvements as well.
- Channel stability changed from a C to a B, most likely due to the inclusion of riprap armor throughout the stream reach.

Walters Creek Phase II:

- The overall assessment area score improved from 60 to 66. Significant changes were shown for the channel stability, hydrologic connectivity, and structural patch richness submetrics.
- Channel stability improved from a B to an A, most likely due to the installation of riprap armor. However hydrologic connectivity, a measure of entrenchment, declined from a B to a C. This may be due to differences in the sections of stream where bankfull measurements were taken. The measurements were bordering between a B and C score.
- Structural patch richness improved from a D to a C. This may be a result of improved stream hydrology from the restoration project. The riprap armor installed may be improving habitat complexity by slowing the water throughout the stream and allowing it to pool.

Conclusions: CRAM scores indicate that the site is improving in both habitat and hydrologic metrics. Due to drought conditions, updated bioassessment could not be conducted to document improvements to habitat. As the project site continues to mature, habitat diversity is expected to continue to improve, leading to a more robust riparian ecosystem which will be reflected in the macroinvertebrate and CRAM data.

SAN LUISITO CREEK RIPARIAN FENCING

Project background: Of the sites monitored for bacteria in the Morro Bay watershed, the site on San Luisito Creek was notable for its year-round elevated bacteria concentrations. Of the samples collected from 2003 through 2008, 62 of 74 samples (84%) had *E. coli* levels above EPA's recommended criteria for safe recreational contact of 235 MPN/100 mL.

Based on this data, the MBNEP teamed with the Coastal San Luis Resource Conservation District (CSLRCD) to work with a private landowner to install approximately 9,000 feet of fencing on each side of San Luisito Creek as well as an off-creek watering system. Construction was completed at the end of January 2009. The project was intended to exclude cattle from the riparian area, other than limited access for weed control. The initial fencing project on the downstream property is referred to as Phase I.

When the fencing project was underway, the owner of the parcel upstream of the project became interested in improving riparian fencing on their property. Completed in May 2009, approximately 4,265 feet of fencing was installed to fill gaps in existing fencing. A few times a year, cattle are allowed into the riparian pasture, which serves as a staging area to prepare for transport off site. This phase of the fencing work is referred to as Phase II.

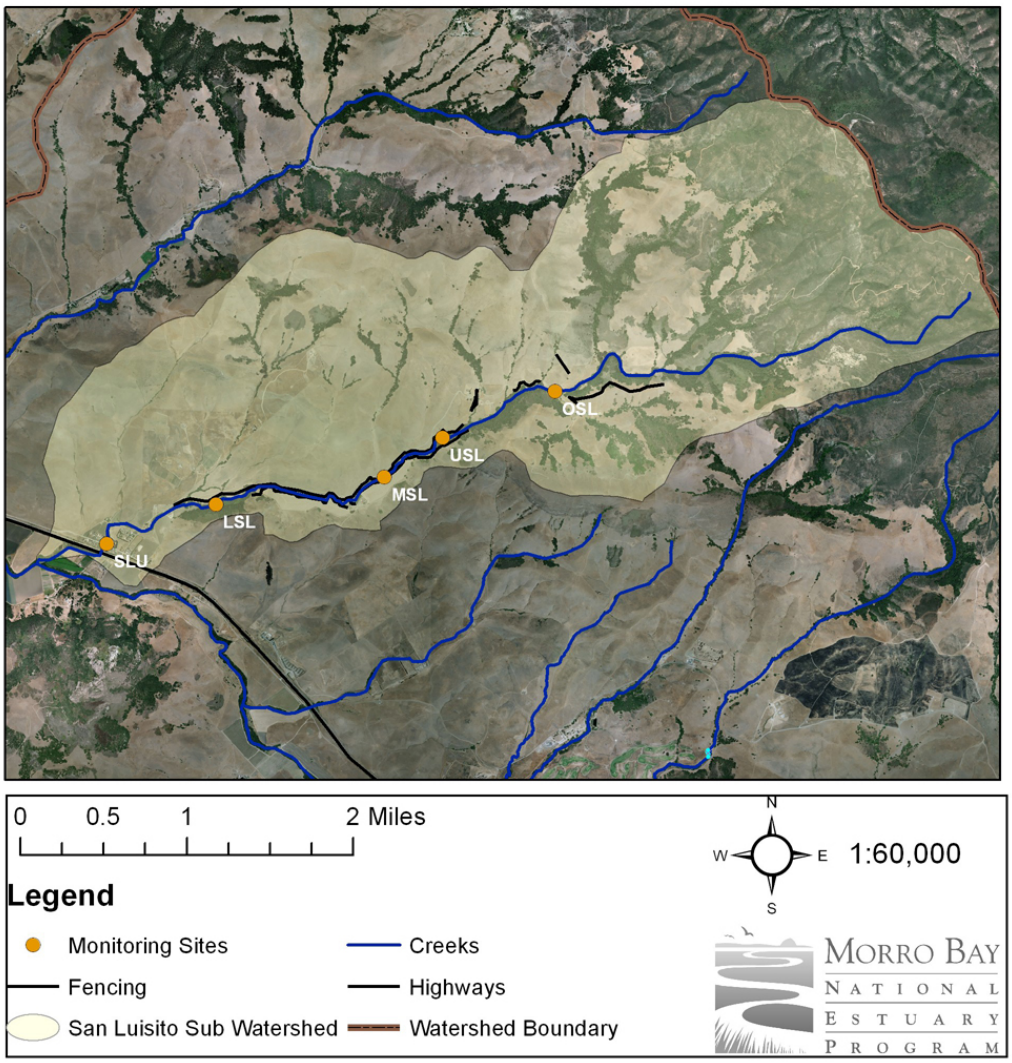
Expected project benefits: The primary goal of the project was to reduce creek bacteria concentrations through exclusion of cattle. Secondary benefits include increased riparian vegetation

and shading of the creek, improved bank stability, reduced erosion, and improved habitat value for fish and wildlife.

Existing data: A site downstream of the fenced area was monitored monthly since February 2003 for total coliform and *E. coli* (site code SLU). Water quality monitoring also took place beginning in 2002 at the historical site downstream from the project. Water quality monitoring included analysis of dissolved oxygen, temperature, pH, turbidity, conductivity, flow, nitrates as N and orthophosphates as P.

Beginning in September 2007, more extensive bacteria monitoring was begun at three sites within the Phase I project area (site codes USL, MSL and LSL). In December 2008, this monitoring was increased to a frequency of twice monthly within the project area as well as at the historical downstream site. Beginning in June 2009, a monitoring site was established within the fencing in the Phase II project area (site code OSL).

The following map shows the location of the three bacteria monitoring sites within the Phase I project area (USL at the top of the project, MSL at the middle, and LSL at the bottom) and the one monitoring site within the Phase II project area (OSL). The map also shows the site downstream of the project (SLU) where monitoring takes place for bacteria and water quality parameters. It also illustrates where fencing was installed. The fencing appears to be unconnected on the map because it was installed in conjunction with existing fencing, which is not displayed on the map.



IEP activities: Annual bioassessment monitoring (including substrate diversity, in-stream habitat, canopy cover and erosion) were conducted starting in spring 2008 at a site within the downstream reach of the project area (LSL). This monitoring was continued in 2009 to 2013. An upstream site at USL was monitored from 2010 to 2013.

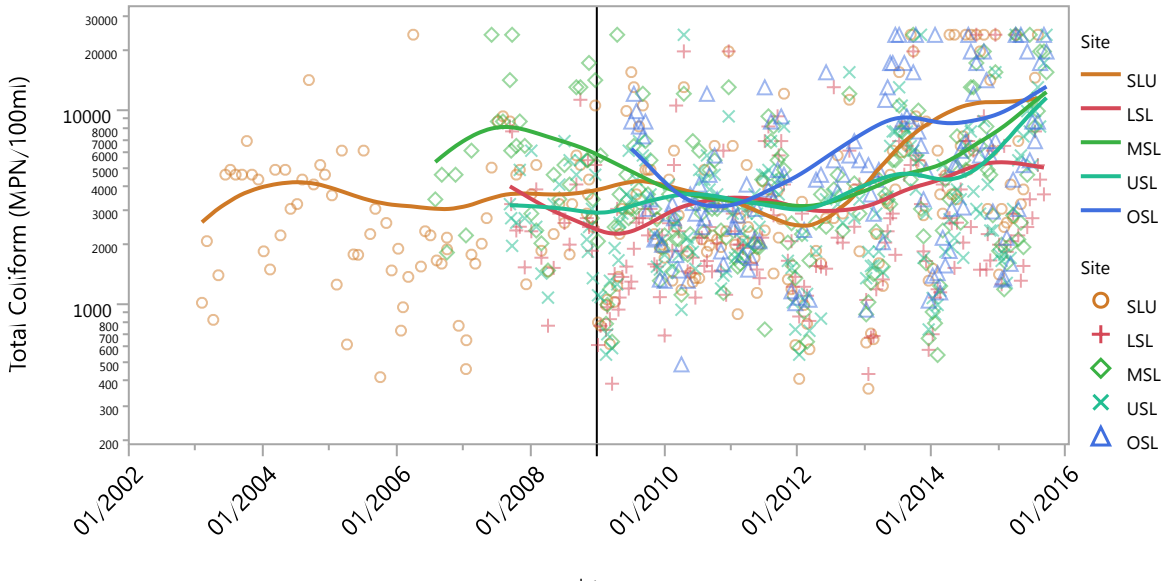
Bacteria monitoring was conducted pre and post-project at three sites within the Phase I project area and at the historical site downstream of the project area that has been monitored since 2003. Bacteria monitoring was only conducted post-project at the Phase II project area, due to the brief timeframe preceding project installation. All five sites are monitored within a brief time period (typically two hours), twice a month.

Sites at the top and bottom of the Phase I project were monitored periodically using Minsonde MS5 continuous monitoring meters. Meters were programmed to collect readings every 30 minutes and were deployed simultaneously at USL and LSL for extended runs, typically between four and seven days. Analysis for DO and temperature was conducted to determine if the implementation project might be having an effect on these parameters.

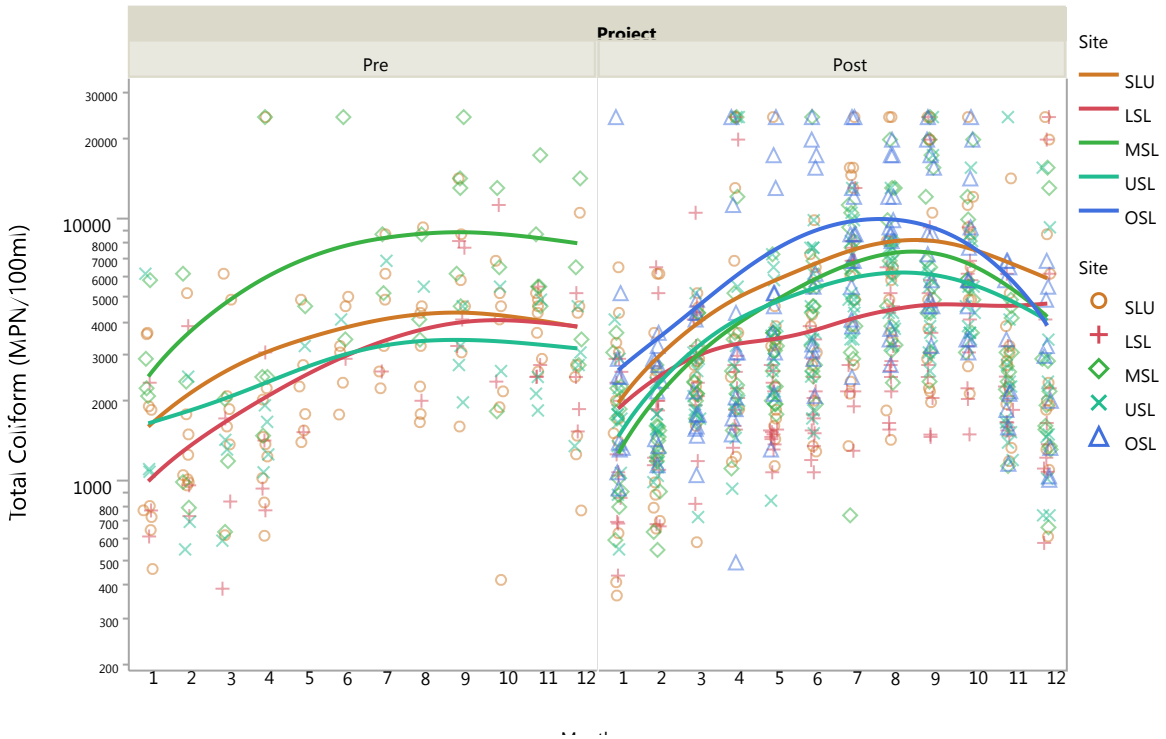
IEP data analysis: A pre and post-project comparison of bacterial levels was conducted, including the percent of samples exceeding recreational contact standards. Statistical models were developed that took into account the seasonal trends that existed at the monitoring sites. Analysis was conducted on DO and temperature data to determine differences between the upstream and downstream sites of the two project areas.

Bacteria

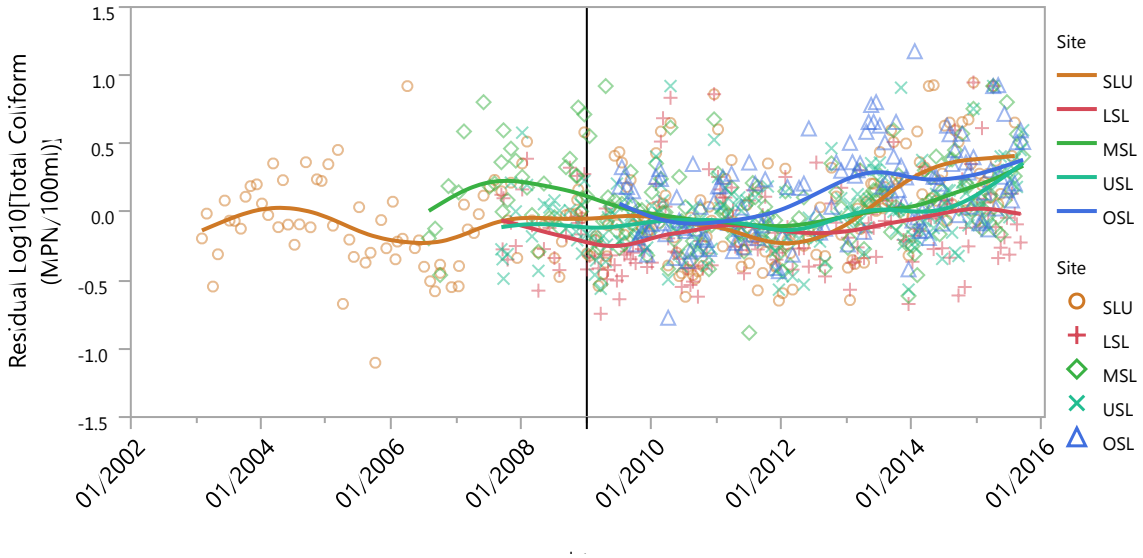
The following graph shows an overview of the total coliform data over time at the five monitoring sites. Three of the sites were within the Phase I project area (USL, MSL, LSL), and one historical site was located downstream of the project (SLU). One site (OSL) is located within the Phase II project area.



The data exhibited a strong seasonal trend. The following plot reveals the seasonal patterns of the data by month, and illustrates the need for a monthly term in the analysis to remove the effect of seasonality to isolate the effect of the project. The plot shows log transformed total coliform concentration data. This plot includes data from SLU beginning in 2004 and all data from the four monitoring sites within the project area. For this plot, all January pre-project data was combined, all February pre-project data was combined, etc.



The next plot shows the seasonally adjusted detrended total coliform data on the log-scale across all sites versus the residual analysis of the model log 10(total coliform = month).



Based on this initial analysis, a model was developed to examine the effect of the project, which included seasonality and a lagged term, which corrects for serial autocorrelation in the data. In other words, each observation should be independent of other observations and if two observations are made too close together, they are not independent.

The model shows strong evidence of an increasing trend in total coliform since 2007 (p-value < 0.00001). This trend was not found to differ between the pre and post-project periods, and thus the interaction was not included in the final model. There was strong evidence that total coliform levels are not the same across sites (p-value = 0.0003). In particular, the levels at MSL are statistically

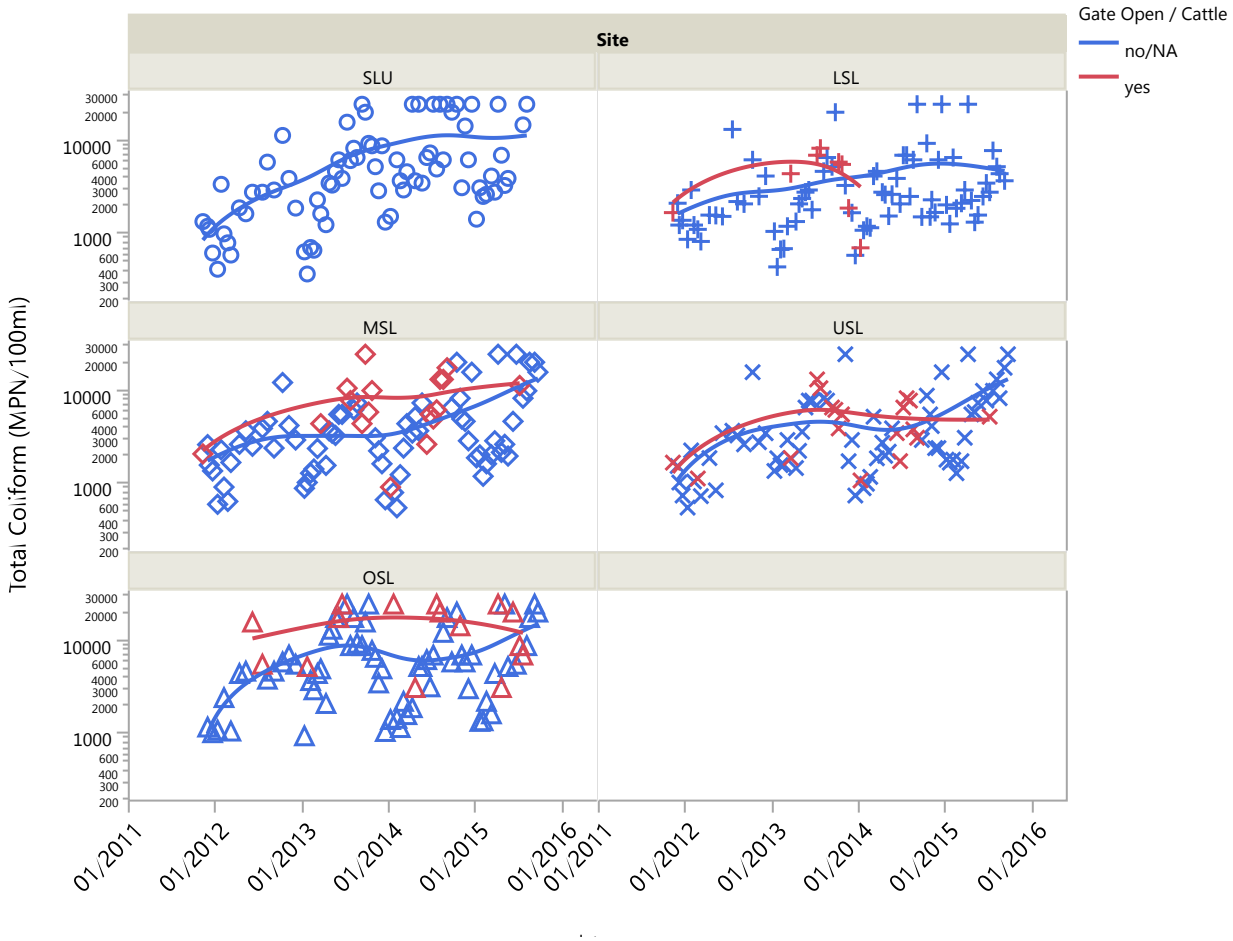
significantly higher than those at LSL (p-value = 0.0001) or USL (p-value = 0.0095). The pre/post project difference in total coliform is largest for MSL (largest amount of improvement) and smallest for USL (least amount of improvement).

The analysis showed the following change in total coliform from pre- project to post-project.

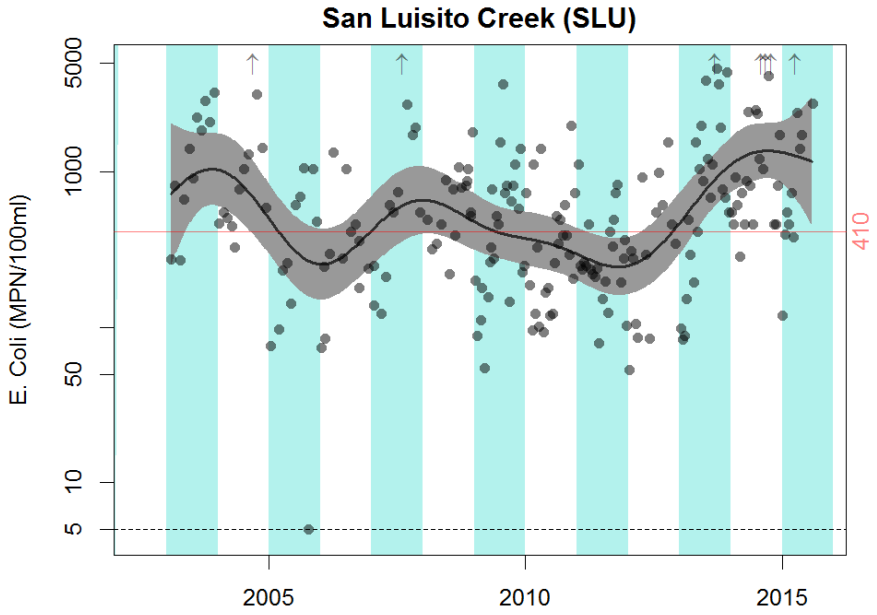
At USL, a 39% reduction in bacteria concentrations from pre- to post-project
At MSL, a 150% reduction in bacteria concentrations from pre- to post-project
At LSL, a 58% reduction in bacteria concentrations from pre- to post-project
At SLU, a 39% reduction in bacteria concentrations from pre- to post-project

Gates were installed in the cattle exclusion fencing to allow periodic limited access for cattle for weed abatement and to allow samplers easy access to the creek. During the past three years, these gates were left open for the majority of the dry season. Drought conditions contributed to a lack of forage, so cattle were allowed nearly continual access at USL, MSL and LSL during the dry season. At OSL, on a few occasions each year, cattle are held just upstream of the monitoring site to prepare them for shipping, conduct branding, etc.

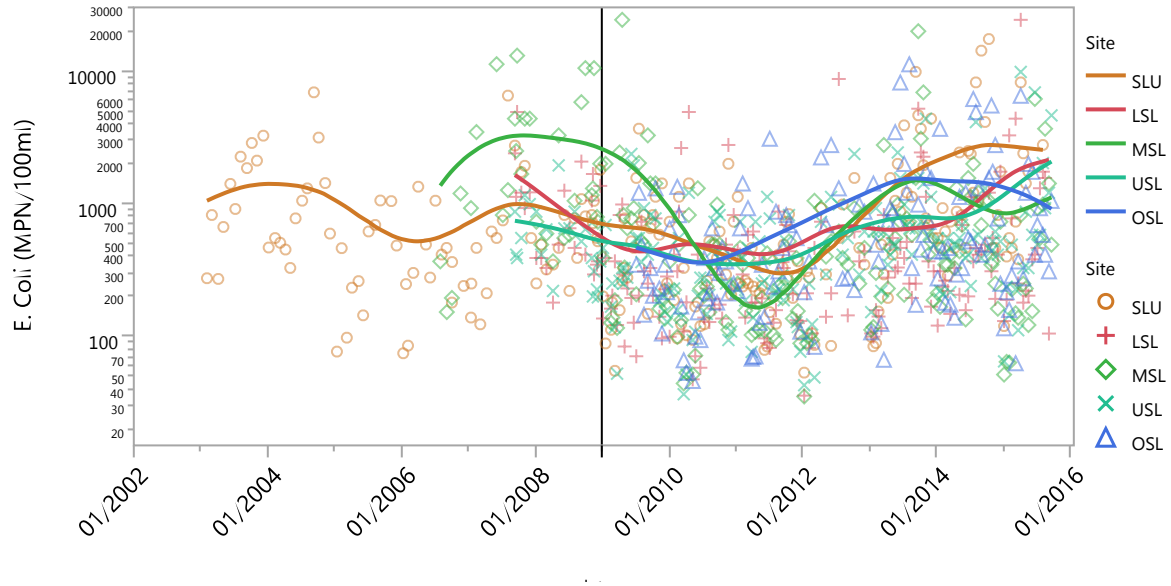
The following plot indicates in blue times when the gates were closed and in red times when they were open. There is moderate evidence that the total coliform counts are higher when the gates are open (p-value = 0.0253). But this difference is only statistically significant at OSL (p-value = 0.0041) with an approximate 75% increase in total coliform when the gates are open. There are no statistically significant differences at USL, LSL or MSL (p-value = 0.1676, 0.4905, and 0.5896, respectively).



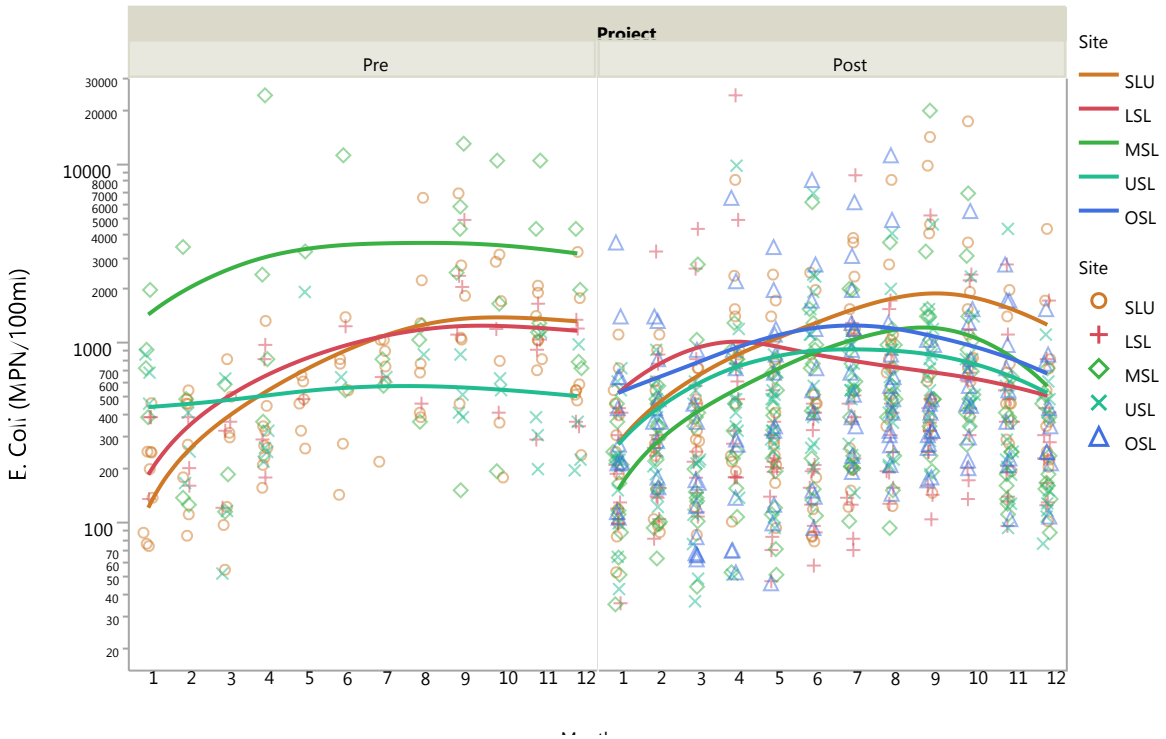
Water samples were also analyzed for *E. coli* concentrations throughout the project. The following graphs plot the *E. coli* data over time and include smoothing splines as well as error bands. The model used has no seasonality term and uses arrows to indicate values over 5,000 MPN/100 mL. The smooth line summarizes the mean bacteria level and the error band reflects the certainty of the trend estimate. The bands can be considered as a 95% confidence interval for the mean bacteria level at any point in time. The analysis indicates a more recent upward trend in the data.



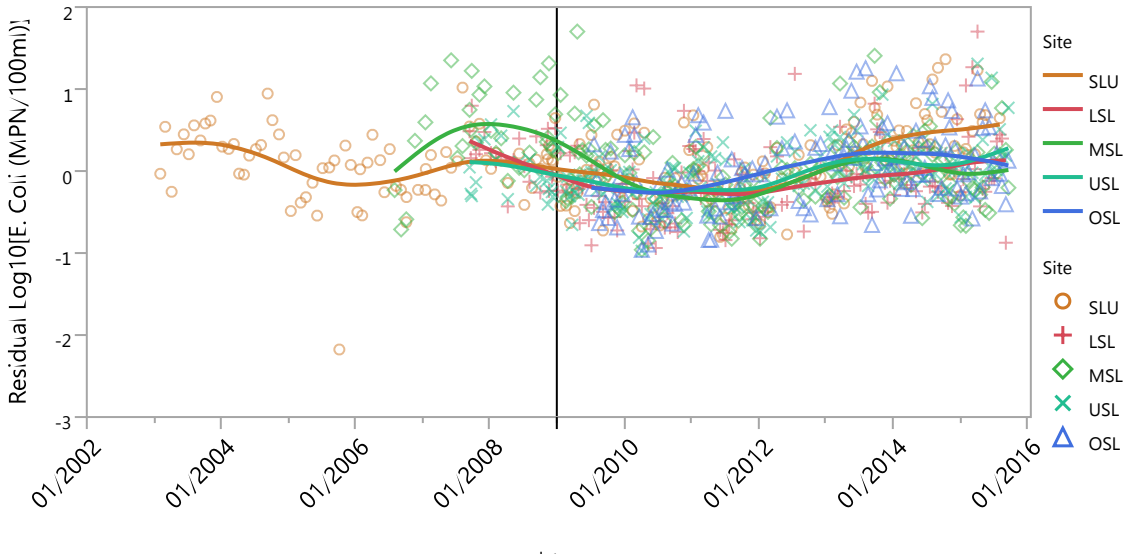
The following graph displays all *E. coli* data across all monitoring sites, with the vertical line in January 2009 indicating the installation of the project.



Next, as with the total coliform data, the seasonal effect was determined so that it could be removed to reveal only the project effect. The following plot illustrates the seasonal patterns of the data by month, and validates the need for a monthly term in the analysis to remove the effect of seasonality to isolate the effect of the project. The plot shows log transformed *E. coli* concentration data. This plot includes data from SLU beginning in 2004 and all data from the four monitoring sites within the project area. For this plot, all January pre-project data was combined, all February pre-project data was combined, etc.



The following plot compares the seasonally adjusted *E. coli* data on the log scale for all sites and times via residual analysis of the model log10(*E. coli*) = month.

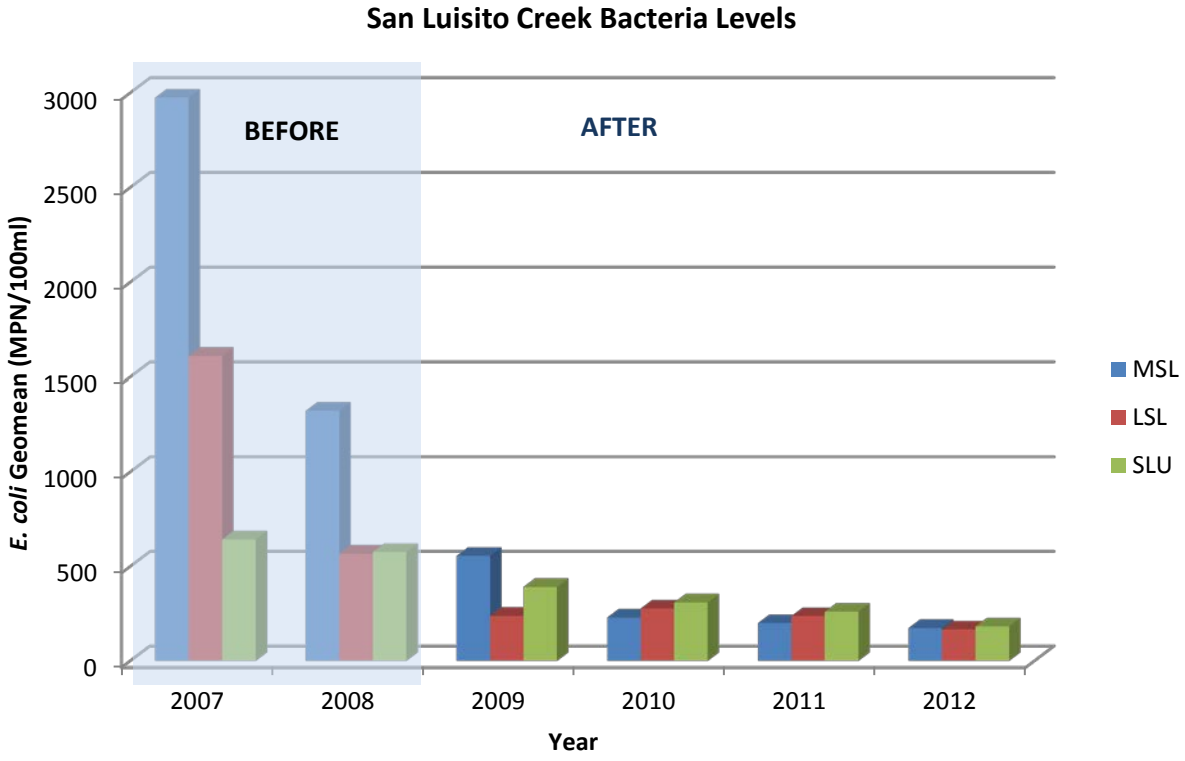


The model is restricted to SLU, LSL, MSL and USL including data since January 1, 2007. This model differs from the models used in past analyses because it corrects for serial autocorrelation in the data by including a lagged term. The results show a strong increasing trend in *E. coli* since 2007 (p-value = 0.0001). This trend was not found to differ between the pre/post project periods and thus the interaction was not included in the final model.

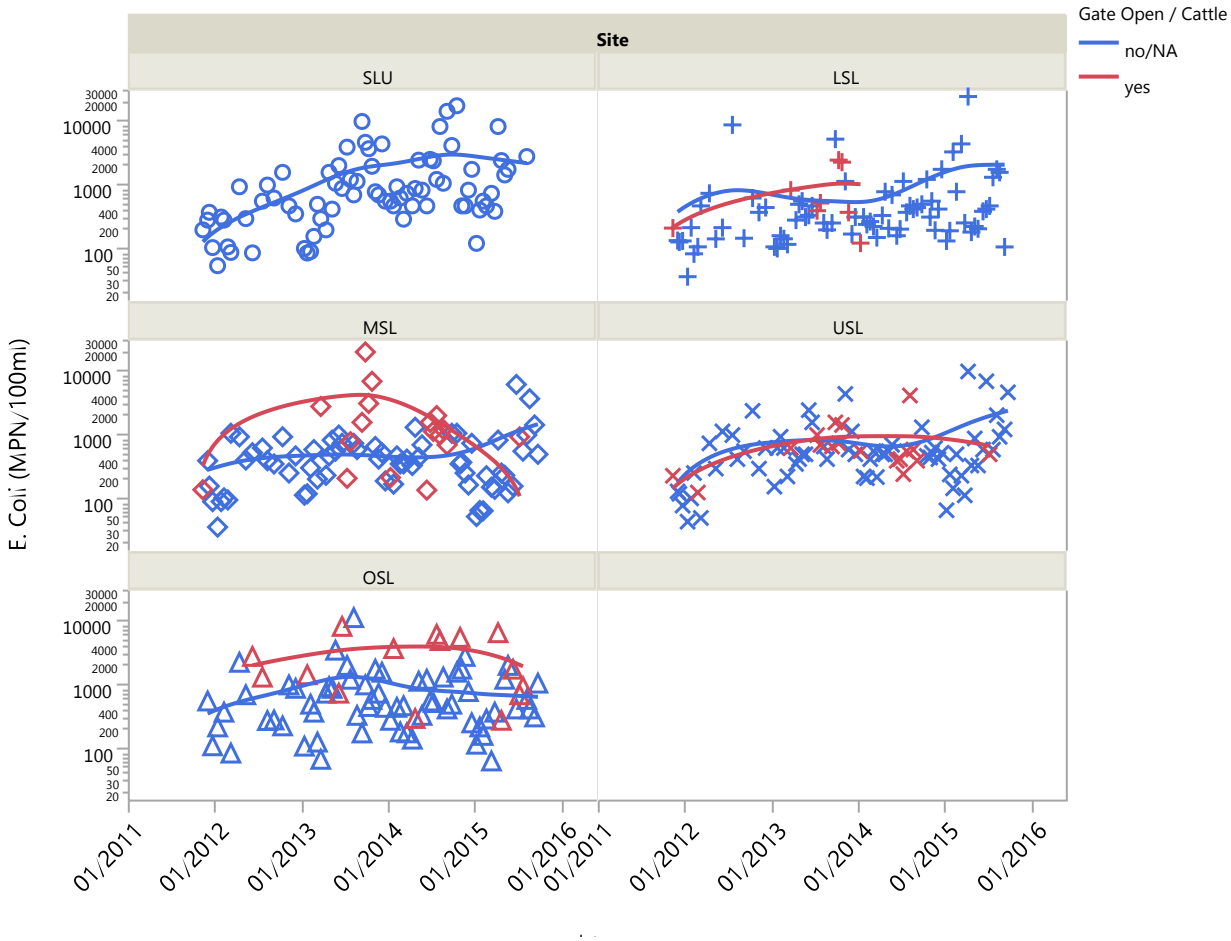
The analysis showed the following change in *E. coli* from pre-project to post-project.

At USL, a 78% reduction in bacteria concentrations from pre- to post-project
At MSL, a 545% reduction in bacteria concentration from pre- to post-project
At LSL, a 208% reduction in bacteria concentrations from pre- to post-project
At SLU, an 86% reduction in bacteria concentrations from pre- to post -project

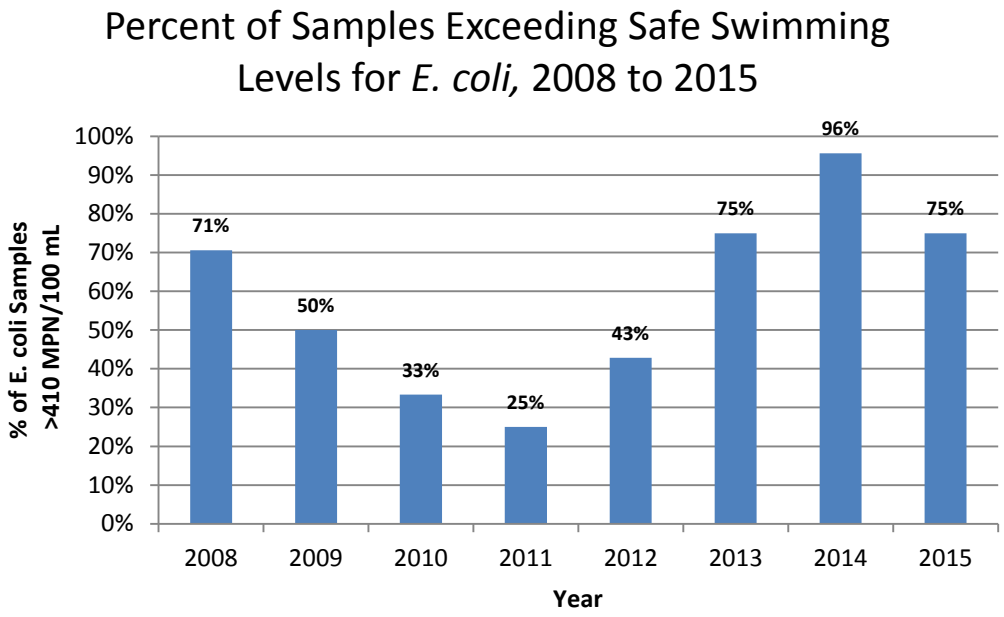
The following graph shows the geomean of the data for three of the sites before and after fencing installation. The largest decrease in *E. coli* concentrations occurred at MSL.



The presence of cattle was added to the model. Data collected at times when gates were open or cattle were staged nearby are shown in red on the following graph. Data collected at times when gates were closed or there were no recent signs of cattle are shown in blue. There is moderate evidence that the *E. coli* counts are higher when the gates are open (p-value = 0.0003). There are statistically significant gate differences at OSL and MSL (p-value = 0.0001 and 0.0140, respectively), but not at LSL or USL (p-value = 0.3585 and 0.5643, respectively). When cattle are present at OSL, there is an approximate 188% increase in *E. coli* counts. At MSL, it is a 90% increase when the gates are open.



A simplified analysis of data was conducted to compare the *E. coli* concentrations to the EPA's recommended standard for safe recreational contact STV of 410 MPN/100 mL. The following figure shows the percent of *E. coli* samples from the downstream SLU site that exceeded 410 MPN/100 mL, by year. The project was installed in January 2009.

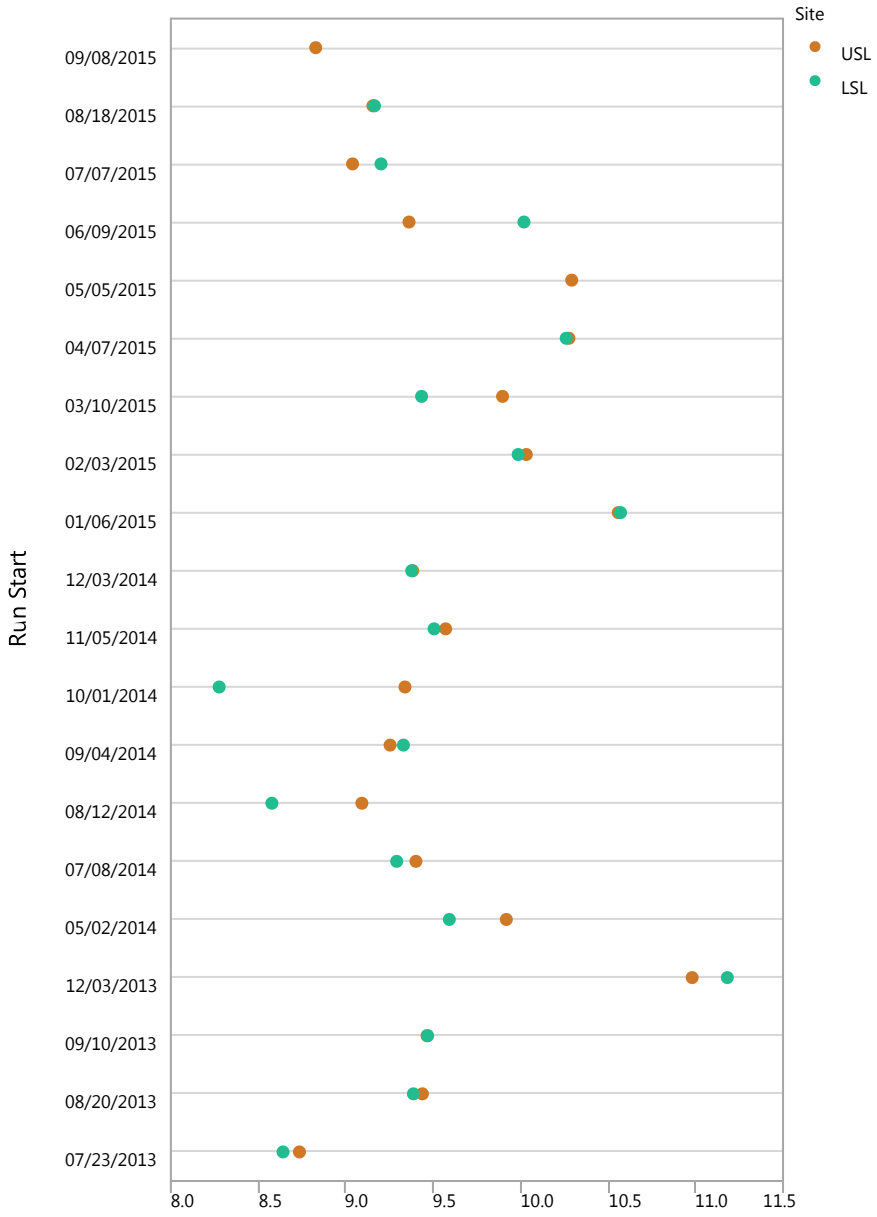


**The 2015 data includes January to September.*

Dissolved Oxygen

Several times a year, Minisonde MS5 continuous monitoring meters are deployed simultaneously at USL and LSL for four to seven-day periods to measure DO and water temperature. An analysis was conducted with the data collected to date, which spans July 2013 to September 2015.

The following graphic provides an overview of the data by plotting the mean of DO data from each sampling run for each site.

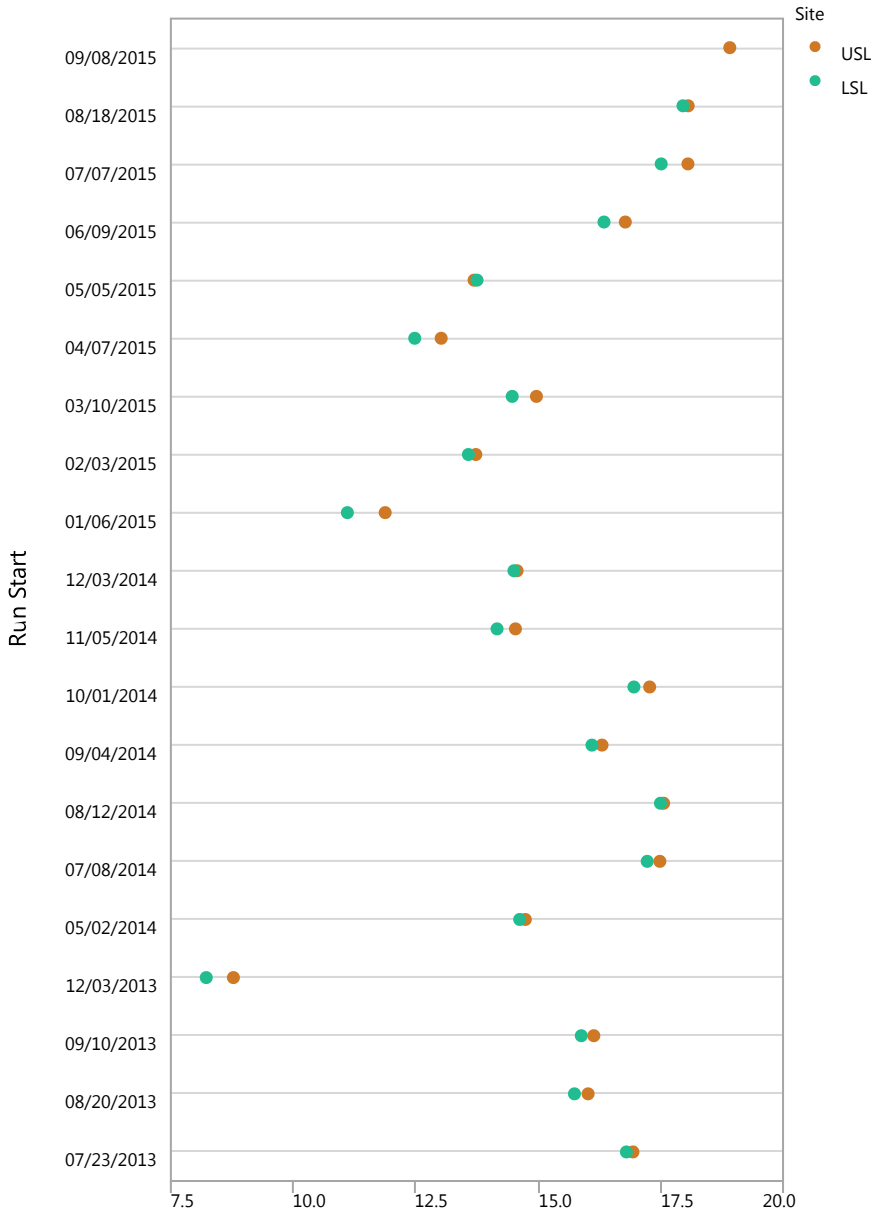


Of note, for all DO data collected, a few readings in an October 2014 run had DO levels that briefly fell below 7 mg/L, but this was not sustained.

Analysis of the data indicated no statistically significant evidence that the mean DO differs for the two San Luisito sites (p-value = 0.2891). If the sites do differ, the difference is less than 0.26 mg/L with 95% confidence. There are minimal issues with depressed DO concentrations at these sites on San Luisito Creek.

Temperature

The following plot summarizes the continuous monitoring water temperature data from USL and LSL, which shows the mean temperature from each sampling run for each site.



For all data collected, temperatures above 21 °C were measured in only a few instances and never for sustained periods of time.

Analysis of the paired data indicated evidence of a statistically significant difference in mean water temperature at the two locations (p-value < 0.0001). The mean temperature at LSL is significantly lower than the mean temperature at USL. The mean temperature at LSL is between 0.19 and 0.40 °C lower than the mean temperature at USL with 95% confidence.

Due to a lack of pre-project data, conclusions cannot be drawn about the impact of the project on relative DO and water temperatures. The inverse trends (higher temperatures and higher DO at USL versus lower temperatures and lower DO at LSL) were not as expected since temperature and DO typically trend together.

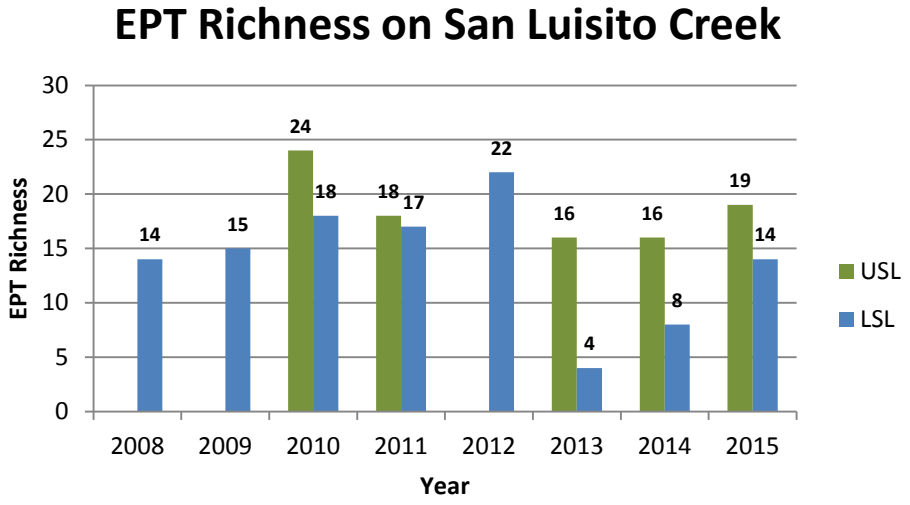
Macroinvertebrates

The LSL macroinvertebrate site, located at the bottom of the Phase I project area, was monitored from 2008 to 2015. The 2008 sampling occurred prior to project installation, and the seven later samplings took place following installation. The USL site, at the top of the Phase I project area, was monitored in 2010, 2011, 2013, 2014 and 2015.

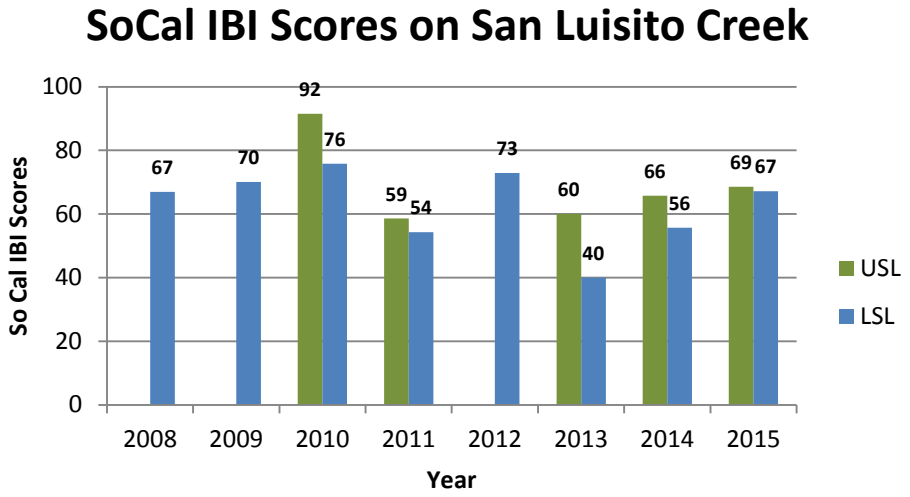
Data at the San Luisito Creek sites were collected utilizing the SWAMP bioassessment procedures titled *Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California*, which was updated in 2007.

The USL site's EPT richness scores were typically some of the highest of the dozen sites monitored throughout the watershed. The site had the highest score in 2010, the third highest of 11 sites in 2011, the third highest of six sites in 2013, the second highest of six sites in 2014, and the highest of seven sites in 2015. USL has had variable Southern California Index of Biotic Integrity (IBI) scores. In 2010, the site had an IBI score of 91.5, the highest score of the sites ten sites monitored that year. The site had only a 'fair' score in 2011 and 'good' scores in 2013, 2014 and 2015.

IBI scores from LSL consistently rank in the 'good' category with occasional drops into the 'fair' category in 2011, 2013 and 2014. In 2015, the score returned to 'good'. The EPT richness scores at LSL varied from having some of the highest scores of the sites monitored that year (in 2009, 2010 and 2012) to having mid-level scores (in 2008 and 2011), to having the lowest score of the year in 2013. In 2014 the EPT richness score was third highest out of six sites, and in 2015 if was the second highest out of seven sites.



The following plot is a comparison of Southern California IBI scores for the two sites. Scores from 0 to 19 are rated 'very poor', from 20 to 39 is 'poor', from 40 to 59 is 'fair', from 60 to 79 is 'good', and from 80 to 100 is 'very good.'



Conclusions: In the analysis conducted with data from 2007 through 2015, it was determined that the MSL site was the most heavily impacted by cattle access prior to project implementation. The project showed a substantial post-project decrease in total coliform concentrations at the MSL site, with a more modest decrease at the other sites. The MSL site also showed a significant reduction in *E. coli* concentration following project implementation. Improvements, while more modest, also occurred at USL, LSL and SLU. The data at SLU for the percent of samples that exceeded the safe recreational contact standard for swimming was not exhibiting a clear trend, possibly due to the variability in rain years. Analysis of open and closed gates clearly demonstrated the impact of cattle access on creek bacteria levels. At OSL, total coliform concentrations were 75% higher when cattle had access to the creek. There was no significant difference in the other sites. For E. coli, there was a 188% increase in bacteria when cattle had access to the creek at OSL, and there was a 90% increase in bacteria when the gates were open at MSL. There was no significant difference at the USL and LSL sites, likely because cattle have easy access to the creek at OSL and MSL, while steep terrain naturally prevent cattle from accessing the water at USL and LSL.

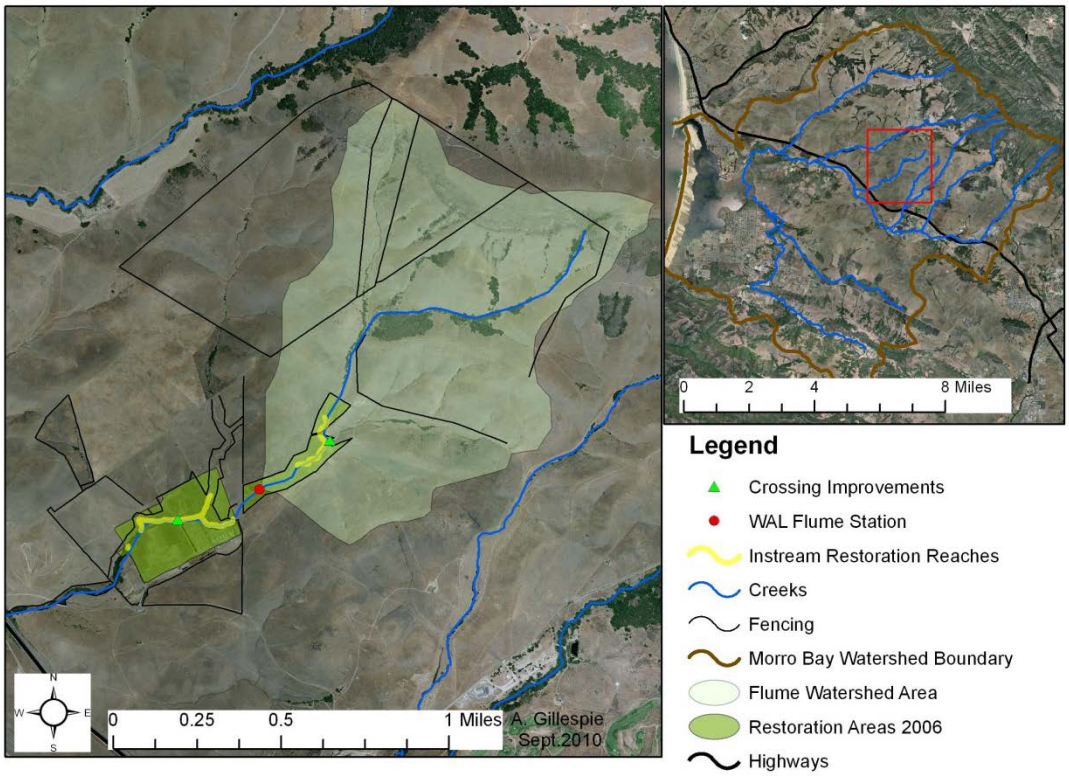
No measurable difference in DO was detected when comparing upstream to downstream within the project area. Mean water temperatures downstream were up to 0.4 °C lower than upstream. Macroinvertebrate scores indicated high quality habitat conditions prior to the project and continue to reflect that following project implementation, with occasionally lower than normal scores likely attributable to conditions such as low flows.

WALTERS CREEK RIPARIAN FENCING

Project background: Walters Creek was part of the NMP paired watershed study conducted in the 1990s and 2000s. Walters was treated as the control site in the study, while BMP implementation was completed at nearby Chumash Creek for comparison. During the study, instrumentation collected total suspended solids (TSS) samples and a flume was constructed to measure flows so that storm event sediment loading could be estimated. Following the completion of the NMP, work was conducted to bring the same types of improvements to Walters Creek. Extensive riparian fencing was installed in the Walters Creek subwatershed from 2003 to 2007. In-stream habitat restoration was conducted in two phases. Phase I, upstream of the flume site, began in 2004 and included installation of fencing, construction of in-stream habitat features, stabilization of banks, and implementation of

rotational cattle grazing practices. Phase II, conducted downstream of the flume site, was analyzed as a separate component of this IEP analysis.

The following map illustrates the fencing installed at Walters Creek since the conclusion of the NMP study.



Expected project benefits: The expectation was to see a reduction in peak storm event suspended sediment load at the flume monitoring station.

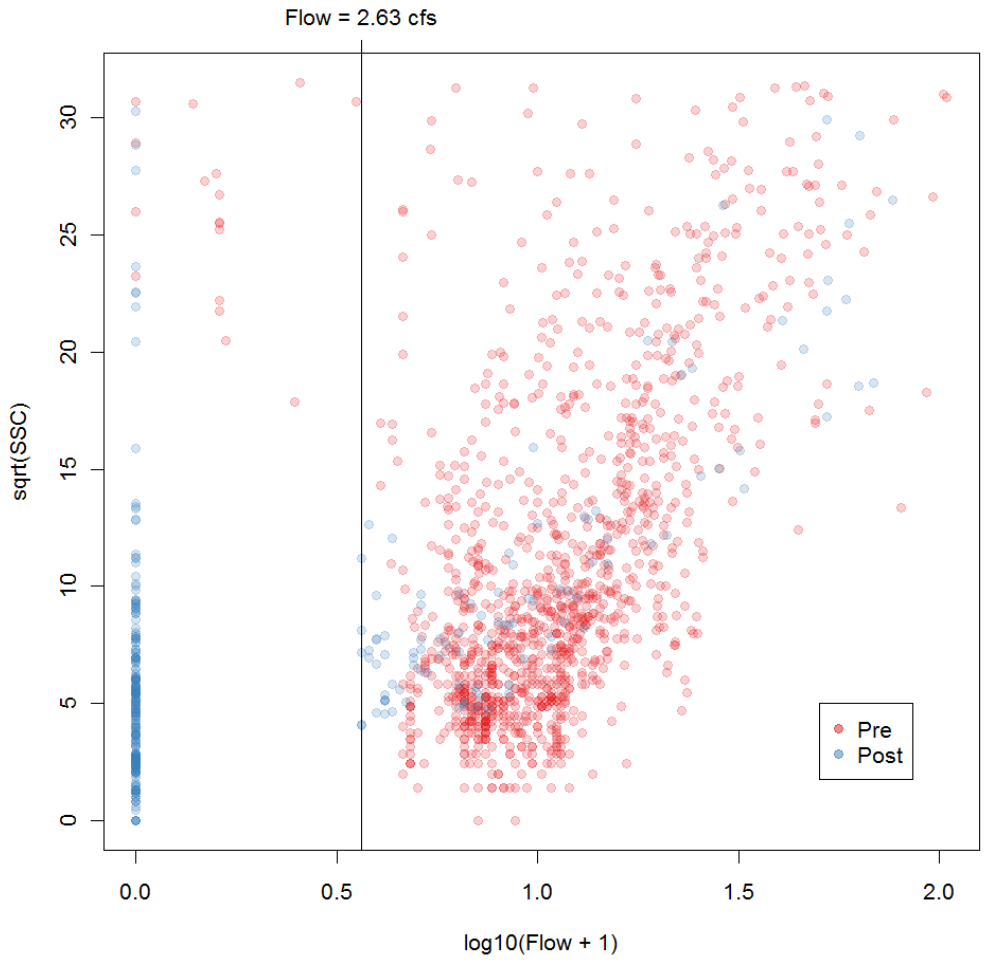
Existing data: During the NMP, an automated sampler collected samples that were analyzed for TSS and turbidity. Flow measurements were taken at the flume. Wet season samples were collected from 1995 through the 2000 to 2001 wet seasons.

IEP activities: Resurrection of the flume site for the IEP was logistically challenging due to the condition of infrastructure at the site. Instrumentation was installed in time for monitoring during the 2009 water year. However, due to lack of rainfall, no data could be collected during the 2009 water year. Data was collected in the 2010 and 2011 water years. Samples were processed for suspended sediment concentration (SSC) by MBNEP staff at a water lab established at Cuesta College in 2007. In addition to SSC measurements, turbidity readings were taken of the samples in the lab. Due to lack of rain, adequate flows for monitoring did not occur during 2012, 2013, 2014 or 2015.

IEP data analysis: This analysis was presented in the MBNEP's Data Summary Report for 2011. Due to lack of adequate flows, additional data and analysis were not available from 2012 through 2015. The analysis from 2011 is repeated in this version of the report to indicate how future data will be assessed.

The Walters Creek post-BMP suspended sediment dataset has been limited by the amount of flow occurring within the range measurable in the flume. Water depths in the flume below 0.25 feet and greater than 3.50 feet cannot be accurately measured in the flume. Discharge data from the pre-BMP dataset illustrates that Walters Creek sustained measurable surface flows for substantial periods following storm events throughout the NMP study period. Although measurable surface flows were sampled during the 2009 to 2010 water year, the falling limb of most storm events rapidly dropped below measurable flow volumes.

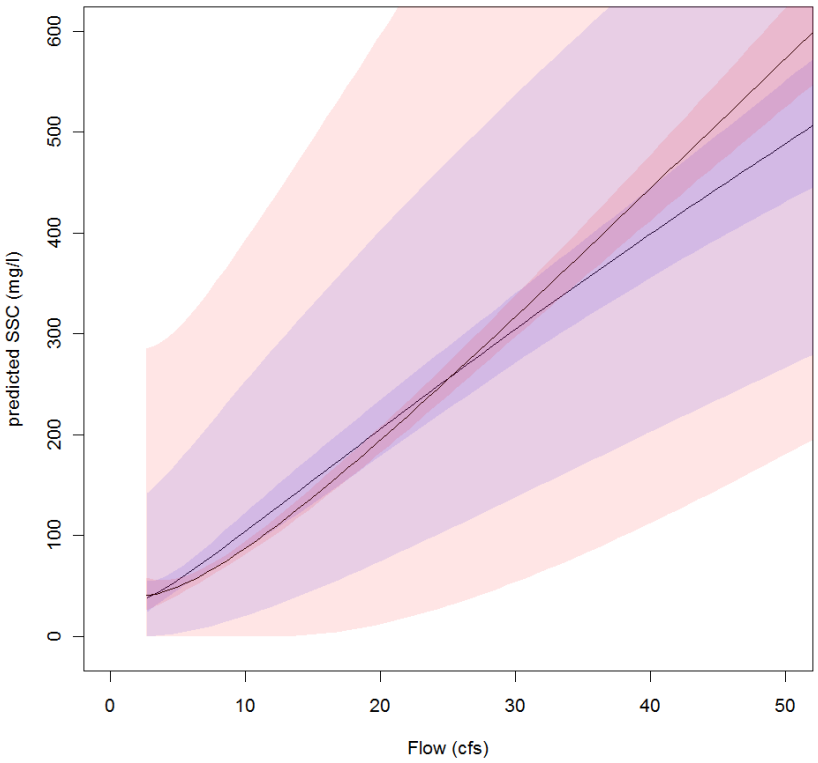
The following graph displays the pre-project TSS and post-project SSC data on the same plot. Due to the different time periods of pre and post-project analysis, there is a greater number of pre-project (red) data points and also greater variability among the pre-project data. Data shown to the left of the reference line at 2.63 cfs was not included in model analysis as it did not meet the minimum flow criteria.



The pre-project data was incorporated into the final model that was used for determining the relationship for the post-project data, assuming that the functional relationship between the two parameters would remain the same. However, the parameters in the pre-project period were allowed to differ from the post-project period. The residual behavior of the pre-project data was checked using the functional form of the post-project data and did not indicate a need for higher order terms in the model.

There was substantially more variability in the pre-project TSS data as noted by the residual standard error (pre-project data = 5.33 mg/l, post-project data = 2.836 mg/l), and thus a lower adjusted R-sq = 41% for pre-project data versus 79% with the post-project data.

The figure below displays the pre- and post-project model results. 95% confidence intervals are indicated by darker bands of red and blue, with lighter shades indicating corresponding prediction intervals for both conditions. The pre-project data (red) had a very narrow confidence band due to the large sample size but a wide prediction band due to highly variable predicted SSC values. The post-project data (blue) had a wider confidence band due to smaller sample size and a narrower prediction band due to less variability within the post-project dataset.



The 95% confidence interval bands essentially overlap for the pre- and post-project datasets. A formal test to compare the model results (considering data for which flow is greater than 2.63 cfs) indicates there was only weak evidence for a difference between pre- and post-project conditions ($F(3,1288) = 2.2912$, $p = 0.077$).

While there was not a significant difference between the pre- and post-project conditions, there was some indication of a change in condition at different ranges of flow. At flows between approximately 5 to 25 cfs, the models indicated that SSC concentrations were higher in post-project conditions. While this may indicate a change of conditions in the watershed, changes in lab methodology (greater recovery of suspended particles) may also be influencing this apparent trend. The appearance of reduced SSC in the post-project condition at higher flows (greater than 30 cfs) may become significant by narrowing of the 95% confidence interval through the addition of more data. These empirical differences are not statistically significant but indicated that further data collection may improve the ability to detect a difference between pre- and post-project conditions.

Further detail on the analysis and assumptions for creation of these plots were contained in the MBNEP's sediment monitoring report, *Morro Bay National Estuary Program's Implementation Effectiveness Program Suspended Sediment Monitoring Report 2011*, available at www.mbnep.org.

Conclusions: Unfortunately, due to lack of adequate rainfall, further monitoring could not be conducted on Walters Creek for this analysis. With the predicted El Nino rainfalls for the upcoming year, we intend to conduct additional post-project monitoring. Additional data collection and analysis will improve the ability to detect differences between the pre- and post-project condition at the site.

TMDL Assessment for Sediment, Pathogens and Nutrients

Project background: The following EPA-approved TMDLs are in place in the Morro Bay estuary and its watershed:

- Chorro Creek Nutrients and Dissolved Oxygen (approved July 2007)
- Los Osos Creek, Warden Creek and Warden Lake Nutrients (approved March 2005)
- Morro Bay (including Chorro and Los Osos Creeks) Pathogens (approved January 2004)
- Morro Bay (including Chorro and Los Osos Creeks) Sediment (approved January 2004)

The MBNEP and its monitoring program are listed in each of these TMDLs as one of the primary entities conducting monitoring to assess the effectiveness of implementation efforts. The MBNEP has selected sites from throughout the estuary and watershed as well as monitoring methodologies with input from the CCRWQCB to ensure that they would provide meaningful information for the TMDL assessment process.

Expected project benefits: MBNEP monitoring provides long-term ambient data to assist the CCRWQB in assessing TMDL progress. The TMDLs are reviewed on a three-year cycle and when those occur, CCRWQCB staff contact the MBNEP to receive updates on projects implemented and data collected. MBNEP data is crucial to the TMDL tracking process as it provides some of the only data from the watershed and estuary for comparison to TMDL targets.

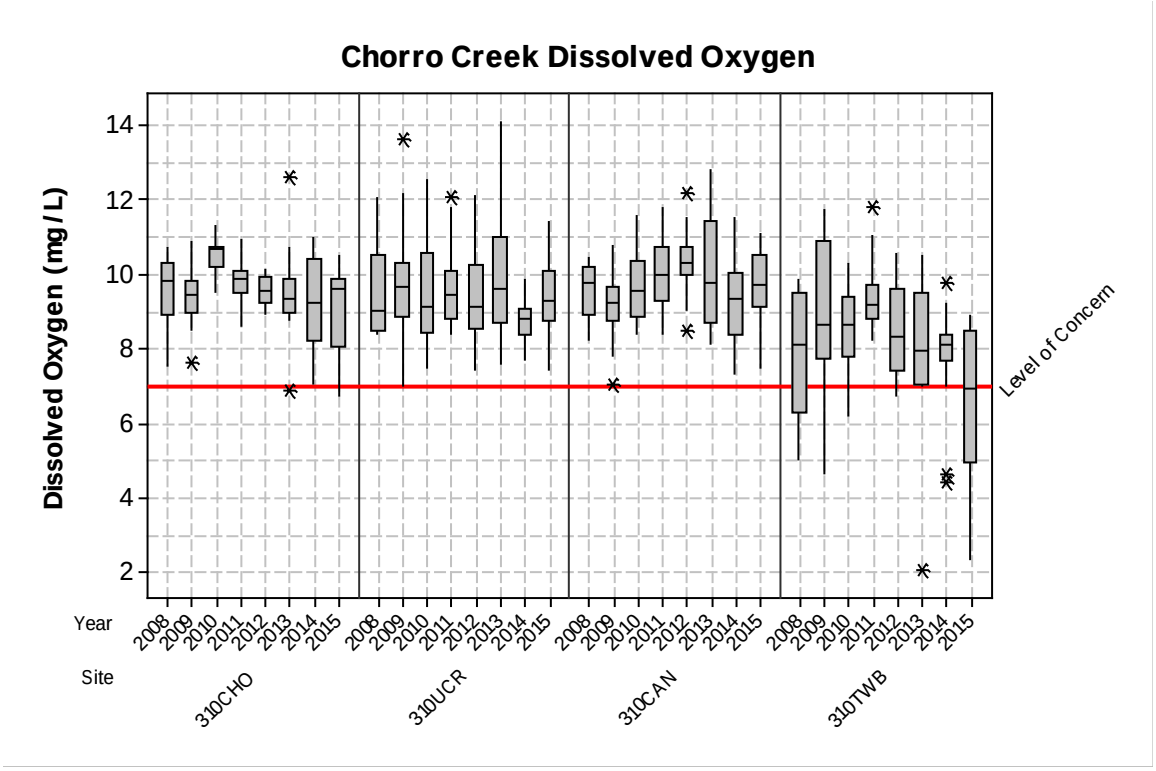
Chorro Creek Nutrients and Dissolved Oxygen

The targets in this TMDL focus on DO levels as well as algal coverage on Chorro Creek. Achieving the numeric targets means DO levels remain above 7 mg/L, median DO % saturation values remain above 85% saturation, and less than 40% algal coverage is present.

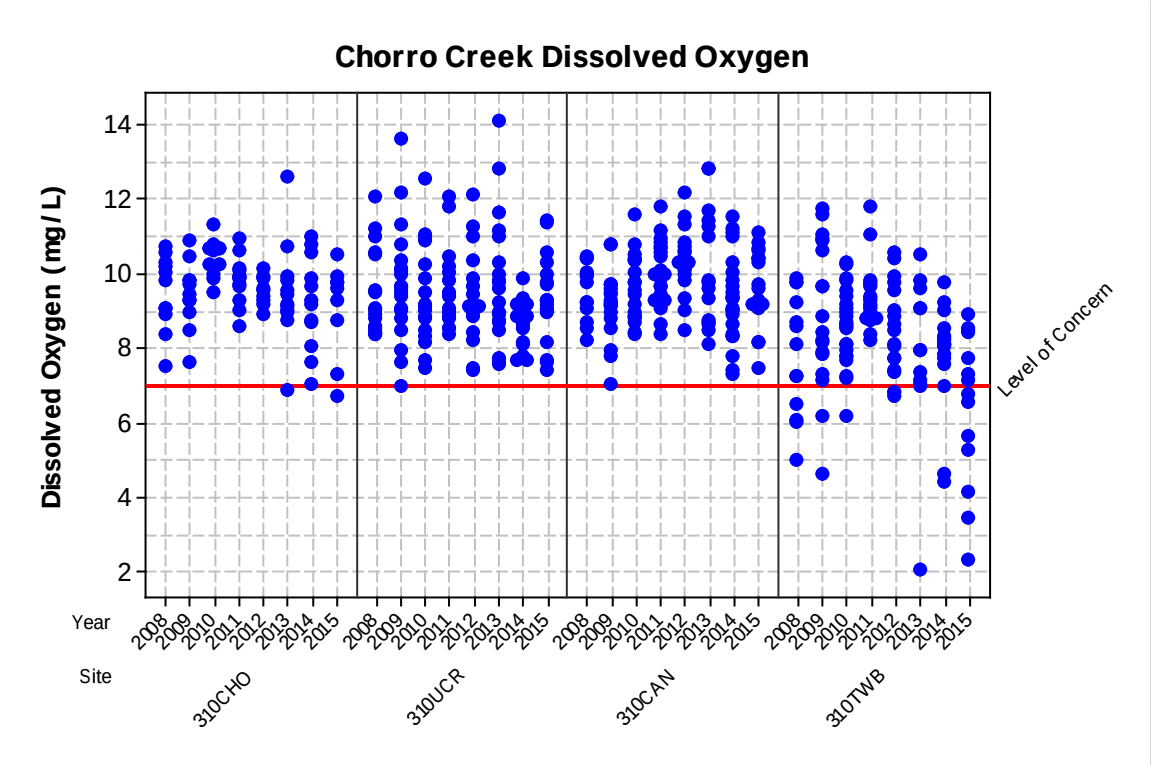
Dissolved Oxygen

Dissolved oxygen measurements are plotted as a concentration in mg/L. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk.

The Central Coast Basin Plan sets a regulatory standard that states that at no time shall DO concentrations fall below 7.0 mg/L.



The data for the same sites is also presented as a scatter plot to show the variability in the data.



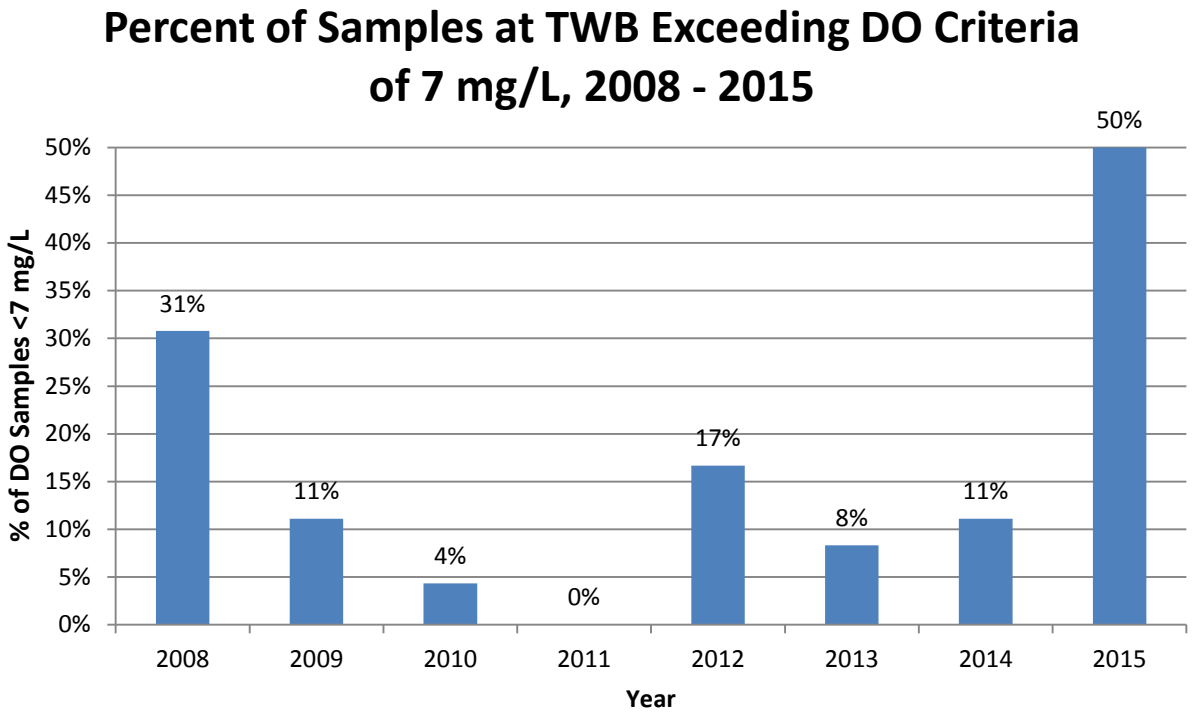
The following tables provide an overview of the DO data, following a format recently adopted by the CCRWQCB in their own analysis of impaired waterbodies. In this analysis, dry season encompasses May to October and the wet season includes November through April.

CHO	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	9.5	9.5	10.5	9.8	9.6	9.5	9.2	9.1
Dry season average	9.0	9.0	10.4	9.5	9.5	9.3	8.3	8.4
Wet season average	10.0	9.8	10.6	10.1	9.6	9.8	10.2	9.9
Range	3.2	2.8	1.8	2.4	1.3	5.7	4.0	3.8
n	11	11	14	13	9	12	12	9
# exceedance for wet season	0	0	0	0	0	0	0	0
# exceedance for dry season	0	0	0	0	0	0	0	1
% exceedance for entire year	0	0	0	0	0	0	0	11

UCR	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	9.5	9.7	9.4	9.6	9.4	9.8	8.7	9.4
Dry season average	9.0	8.8	9.0	9.2	8.8	8.7	8.7	8.8
Wet season average	10.0	10.5	9.9	10.1	10.2	10.6	8.8	10.1
Range	3.7	6.6	5.1	3.7	4.7	6.5	2.2	4.0
n	16	20	17	17	16	19	21	18
# exceedance for wet season	0	0	0	0	0	0	0	0
# exceedance for dry season	0	0	0	0	0	0	0	0
% exceedance for entire year	0	0	0	0	0	0	0	0

TWB	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	7.7	8.9	8.6	9.4	8.5	7.9	7.8	6.5
Dry season average	6.5	7.5	8.2	8.8	7.4	5.9	7.1	3.3
Wet season average	9.3	9.8	9.1	9.7	9.3	8.9	7.9	7.4
Range	4.9	7.1	4.1	3.6	3.8	8.5	5.4	6.6
n	13	18	23	19	17	12	18	14
# exceedance for wet season	0	0	0	0	0	0	1	3
# exceedance for dry season	4	2	1	0	3	1	1	4
% exceedance for entire year	31	11	4	0	18	8	6	29

The following graph shows the percent of DO readings that fell below 7 mg/L during the time period of 2008 to September 2015 at TWB. The increase in 2015 is likely due to the hydrology under the bridge. During low flows, the flow becomes sub-surface through the gravel that has built up under the bridge. When it emerges downstream of the bridge, it continues along to the bay. However DO levels are lower than typical due to the sub-surface flows.



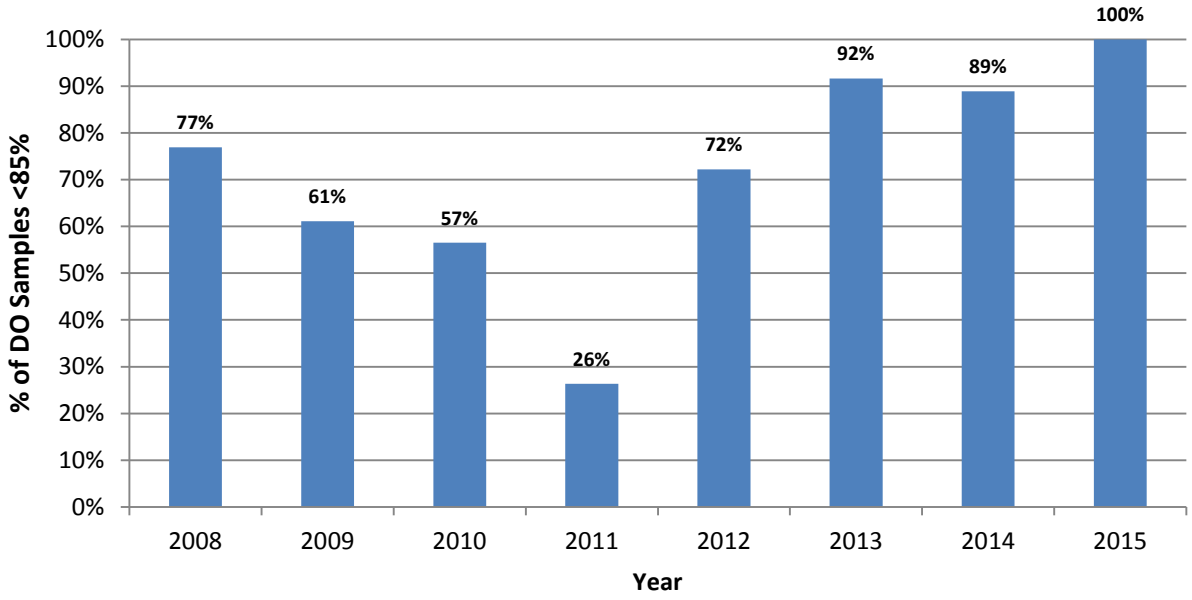
Because the TMDL has numeric targets for the percent saturation criteria as well as concentration, the above analysis was repeated with the percent saturation data.

CHO	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	90.9	94.6	105.5	97.8	95.1	93.8	93.5	93.7
Dry season average	93.7	92.8	108.8	97.7	95.7	94.7	92.0	92.0
Wet season average	88.6	96.0	102.1	97.9	94.7	92.8	94.2	95.8
Range	44.1	33.3	21.4	15.9	11.9	49.5	33.6	30.9
n	11	11	14	13	9	12	12	9
# exceedance for wet season	1	1	0	0	0	1	1	0
# exceedance for dry season	1	1	0	0	0	0	1	2
% exceedance for entire year	18.2	18.2	0.0	0.0	0.0	8.3	16.7	22.2
Median	90.9	85.6	85.0	98.2	95.1	92.8	93.3	96.6

UCR	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	97.0	97.2	96.1	97.2	95.5	96.6	90.8	95.8
Dry season average	96.9	92.8	94.4	97.7	91.5	90.3	93.1	93.1
Wet season average	97.0	100.8	98.0	96.6	0.0	101.2	88.7	98.7
Range	46.	58.1	62.9	33.5	36.9	47.0	23.2	30.3
n	17	20	17	17	16	19	21	19
# exceedance for wet season	2	0	2	0	0	2	3	0
# exceedance for dry season	0	2	1	1	3	2	2	3
% exceedance for entire year	11.8	10.0	17.6	5.9	18.8	21.1	23.8	15.8
Median	94.4	94.1	94.4	94.8	97.8	91.3	90.1	94.3

TWB	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	73.9	84.3	84.6	89.9	79.4	71.8	73.4	60.8
Dry season average	63.7	75.7	83.7	89.3	72.7	57.6	68.1	32.9
Wet season average	84.8	89.7	85.5	90.3	84.8	78.9	74.0	68.4
Range	45.0	68.6	29.6	24.5	31.5	67.1	49.1	56.9
n	14	18	23	19	17	12	18	14
# exceedance for wet season	4	5	5	3	6	7	15	11
# exceedance for dry season	6	6	7	2	8	4	1	3
% exceedance for entire year	71.4	61.1	52.2	26.3	82.4	91.7	88.9	100.0
Median	77.3	81.4	84.4	88.9	80.9	74.2	73.9	65.0

The following plot contains the percent of readings that violate the DO % saturation criteria of 85% saturation. Violations are more common for the % saturation criteria than for the concentration criteria.



In addition to monthly monitoring of water quality, continuous monitoring meters were deployed approximately quarterly. From the data collected, sampling runs from July 2013 and June 2014 had sustained periods of depressed DO concentrations at TWB, likely due to low water levels since the creek went dry at that site in each of those years. A detailed assessment of this dataset is included in the section of this report addressing 303(d) status on Chorro Creek.

The tenth percentile of the DO data was calculated. The DO values would be below this value 10% of the time. The values were as follows:

Site	N	Mean	Std Dev	Min	Median	Quantiles10	Max	Start	End
CHO	91	9.62	1.01	6.70	9.77	8.40	12.62	01/11/2008	09/15/2015
TWB	140	8.11	1.91	1.65	8.34	5.66	11.80	01/31/2008	07/21/2015
UCR	146	9.44	1.29	7.01	9.14	7.76	14.13	01/30/2008	09/14/2015

The DO data was analyzed with a periodic model that allowed for estimation of general trends over time (β_1) as well as annual cycling (β_2 and β_3). Additional semi-annual terms (β_4 and β_5) are also included to account for significant extra semi-annual variation present in many of the analytes. The errors (ε) are assumed to be independent and normally distributed. While the data is time-series data, after accounting for the periodicity and because the sampling frequency was not high, the autocorrelation among errors was minimal.

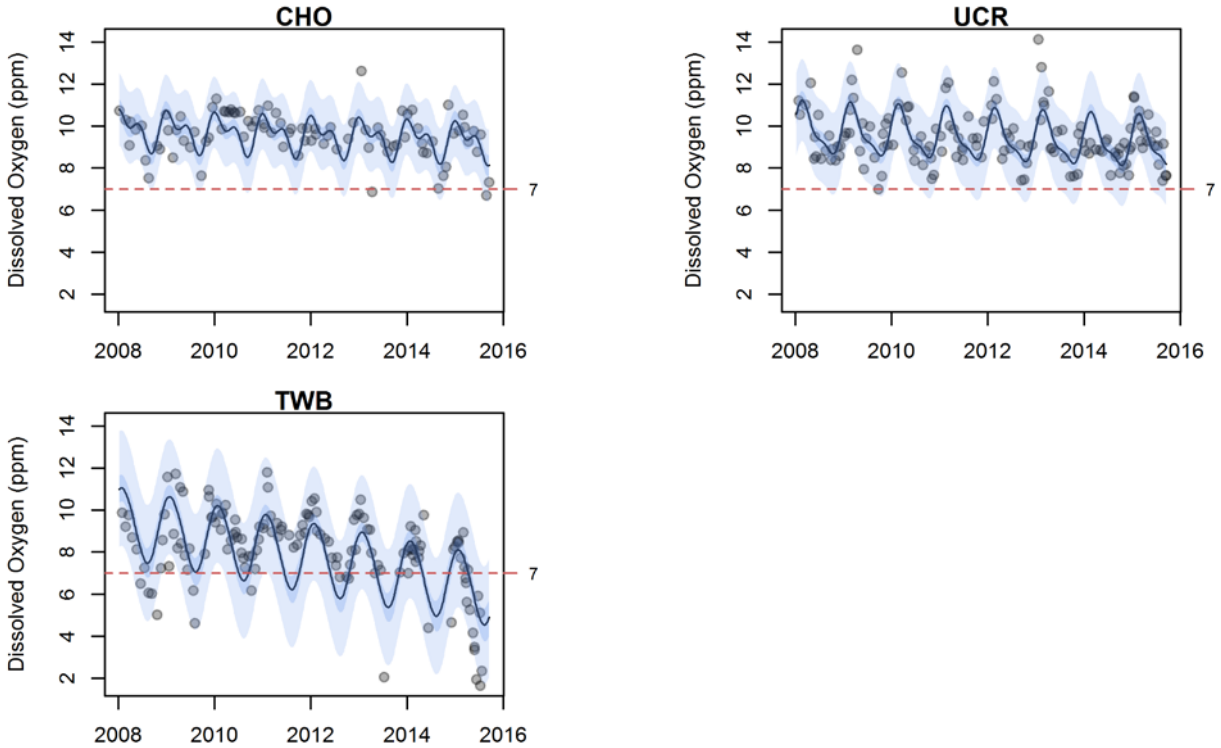
$$y \sim \beta_0 + \beta_1 x + \underbrace{\beta_2 \sin\left(2\pi \frac{x}{365}\right) + \beta_3 \cos\left(2\pi \frac{x}{365}\right)}_{\text{annual period}} + \underbrace{\beta_4 \sin\left(4\pi \frac{x}{365}\right) + \beta_5 \cos\left(4\pi \frac{x}{365}\right)}_{\text{semi-annual period}} + \varepsilon$$

For each site and analyte, three models were fit: (1) the full model shown above, (2) a reduced model without the semi-annual terms, and (3) a model with no periodic terms (i.e., a simple linear model). Reduced models were selected when the partial-F tests for higher order terms were not significant at the $\alpha = 0.01$ level. This level was conservatively chosen to favor simpler models and reduce the chance of Type I errors, as multiple models are being compared.

Plots display the estimated mean (black lines), as well as 95% confidence (darker blue) and prediction (lighter blue) intervals. The prediction interval is particularly useful to compare against the regulatory standards; however, one should use caution and not extrapolate the results. That is, one should not compare the intervals to the regulatory thresholds in regions where there are no or few data values.

The 95% prediction interval is used as an estimate of unobserved analyte values and describes where we would expect these values to fall 95% of the time. Expressed differently, we would only expect about 5% of analyte values to fall outside the prediction interval.

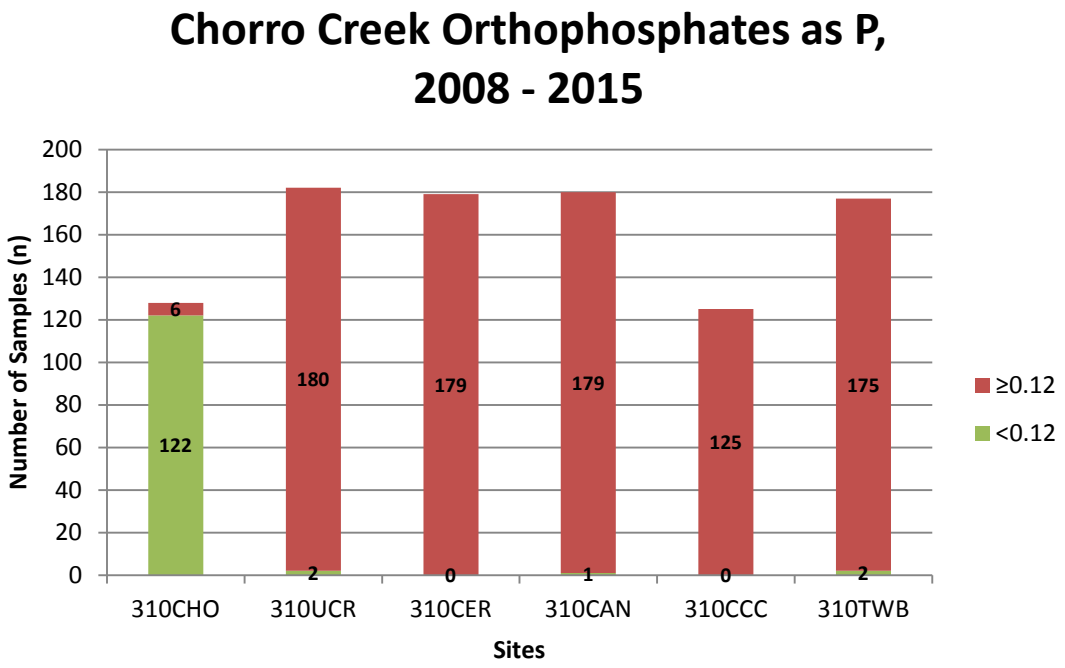
DO concentrations at CHO and UCR have been consistently above the regulatory threshold. Dissolved oxygen concentrations at TWB have periodically fallen below the threshold and recently have been consistently below the threshold. All three sites have statically significant downward trends (p-value = 0.0376, 0.0092, <0.0001 for CHO, UCR and TWB respectively).



At TWB, the more recent low readings are driving the overall downward trend. In the past two years, flow at TWB has gone sub-surface underneath the bridge where the substrate has built up over the years. The creek continues to flow normally downstream of the bridge, however the flow has lower than normal DO levels. This is the likely reason for the depressed DO levels which is driving the overall trend.

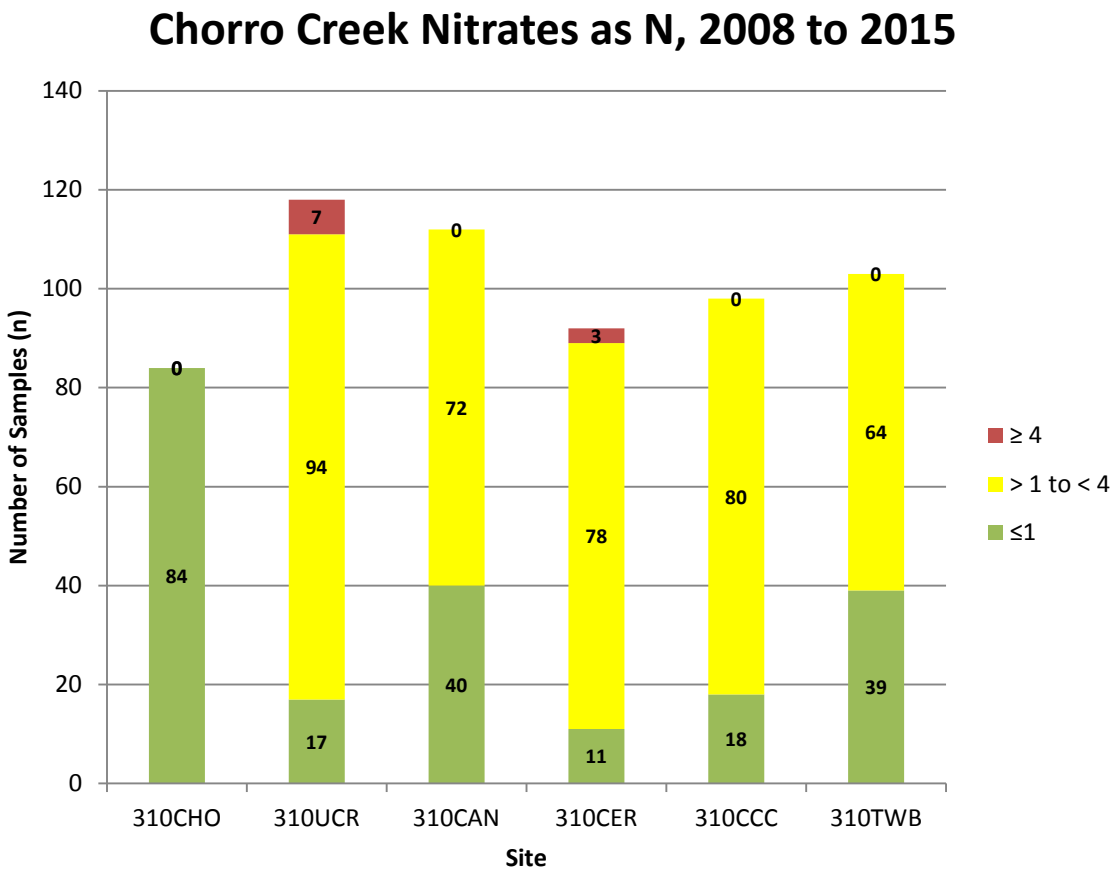
Nutrients

The CCAMP informal attention level for orthophosphates is 0.12 mg/L as P, a value created specifically for the Pajaro River but adapted for the Morro Bay watershed. This value was developed to be protective of aquatic life. The following bar graph illustrates the number of samples with orthophosphate as P concentrations in two categories: less than 0.12 mg/L as P (shown in green) and greater than or equal to 0.12 mg/L as P (shown in red). Site CHO is located above the CMC WWTP outfall on Camp SLO property, while the remaining five sites are located downstream of the WWTP outfall. The data included in the graph is from 2008 through 2015.



The CCRWQCB 303(d) Listing Guidance Value for nitrates as nitrogen is 1.0 mg/L to be protective of aquatic life. The drinking water standard protective of human health is 10.0 mg/L.

The following plot shows the number of nitrate as nitrogen samples in each of three categories: less than or equal to 1 mg/L (shown in green), greater than 1 and less than 4 mg/L (shown in yellow), and greater or equal to 4 mg/L (shown in red). The plot includes data collected from January 2008 through September 2015. During this time period, nitrate as N values greater than 10 mg/L have not been detected.



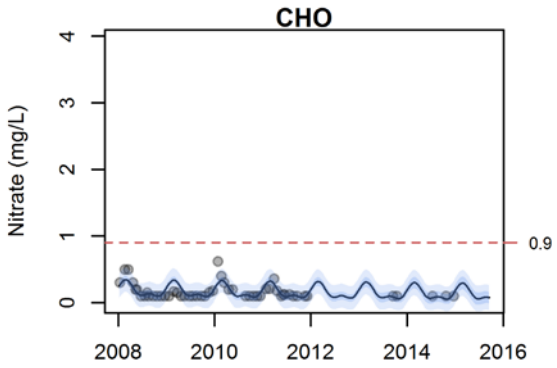
Further analysis was conducted with lab-generated nitrate as nitrogen data. The 90th percentile of the data was calculated. This means that 90% of the time, the nitrate concentrations are less than these values.

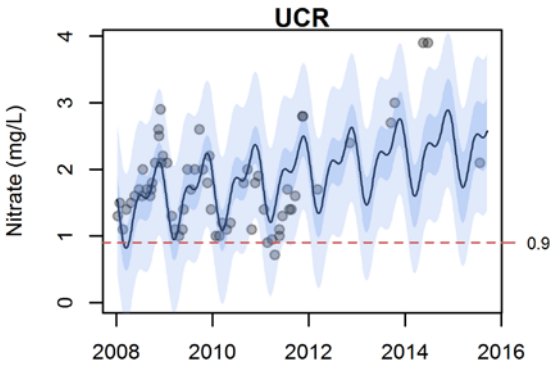
Site	N	Mean	Std Dev	Min	Median	Quantiles90	Max	Start	End
CHO	53	0.167	0.118	0.100	0.100	0.336	0.620	01/14/2008	12/21/2014
TWB	60	2.047	0.583	0.100	2.100	2.700	3.200	01/14/2008	06/11/2015
UCR	63	1.769	0.675	0.720	1.700	2.760	3.900	01/14/2008	07/22/2105

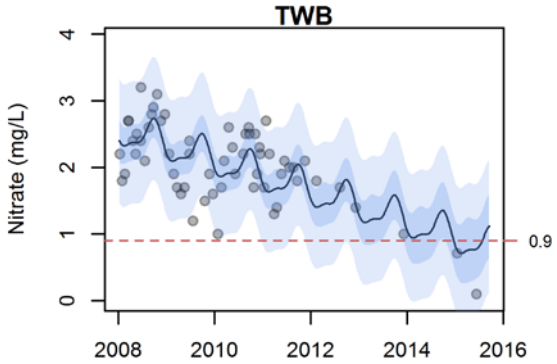
Analysis was conducted with the same regression model as was used for the DO data. The nitrate levels at CHO have been consistently below threshold values. While the data after 2012 is sparse, there is no evidence of any temporal trends at CHO (p-value = 0.3121). There is significant evidence of an increasing trend at UCR (p-value = 0.0021) and decreasing trend at TWB (p-value < 0.0001). However the sparse data more recently at TWB means that this is an extrapolation rather than a trend.

Plots display the estimated mean (black lines), as well as 95% confidence (darker blue) and prediction (lighter blue) intervals. The prediction interval is particularly useful to compare against the regulatory standards; however, one should use caution and not extrapolate the results. That is, one should not compare the intervals to the regulatory thresholds in regions where there are no or few data values.

The 95% prediction interval is used as an estimate of unobserved analyte values and describes where we would expect these values to fall 95% of the time. Expressed differently, we would only expect about 5% of analyte values to fall outside the prediction interval.

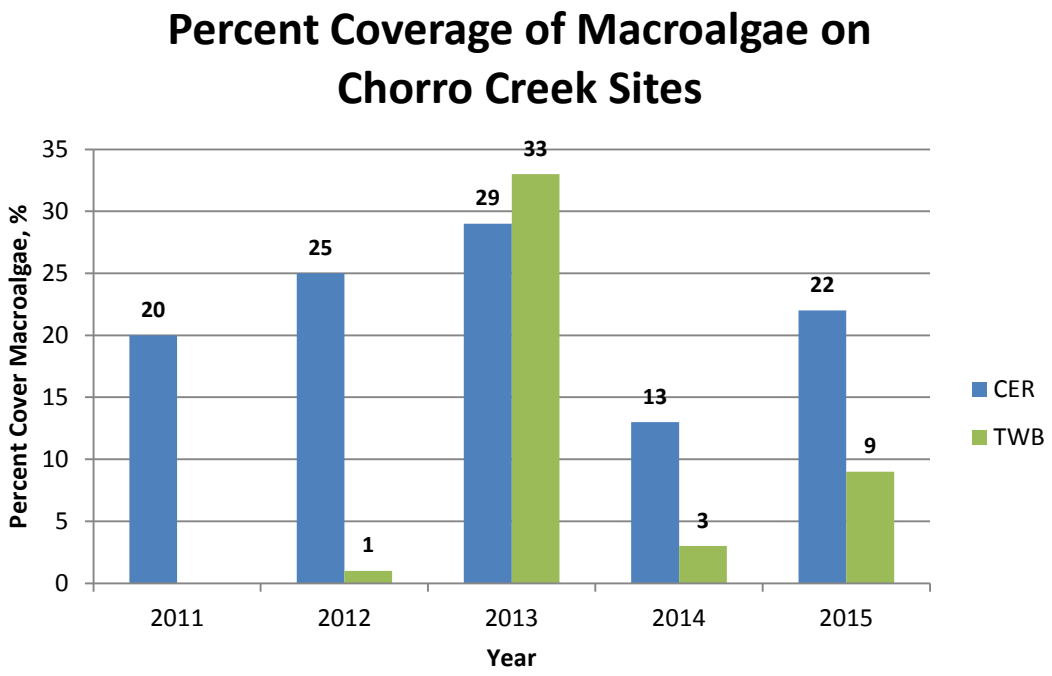




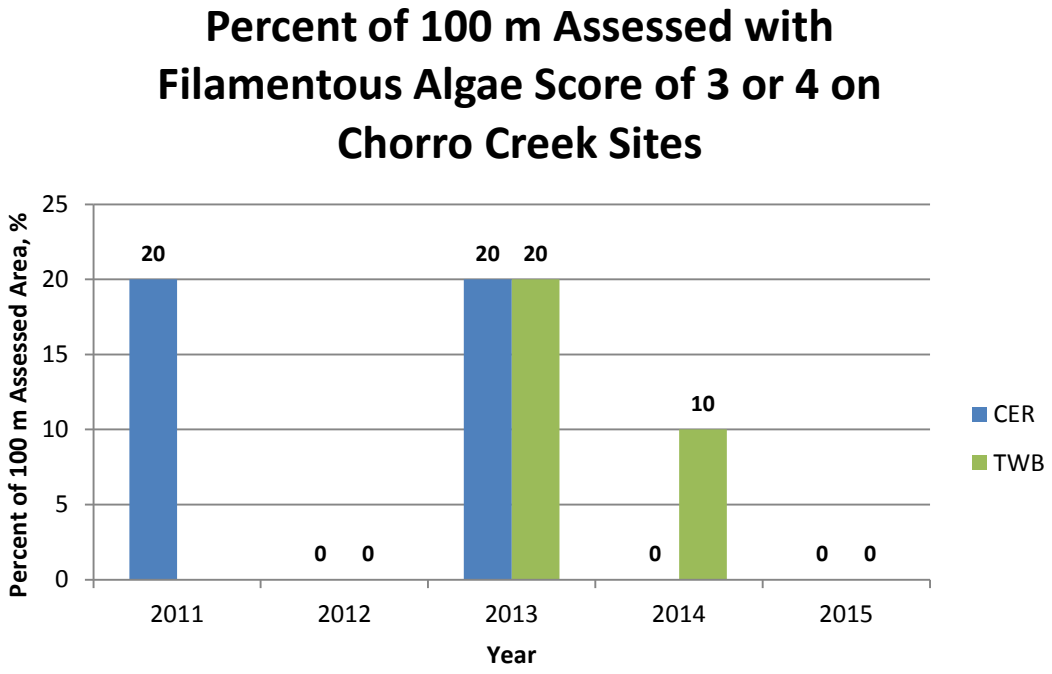


Algae Data

Algae data was analyzed through two data sets generated by bioassessment monitoring at CER and TWB. The percent coverage of macroalgae at the site was determined by calculating algae presence at wetted points located on the transects and inter-transects. This calculated value is used to represent percent algal coverage throughout the 150 m reach.



Additionally, the qualitative spatial coverage of filamentous algae was scored for defined areas 5 m above and 5 m below each of ten transects assessed within each site. Each assessment area (10 m of wetted reach) was assigned a score between 0 to 4, with 0 indicating less than 5% algae coverage, 1 indicating less than 10% coverage, 2 indicating 10 to 40% coverage, 3 indicating 40 to 75% coverage, and 4 indicating greater than 75% coverage.



Conclusions for Chorro Creek Nutrient and DO TMDL

The data presented, which spans 2008 to 2015, indicates minimal issues with DO levels at CHO and UCR. TWB had greater than 10% of samples fall below 7 mg/L for DO in five of the eight years assessed. Regression modeling shows a statistically significant downward trend in DO at all three sites. The percent average of algae cover has been consistently below the 40% numeric target. Nutrient data indicates elevated orthophosphates and nitrates downstream of the CMC WWTP. The site upstream of the plant does not have elevated concentrations of either nutrient. While the TMDL does not contain a numeric target for nutrients, it is noteworthy that the levels downstream of the CMC plant are elevated above the guidance values determined to be protective of aquatic life. There were no measured nitrate concentrations that exceeded the drinking water standard at any of the monitoring sites during the eight-year period assessed. Regression modeling of nitrate data indicates no trend at CHO. The model shows an increasing trend at UCR and a decreasing trend at TWB, although minimal data makes this more of an extrapolation.

Los Osos, Warden Creek and Warden Lake Nutrients

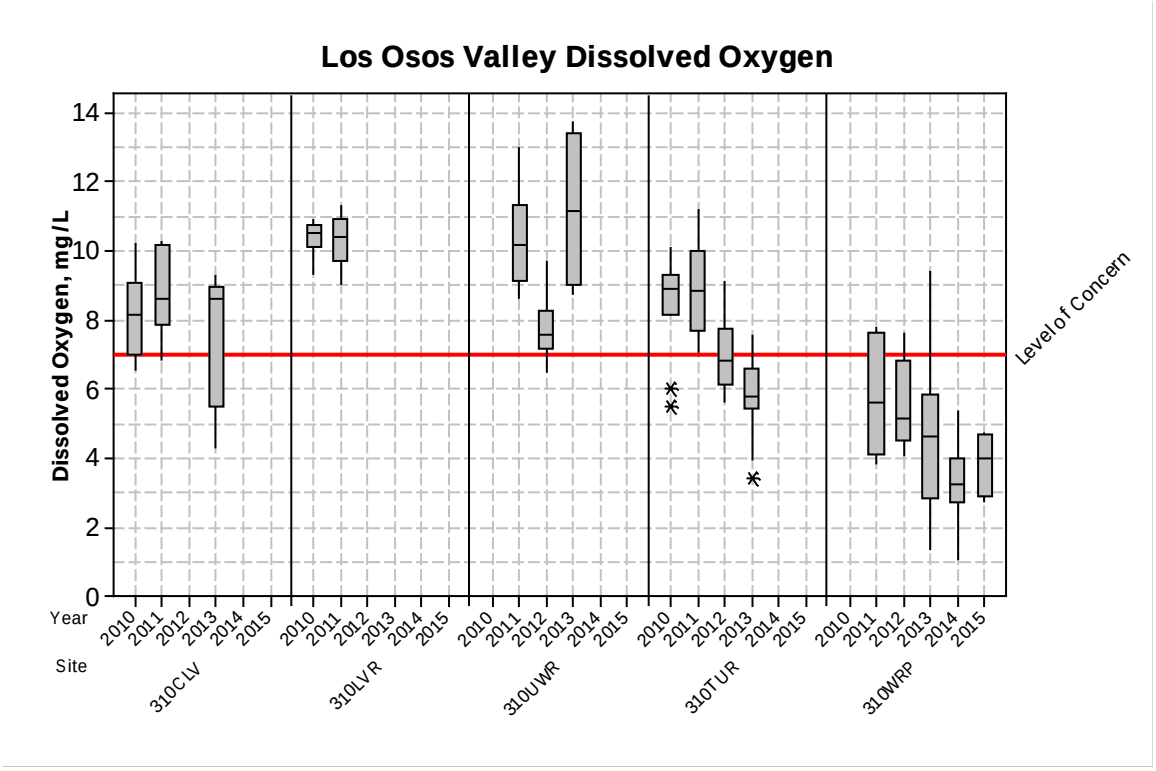
This TMDL addresses nitrate concentrations on Los Osos Creek, Warden Lake and Warden Creek. This TMDL contains a numeric target for nitrates as N of 10 mg/L to protect the MUN beneficial use on Warden Creek. MBNEP monitoring and analysis was focused on the two creeks.

Dissolved Oxygen

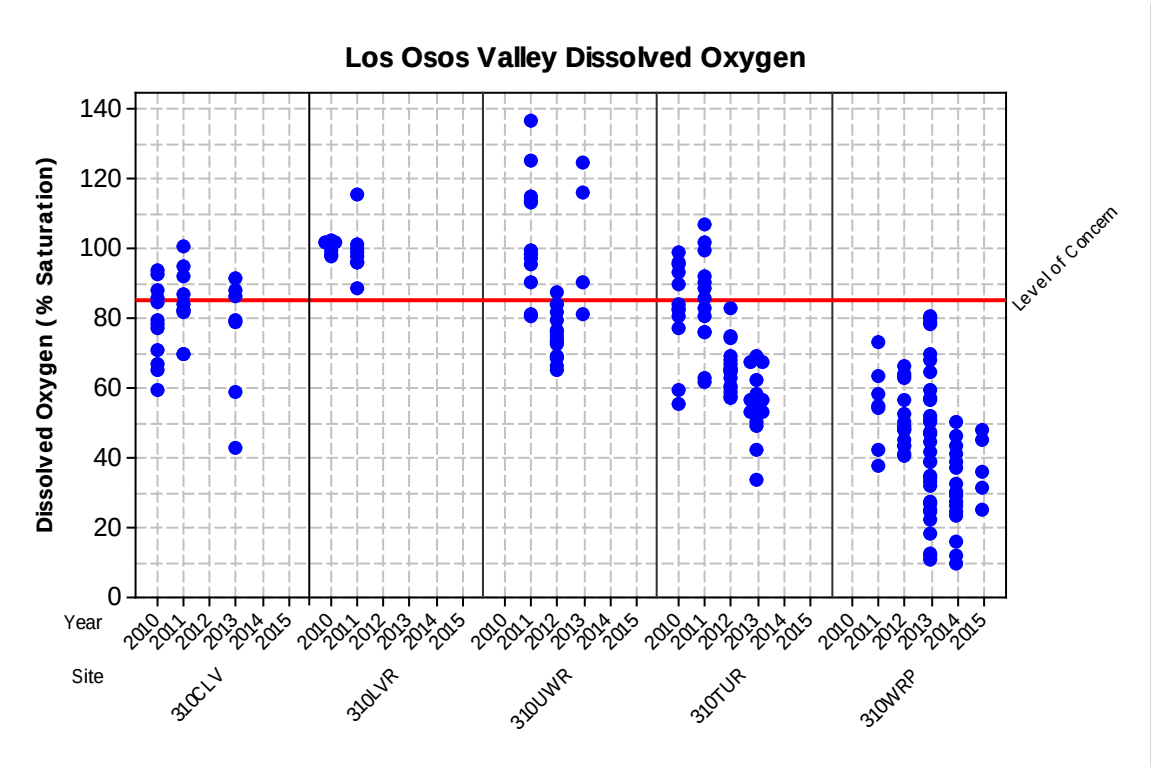
Due to the link between nutrient concentrations and DO levels, the MBNEP conducted analysis of DO on the creeks. Los Osos Creek has a Water Quality Objective of 7 mg/L for DO levels in habitat with the beneficial use of SPWN. The general numeric objective for DO, that the median value should not fall below 85% saturation, applies to Warden Creek.

The following graph shows the DO concentration data at three sites on Warden Creek and CLV in Los Osos Creek. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk. The Central Coast Basin Plan set a regulatory standard that states that at no time shall DO concentrations fall below 7.0 mg/L.

Time of day has a significant impact on DO levels. Monitoring at the three Warden Creek sites consistently occurred on the same day, i.e., the monitoring team would visit all three sites within a two-hour period.



The following plot shows a scatter plot of the same data.

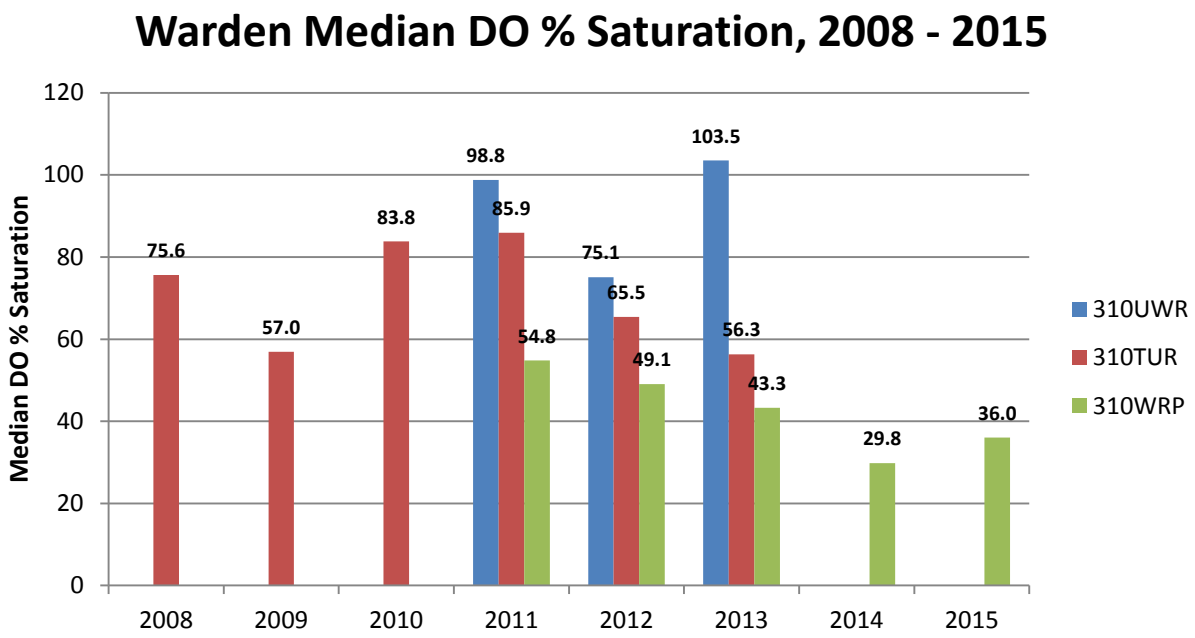


The following tables provide an overview of the DO % saturation data, following a format recently adopted by the CCRWQCB in their own analysis of impaired waterbodies. In this analysis, the dry season encompasses May to October and the wet season includes November through April.

UWR	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	-	-	-	103.7	75.7	103.3	-	-
Wet season average	-	-	-	97.0	76.7	103.3	-	-
Dry season average	-	-	-	118.7	74.1	-	-	-
Range	-	-	-	55.8	22.3	43.2	-	-
n	-	-	-	13	15	4	-	-
# exceedance for wet season	-	-	-	2	8	1	-	-
# exceedance for dry season	-	-	-	0	6	-	-	-
% exceedance for entire year	-	-	-	15.4	93.3	25.0	-	-
Median	-	-	-	98.8	75.1	103.5	-	-

TUR	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	74.7	60.6	83.2	85.2	66.1	55.9	-	-
Wet season average	74.5	62.0	89.9	86.3	70.2	57.8	-	-
Dry season average	75.6*	56.4*	76.6	82.8	60.9	53.1	-	-
Range	37.3	32.4	43.6	44.9	25.7	35.6	-	-
n	5	4	12	13	16	20	-	-
# exceedance for wet season	3	3	2	3	9	12	-	-
# exceedance for dry season	1	1	5	3	7	8	-	-
% exceedance for entire year	80.0	100.0	58.3	46.2	100.0	100.0	-	-
Median	75.6	57.0	83.8	85.9	65.45	56.3	-	-

WRP	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	-	-	-	54.9	51.7	44.5	30.6	37.3
Wet season average	-	-	-	65.1	56.9	48.4	30.4	37.3
Dry season average	-	-	-	47.3	45.0	39.5	32.5	-
Range	-	-	-	35.2	25.7	70.1	40.9	22.5
n	-	-	-	7	16	32	17	5
# exceedance for wet season	-	-	-	3	9	18	15	5
# exceedance for dry season	-	-	-	4	7	14	2	-
% exceedance for entire year	-	-	-	100.0	100.0	100.0	100.0	100.0
Median	-	-	-	54.8	49.1	43.3	29.8	36.0

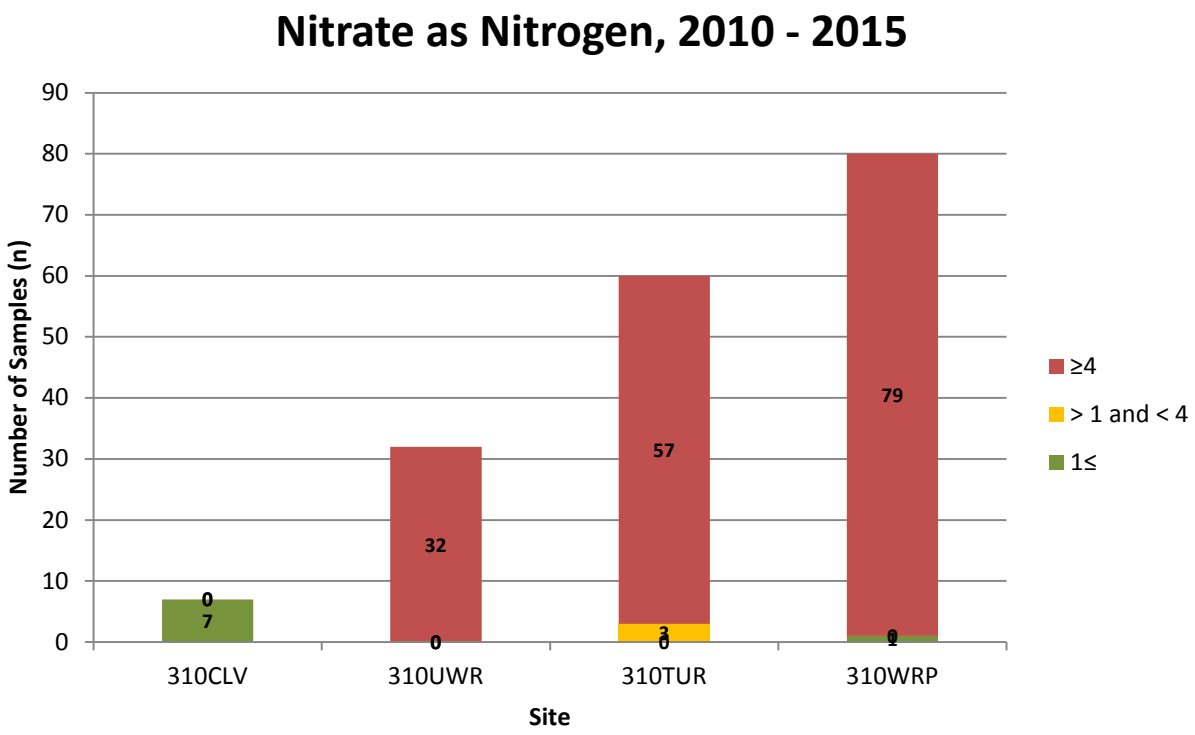


Nutrients

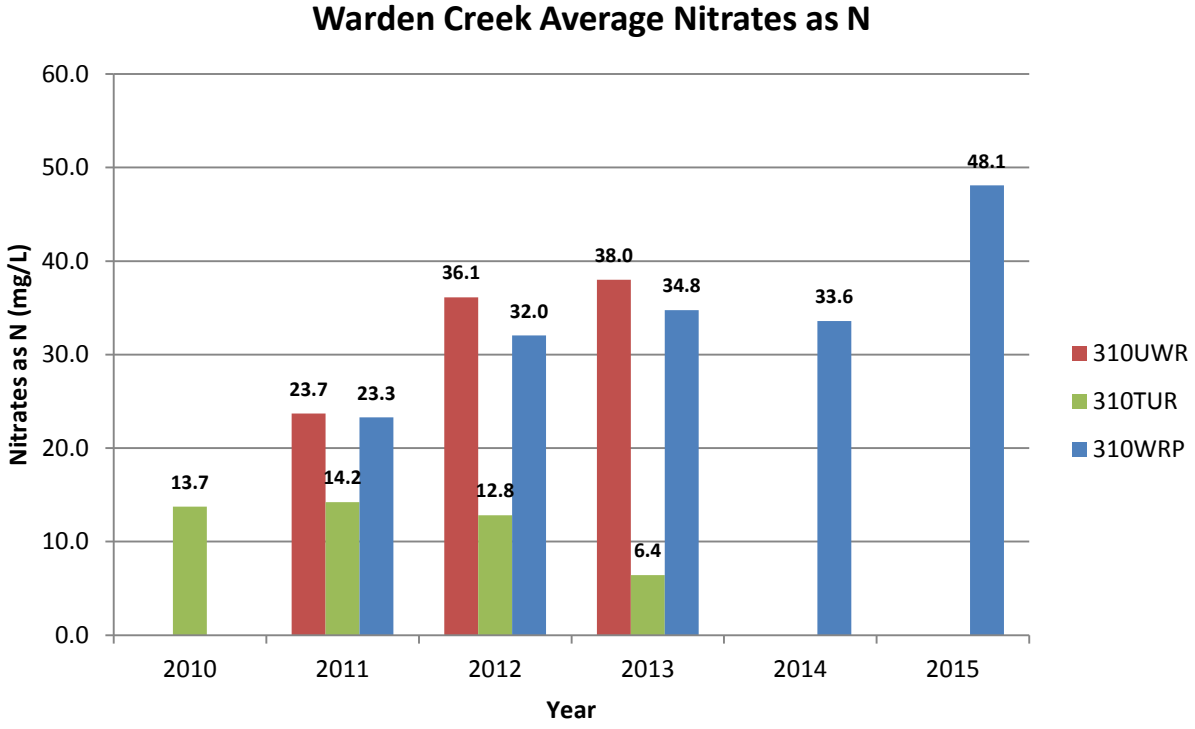
The MBNEP measured nitrates as nitrogen during each water quality field visit. Samples were collected by trained staff and volunteers. For samples from CLV, analysis was conducted at the MBNEP office using field colorimeters.

The MBNEP collected samples which were sent to a certified laboratory for nutrient analysis. The following graphs contain the lab-generated nutrient data for sites UWR, WRP, TUR and LVR from 2010 through 2012. Due to lower than average annual rainfall, LVR did not have measurable surface flows during 2012, 2013, 2014 or 2015.

The following plot shows the number of nitrate as nitrogen samples in each of three categories: less than or equal to 1 mg/L (shown in green), greater than 1 and less than 4 mg/L (shown in yellow), and greater than or equal to 4 mg/L (shown in red). The data is lab-generated analysis for UWR, TUR and WRP on Warden Creek. The data from CLV included in the graph was generated using a HACH colorimeter during 2013. All seven results were less than 1 mg/L. From 2010 through 2012, CLV was monitored 22 additional times for nitrates using a LaMotte 3354 nitrate as N kit, and all results were less than 1 mg/L. While this data can only be considered screening level data and was not included in the analysis, it indicates a long-running trend of minimal nitrates at the site.



The average nitrate concentrations for the three sites on Warden Creek from 2010 through 2015 are illustrated in the following graph. All data used in this analysis was from analysis by a certified laboratory.



Conclusions for Los Osos and Warden Creek Nutrient TMDL

The data presented, which spans 2008 to 2015, indicates minimal issues with DO levels at CLV on Los Osos Creek and UWR on Warden Creek. TUR and WRP on Warden Creek had more frequent violations of the median remaining above 85% saturation during the same time period. Although only screening level data is available for CLV, the nitrate levels are typically below 1 mg/L. Of note is that CLV is located fairly high in the watershed and does not capture the influence of potential downstream anthropogenic sources. Nitrate data from the three Warden Creek sites consistently exceeded the drinking water standard of 10 mg/L during the time period analyzed. Nitrates at UWR and WRP were typically higher than the values at TUR. Warden Creek had issues with both DO and nitrates that make it appear unlikely that TMDL targets will be met. Los Osos Creek in the upper watershed had excellent water quality, but the influence of human activity downstream of the monitoring site was not captured in the current monitoring scenario.

MORRO BAY (INCLUDING CHORRO AND LOS OSOS CREEKS) SEDIMENT TMDL

The TMDL addresses sediment loading to the bay from throughout the watershed. The numeric targets in this TMDL address residual pool volume, tidal prism volume, median diameter of sediment particles in spawning gravels, percent of fine fines in spawning gravels, and percent of coarse fines in spawning gravels, none of which are collected by the MBNEP. These metrics have not been a part of more recently developed TMDLs.

The MBNEP conducts suspended sediment concentration (SSC) and turbidity monitoring in Chorro, San Luisito and Walters Creeks during storms. Estimates of sediment loading developed using this SSC data can be compared to the values documented in the TMDL staff report. Additionally, more recent sediment TMDLs have included methods by Dave Herbst of the Sierra Nevada Aquatic Research Lab (SNARL) looking at a combination of macroinvertebrate data and habitat data collected during bioassessment monitoring. MBNEP data was also compared to some of the criteria for the Herbst analysis to assess the impacts of sedimentation on bioassessment criteria. So while the data collected and analyzed by the MBNEP does not allow direct comparison to TMDL numeric targets, it does provide some context for sedimentation in the watershed and estuary.

SUSPENDED SEDIMENT CONCENTRATION

The MBNEP has permanent sediment monitoring stations on Chorro Creek at Canet Road (site code CAN), at San Luisito Creek near the frontage road (SLU) and on Walters Creek at the historic flume site that was monitored during the NMP (WAL). Each of the stations consists of an ISCO automated sampler to collect water at pre-determined time periods and a bubbler or pressure transducer to determine water depth. A rain gauge was installed at CAN to provide rainfall data for all three stations. During storm events, the MBNEP programs the ISCOs to collect water from the creeks. The samples are analyzed for turbidity and for SSC. This data, along with discharge data, can be used to estimate annual sediment loading from the three stations. This monitoring effort is discussed in much greater detail in the MBNEP's annual sediment monitoring reports which are available at www.mbnep.org.

The following table provides the annual discharge and an estimate of annual sediment load for the 2009, 2010 and 2011 rain years (Oct. 1 to Sept. 30).

Chorro Creek	2008 to 2009	2009 to 2010	2010 to 2011
Annual Discharge, acre-ft/yr	20,220	29,796	38,357
Annual estimated sediment load, tons	146	8,604	136,043

For comparison, the Sediment TMDL contains a table of event-based and annual average loadings. This information is of interest for comparison of MBNEP SSC load data. The following is Table 18 from the Morro Bay TMDL for Sediment, Appendix 2, prepared on April 24, 2002. The original source of the table was the *1998 Morro Bay Estuary Sediment Study* by TetraTech.

Watershed	Events (tons)						Probability-weighted avg event (tons/yr)	Annual Average Loading (tons/yr)	Annual Loading
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr			
Chorro Creek at res.	1170	4947	11258	29472	53994	93471	5946	13082	19%
Dairy Creek	17	157	551	2135	4631	9303	400	880	1%
Pennington Creek	40	372	1269	4688	10100	19891	878	1932	3%
San Luisito Creek	150	2685	9431	35681	77408	154863	6650	14630	21%
San Bernardo Creek	263	3940	13463	50244	107498	214041	9336	20539	29%
Minor tributaries	510	2906	7293	21256	40541	72829	4081	8978	13%
Chorro Creek	**1330**	**13634**	**43354**	**154348**	**325075**	**637272**	**28897**	**60041**	**86%**
Los Osos Creek		551	2838	14509	34624	7554	2775	6105	9%
Warden Creek		413	1870	8559	20040	43616	1647	3624	5%
Los Osos Creek	**38**	**1089**	**5321**	**26067**	**61771**	**134661**	**5012**	**9729**	**14%**
Morro Bay Watershed							**33910**	**69770**	**100%**

Analysis conducted on Chorro Creek over three years indicated that most of the sediment transport occurred during bigger storms. Specifically on Chorro Creek, a water year with 20,220 acre-feet of flow had 146 tons/year of sediment load, while a water year with 38,357 acre-feet had 136,043 tons/year of sediment loading. Note that the average annual loading was determined by TetraTech to be 60,041 tons/year for the Chorro Creek subwatershed.

On March 20, 2011, flows at Chorro Creek during a storm event peaked at 5,956 cfs from 3 to 3:30 a.m., which exceeds most estimated criteria for 10-year flood frequency event. The estimated sediment load during that half hour time period was approximately 87,000 tons. This value does not include sediment transported during the entire storm event, which lasted for 36 hours. The TetraTech analysis determined 43,354 tons of sediment from a 10-year event (it is unclear whether this is a 10-year storm or a 10-year flood), which is nearly half the measured sediment load for only a portion of that particular event. The annual load for that year was 136,043 tons, which greatly exceeds the 60,041 tons/year annual average loading for the Chorro subwatershed that was estimated by TetraTech.

STREAMBED SEDIMENT IMPAIRMENT INDICATORS

The relationship between aquatic health in a watershed and impacts due to sediment loading is of great interest in the regulation of sediment. Over a three-year period, researchers from SNARL (associated with the University of California) conducted research to develop numeric targets for sediment impairment and biological thresholds in riverine systems in the Central Coast region. Although these criteria were not specifically developed for the Morro Bay watershed, they are being evaluated for assessments throughout the Central Coast region. Initial analysis shows that the indicators are applicable in the Central Coast region.

An extensive number of indices were tested across a gradient of test sites. The final outcome included 16 indicators of sediment impairment on aquatic habitat. The indicators cover both the physical characteristics (sediment) and the biological community.

A significant data collection effort is required to determine the status of all 16 sediment and biological indicators for a study reach. The current SWAMP Bioassessment Protocol metrics can be used to generate seven (in bold) of the nine sediment indicators, and six (in bold) of the seven biological indicators.

Sediment Indicators:

1. **Percent of Fines (F) on transects**
2. **Percent of Sand (S) on transects**
3. **Percent of Fines (F) + Percent of Sands (S) on transects**
4. **Percent of Fines, Sands and Gravels < 8mm on transects**
5. **D50 Median particle size**
6. Percent patch-scale grid Fines and Sands
7. Log Relative Bed Stability
8. **Percent of Fines (Steelhead)**
9. **Percent Cover of Fines and Sands (BMI Limits)**

Biological Indicators:

1. **Total Richness**
2. **EPT Richness**
3. **% EPT**
4. **Biotic Index**
5. **Percent Tolerant**
6. **Sensitive Number**
7. Crayfish Number and Size

There are three threshold criteria for comparison of each of these indicators, shown in the following table of sediment and biological indicator criteria.

	Recommended Numeric Targets To Support Beneficial Uses	Recommended Numeric Targets to Support Preliminary 303(d) Listing (lower priority)	Recommended Numeric Targets To Support 303(d) Listing (high priority)
Sediment Indicators		**75/25**	**90/10**
Percent Fines on transects	<8.5%	8.5 to 15.2%	>15.2%
Percent Sands on transects	<27.5%	27.5 to 35.3%	>35.3%
Percent Fines + Sands on transects	<35.5%	35.5 to 42.0%	>42.0%
Percent Fines, Sands, Gravel <8mm on transects	<40.0%	40.0 to 50.2%	>50.2%
D50 median particle size	>15 mm	7.7 to 15 mm	<7.7 mm
Percent Fines (steelhead)	<6%	6 to 10%	>10%
Percent cover of FS (BMI limits)	<30%	30 to 40%	>40%
Biological Indicators		**75/25**	**90/10**
Total Richness	>50.0	<50.0	<44.2
EPT Richness	>16.5	<16.5	<11.6
Biotic Index	<5.48	>5.48	>5.92
Percent Tolerant	<26.3%	>26.3%	>37.7
Sensitive Number	>9.5	<9.5	<5.8

The MBNEP has conducted SWAMP Bioassessment on an annual basis since 2007. Sites are selected for monitoring based on program data needs and hydrologic conditions. Thus, many sites are monitored on a rotating basis, and data is not available across all sites each year.

Five bioassessment monitoring sites were selected to be included in this analysis. These monitoring sites are located on Pennington Creek (site code UPN), San Luisito Creek (site code LSL), San Bernardo Creek (site code MNO), Chorro Creek, lower (site code TWB), and Chorro Creek, middle (site code CER). A map of the monitoring locations is included in Section 2 of this report. The scores for six years were averaged (2008, 2010, 2012, 2013, 2014 and 2015) for the analysis for MNO and for LSL. Six years of data (2008, 2011, 2012, 2013, 2014 and 2015) was averaged for the analysis for UPN and for CER. For TWB, data from 2008, 2012, 2013, 2014 and 2015 were used. Averaged scores are presented in the following table. Each indicator is color-coded red, yellow or green to designate the appropriate category of impairment.

	Sediment Indicators							Biological Indicators					
Site Code	Percent Fines	Percent Sands	Percent <8mm	FS Sum Percent	D50 Median particle size	Percent Fines (steelhead)	Percent cover of FS (BMI limits)	Total Richness	EPT Richness	Percent EPT	Biotic Index	Percent Tolerant	Sensitive Number
310UPN	2.7	10.1	16.1	12.8	75.3	2.7	12.8	62.2	19.5	32.9	4.7	6.8	13.2
310MNO	3.1	16.5	25.0	19.6	23.8	3.1	19.6	57.3	13.7	30.3	5.7	11.0	7.7
310LSL	10.3	14.3	32.8	24.6	14.5	10.3	24.6	50.2	13.3	19.5	4.9	10.4	8.0
310TWB	12.3	21.6	46.5	33.8	8.5	12.3	33.8	45.0	7.0	8.9	6.5	22.2	3.2
310CER	16.6	18.5	38.5	35.1	15.9	16.6	35.1	42.2	8.7	20.0	5.9	17.0	1.7

Recommended numeric targets to support beneficial uses

Recommended numeric targets to support preliminary 303(d) listing (low priority)

Recommended numeric targets to support 303(d) listing (high priority)

The two sites on Chorro Creek, TWB and CER, have four criteria in the high priority for 303(d) listing range and several criteria in the low priority for listing range, out of a total of 13 criteria assessed. The site on San Luisito Creek, LSL, has four of the 13 criteria scoring in the low priority for 303(d) listing category. The sites on Pennington Creek (UPN) and San Bernardo Creek (MNO) have averaged results for all 13 criteria that fall in the category of supporting beneficial uses.

Conclusions for Morro Bay Sedimentation TMDL

While monitoring efforts by the MBNEP do not allow for direct comparison to Sedimentation TMDL targets, the sediment monitoring does provide some indication of the progress with sedimentation:

- Suspended Sediment Concentration monitoring: The results of three years of estimated annual loading indicated that most of the sediment moves during the larger storm events. This variability makes an average annual sediment load a poor estimate of actual sediment loading.
- Streambed Sediment Impairment Indicators: A preliminary application of this method, which is still under development by SNARL researchers, indicated that two sites on Chorro have potential issues meriting a high priority for 303(d) listing. For the site on San Luisito Creek, four of the 13 indicators are in the low priority for listing category, and the remaining nine indicators are in the category of supporting beneficial uses. The sites on Pennington and San Bernardo Creeks have all 13 indicators in the category of supporting beneficial uses, indicating minimal impairment by sediment.

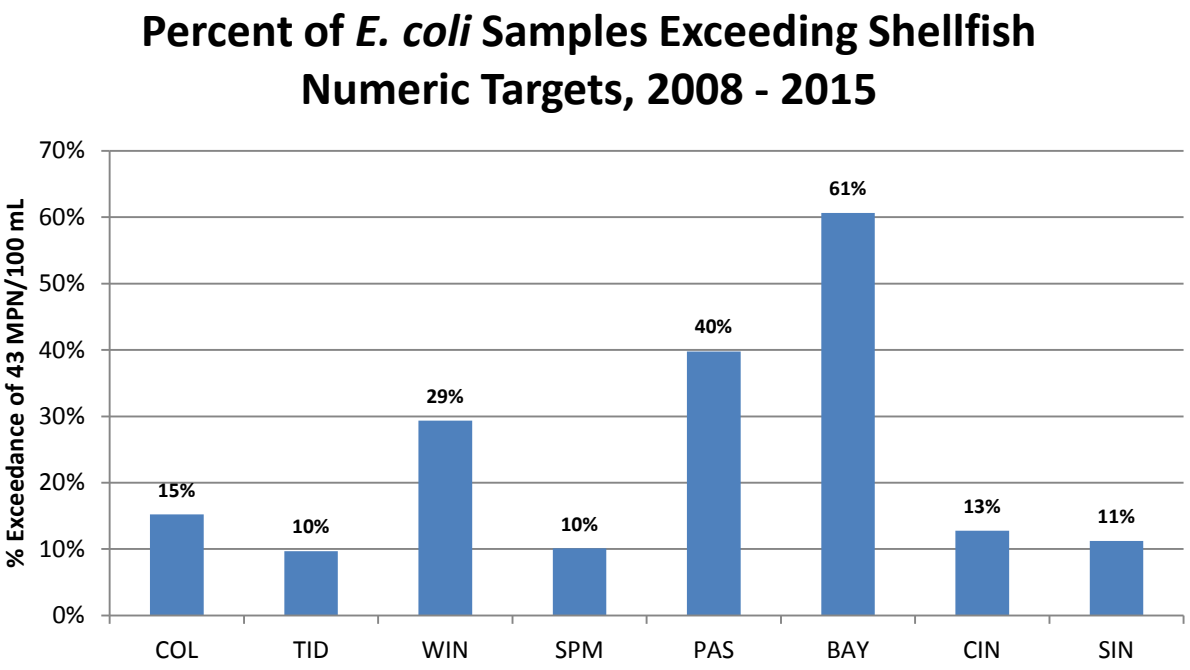
Morro Bay (including Chorro and Los Osos Creeks) Pathogens TMDL

The pathogen TMDL addresses protection of Morro Bay and its tributaries for recreational use and shellfish harvesting. The numeric targets are for fecal coliform. For the bay, the geomean of monthly sampling evaluated over an annual or triennial basis should not exceed 14 MPN/100 mL. No more than 10% of total samples may exceed 43 MPN/100 mL when evaluated over an annual and triennial basis. For the creeks and freshwater seeps along the Los Osos shoreline, there are two numeric targets for fecal coliform. The geomean of not less than five samples over a period of 30 days cannot exceed 200 MPN/100 mL. No more than 10% of total samples during a period of 30 days can exceed 400 MPN/100 mL.

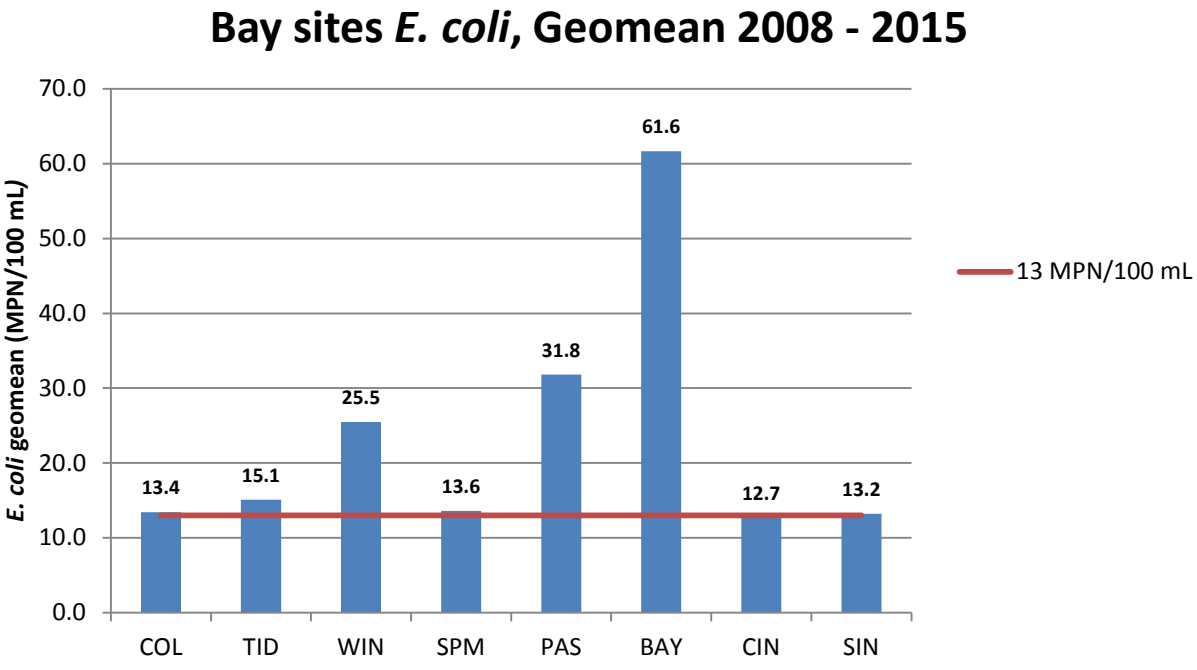
Bay Data

MBNEP conducts analysis of bay waters for *E. coli* and for enterococcus. In order to assess bay data against the TMDL targets, *E. coli* data was compared to the 43 MPN/100 mL value and the geomean of 14 MPN/100 mL. A direct comparison of *E. coli* data to fecal coliform standards is not entirely correct. Given that this is the only MBNEP data available for analysis, a brief comparison is presented. The data spans January 2008 through September 2015, and each site had at least 89 samples analyzed over that time period.

The following graph depicts bay *E. coli* data compared to the shellfish numeric target of 43 MPN/100 mL for fecal coliform. The 43 MPN/100 mL criteria was exceeded by 10% or more of the samples at COL, WIN, CIN, SIN, PAS and BAY.



The following graph illustrates the geomeans of the same data. For the geomean criteria, TID, WIN, PAS and BAY exceeded 14 MPN/100 mL.



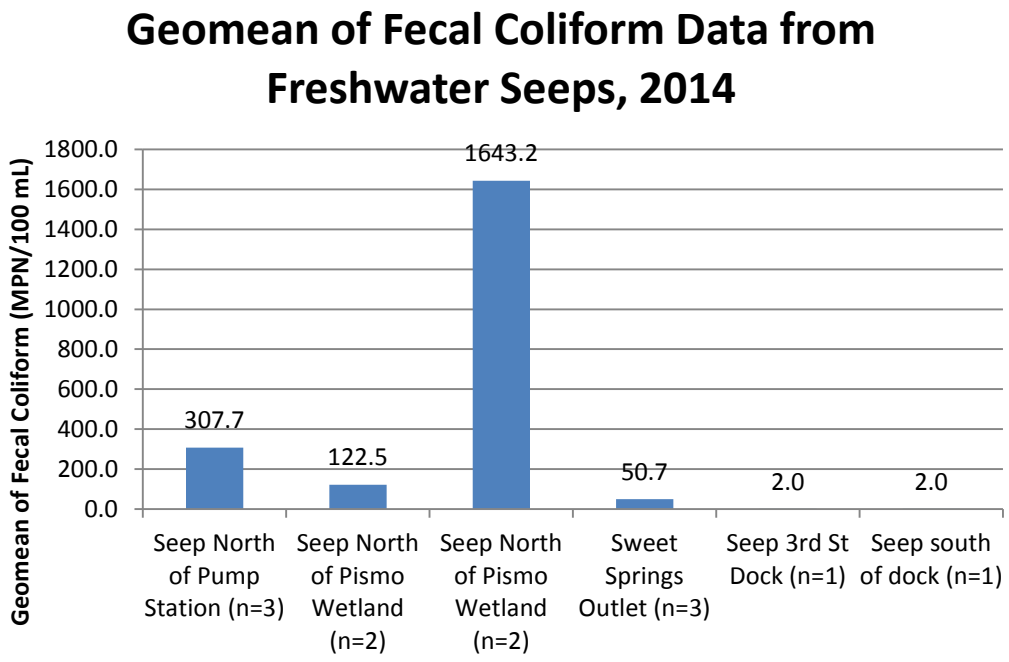
EPA Recreational Water Quality Criteria from 2012 has standards for enterococcus of 35 MPN/100 mL geomean and 130 MPN/100 mL statistical threshold value (STV), which means that up to 10% of results can exceed that level. The following table shows the STV and geomean for the bay enterococcus data for January 2008 through September 2015. Only one site, BAY, exceeded the geomean criteria. Two sites, PAS and BAY, exceeded the STV threshold.

Site	Enterococcus Geomean (MPN/100 mL)	% Enterococcus samples > 130 MPN/100 mL
COL	10.2	3%
TID	6.9	0%
WIN	13.3	6%
SPM	8.3	1%
PAS	22.3	14%
BAY	34.5	19%
CIN	11.0	5%
SIN	10.9	1%

SEEPS

CDPH has long been interested in bacteria concentrations in the freshwater seeps along the Los Osos shoreline due to their proximity to shellfish harvesting areas in the bay. Preliminary data is available from a sampling effort that CDPH has been conducting in the seeps. During their approximately monthly trips to Morro Bay, CDPH personnel are collecting samples from the seeps for fecal coliform analysis. The seeps were not flowing early in 2014, and CDPH speculated that this was because of the de-watering effort going on during construction of the distribution system for the upcoming Los Osos Wastewater Project, which is scheduled to come online in the spring of 2016. The seeps were sampled in April, May, June and September of 2014. Adequate flow was likely present in July and August for sampling, but monitoring was not conducted due to scheduling logistics.

Minimal data was available for analysis. The following graph shows the geomean of the fecal coliform data. After each site name, the number of samples is listed in parentheses.



The TMDL target for the geomean is five samples over a period of 30 days cannot exceed 200 MPN/100 mL. With the minimal data collected to date, the geomean for two of the sites exceeded the criteria.

CDPH Fecal Coliform Testing for Shellfish Growing Waters

There are three active commercial shellfish leases utilized by two commercial shellfish companies in Morro Bay. Oversight of the sanitary quality of the shellfish growing waters is provided by the CDPH Preharvest Shellfish Unit (PSU). The PSU conducts ongoing evaluation of the classification of the shellfish growing waters following the National Shellfish Sanitation Program (NSSP) Guide for the Control of Molluscan Shellfish. The NSSP is administered by the U.S. Food and Drug Administration. Data for fecal coliform (FC) concentrations is used as an indicator of the sanitary quality of shellfish waters.

The MBNEP and the CDPH collaborated with two commercial shellfish farms, Morro Bay Oyster Company (MBOC) and Grassy Bar Oyster Company (GBOC), on the collection of water quality samples from Morro Bay and its watershed for FC analysis. The objectives of the joint sampling effort are to:

- Assess patterns in the spatial distribution of FC concentrations in the bay.
- Track the FC concentrations from the tributaries.
- Evaluate the appropriate classification of unclassified portions of two commercial shellfish leases.

Samples were collected from January 2013 through October 2015 in times without significant influence from runoff, with the exception of storm flow monitoring in the creeks. Samples were collected from water quality stations along the Morro Bay main channel, the two tributary creeks to the bay, and bay shoreline stations.

Sampling locations and objectives for each were as follows.

Commercial Shellfish Leases: Two of the three commercial shellfish growing leases of Morro Bay have portions of the lease that are classified by CDPH as *Prohibited* for purposes of shellfish harvest. The *Prohibited* classification is due to historical water quality not meeting the standards for the *Conditionally Approved* classification and a lack of current FC results. CDPH typically classifies growing areas based on the 30 most recent FC samples. It is preferable that the samples used for establishing the classification be collected monthly.

On M-604-01 Parcel 1, two new water quality stations, #64 and #65, were established on GBOC's lease M-614-01 Parcel 1 as part of this study. These stations and the historical station #58 were sampled monthly as part of the study.

On M-614-01 Parcel 2, existing historical CDPH water quality stations in the Prohibited portions of MBOC's lease M-614-01 Parcel 2 were sampled monthly as part of the study. These stations were #70, #71, #75 and #79. MBOC collected additional samples from these stations.

Channel: Sites near the mouth of Morro Bay (station #3), along the Embarcadero channel among the moorings (#5A and #5B) and in the channel near the center of the Bay (#5C) were sampled on the flood tide. This was to assess the background FC levels of the marine water entering the bay and determine if there is degradation in water quality along the Embarcadero. Additionally, four samples were collected

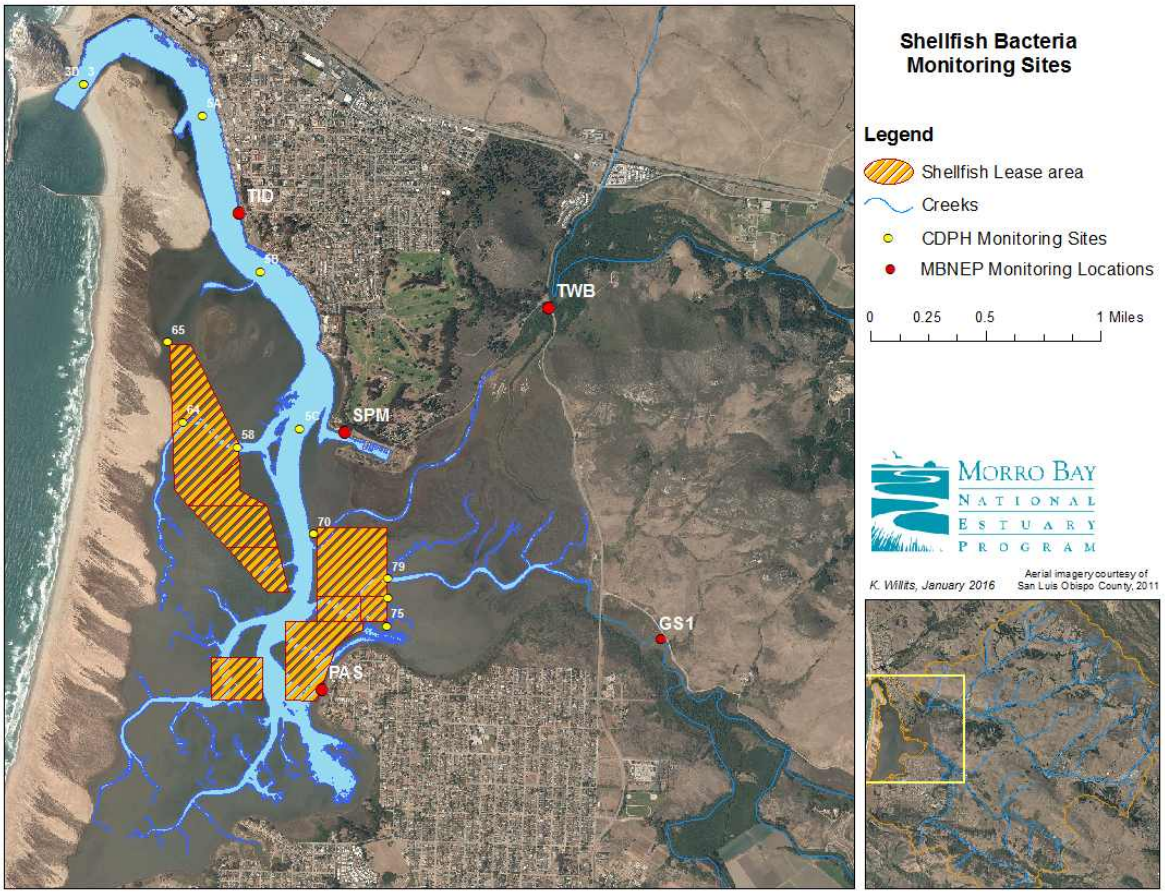
just above the bottom near the mouth (#3D). The channel stations were sampled opportunistically on the flood tide on five runs.

Bay Shoreline: Three established MBNEP sites along the shoreline of Morro Bay were sample quarterly over the study period. These stations are Tidelands Park (TID), State Park Marina (SPM) and Pasadena Point (PAS).

Creeks: Chorro Creek and Los Osos Creek were sampled monthly upstream of their mouths. The stations were Chorro Creek at the South Bay Boulevard Twin Bridges (TWB) and Los Osos Creek approximately 1,700 feet upstream of South Bay Boulevard (GS1). Additional samples were collected from the creeks after rainfall to demonstrate the storm flow condition.

Los Osos Creek is tidally-influenced at GS1 and in absence of runoff is mostly representative of bay water. As such, GS1 represents water quality of the tidal flats along the eastern most shore. Samples were collected during low tide while ebbing from this station.

Chorro Creek at TWB typically has freshwater flow year round but was dry for large periods due to drought conditions during the study period.



Results of Shellfish Monitoring Data: The FC sample results were evaluated in the context of NSSP criteria for water quality for the *Approved* classification using the NSSP Adverse Pollution Condition (APC) sampling strategy. These criteria for FC concentrations consist of a geometric mean of not more than 14 MPN/100 mL and no more than 10% of the samples can be greater than 43 MPN/100mL in order for the waters to meet the *Approved* classification. It should be noted that there needs to be a minimum of 30 APC samples for classifying previously unclassified or *Prohibited* growing waters.

FC levels in the main Morro Bay channel did not show elevations during the flood tide from the mouth of the bay down to station #5C across from the State Park Marina. All of the other bay stations had occasional elevations in FC that were not driven by runoff. Station #58 was the only non-channel station to have less than 10% of the samples test below 43 MPN and meet the NSSP *Conditionally Approved* criteria. This may be due to its proximity to the channel. However station #70 was closer to the main channel than #58, yet had the worst water quality of the lease stations. The more frequent elevations at this station may be due to wildlife. There is a sand bar approximately 300 feet east of station #70 where birds frequently roost and harbor seals haul out.

The most degraded observed water quality in the bay was at the bay shoreline station PAS. This may in part be due to proximity to naturally-occurring freshwater seepage in the area which has demonstrated FC contamination and longer residence times of FC pollution due to its location in the south bay and its distance from the main channel. The poor water quality at PAS suggests that FC concentrations in the portion of shellfish lease M-614-01 Parcel 2 in the vicinity of the station would not meet the *Conditionally Approved* criteria.

The baseflow samples collected at Los Osos Creek station GS1 were more representative of bay water than Los Osos Creek input as verified by salinity readings. Water quality at this station during baseflow conditions was similar to that of the lease stations in the bay further to the west. This suggests that this creek and nearshore area is not a load source of FC to the bay during baseflow conditions. Baseflow FC concentrations in Chorro Creek were frequently elevated when the creek was flowing. The elevated FC levels may be due to agriculture activities. FC loads from Chorro Creek baseflow likely did not have an impact on water quality at the bay stations as there was no evidence of less frequent FC elevations in the bay during the periods when Chorro Creek at TWB was dry.

Water quality stations #64 and #65 along the northern portion of lease M-614-01 Parcel 1 were the lease stations closest to the mouth of the bay yet had a similar percentage of results greater than 43 MPN as stations further south in the bay on lease M-614-01 Parcel 2. This is likely due to all the stations being further from the main channel, suggesting that proximity to the main channel is more important than proximity to the mouth of the bay for diluting FC concentrations.

Summary information for the FC concentration data collected from January 2013 through October 2015 is presented in the following table.

Site Type	Site Code	n	Geometric Mean (MPN/100 mL)	% of Samples > 43 MPN
Creeks	TWB – baseflow	19	33	58%
	TWB – storm	3	275	100%
	GS1 – baseflow	31	11	23%
	GS1 – storm	4	109	75%
Bay Shoreline	SPM	8	8	13%
	PAS	8	29	38%
	TID	8	7	0%
Bay Channel	WQ #3	5	3	0%
	WQ #3D	4	5	0%
	WQ #5A	5	3	0%
	WQ #5B	5	4	0%
	WQ #5C	6	8	0%
Shellfish Growing Areas	WQ #58	35	5	6%
	WQ #64	33	6	15%
	WQ #65	33	6	15%
	WQ #70	34	11	24%
	WQ #71	45	9	18%
	WQ #75	46	8	17%
	WQ #79	40	7	13%

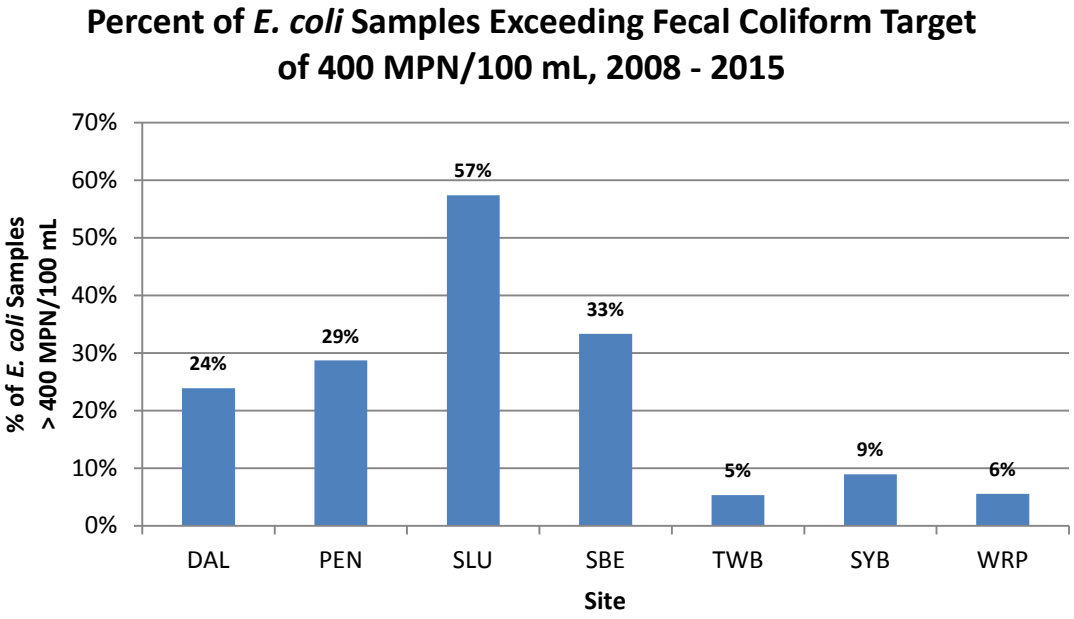
**With the exception of TWB-storm and GS1-storm all samples were collected when there was no significant rainfall (> 0.3" rain in 24 hours) in the 3 days prior to collection.*

Overall, water quality in the bay south of the Embarcadero and outside of the main channel was degraded compared to that of the mouth of the bay and the channel along the Embarcadero during the flood tide. The bay station with the worst water quality under non-rainfall conditions was at the Pasadena Point shore station along the Los Osos shoreline. The summary statistics for samples collected from six of the seven shellfish lease sample sites did not meet the NSSP Adverse Pollution Condition criteria for a *Conditionally Approved* classification. This suggests that the represented areas should continue to be in the NSSP default classification of *Prohibited*. As for the creeks, Los Osos Creek does not appear to be a load source of FC to the bay during times of baseflow. While Chorro Creek frequently had elevated FC concentrations at baseflow, there was no evidence of less frequent FC elevations in the bay when Chorro Creek was dry.

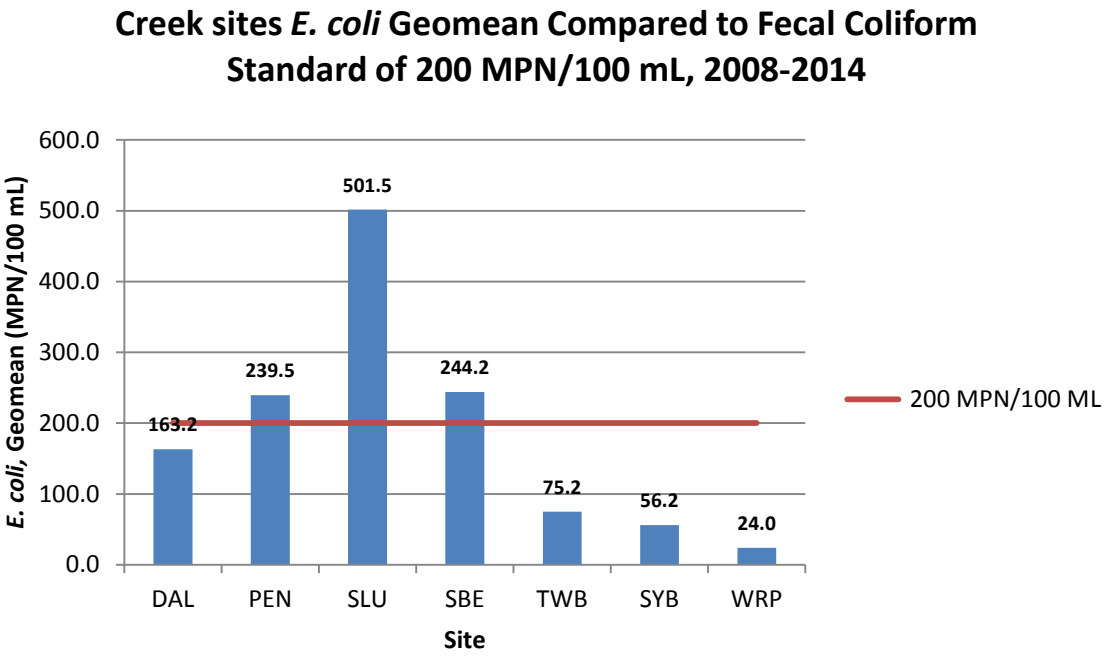
CREEKS

The MBNEP monitors the creeks for total coliform and *E. coli* indicators. As with the previous analysis, MBNEP *E. coli* data was compared to the fecal coliform standards in the TMDL. For the creeks, the geomean of five samples over a period of 30 days cannot exceed 200 MPN/100 mL, and no more than 10% of total samples during a period of 30 days can exceed 400 MPN/100 mL.

The following graph compares the MBNEP *E. coli* data to the 400 MPN/100 mL fecal coliform standard. The tributaries to Chorro Creek have more than 10% exceedances of the 400 MPN/100 mL fecal coliform standard.



The geomean of MBNEP data was calculated and graphed to compare to the 200 MPN/100 mL fecal coliform standard. Pennington, San Luisito and San Bernardo Creeks exceeded the target.



Conclusions for Morro Bay Pathogen TMDL

This overview of pathogens in Morro Bay and its watershed indicates that the TMDL has not met its target, which was attainment of targets in 2014. To summarize:

- Bay waters: For the *E. coli* data compared to the fecal coliform criteria for protection of shellfish harvesting waters, six of eight sites fail the STV criteria and all eight fail the geomean criteria. Problems were seen most consistently at Baywood Pier and Pasadena Point.
- Seeps waters: Although only preliminary data was available, two of the sites appeared to have consistently elevated fecal coliform concentrations.
- Shellfish growing waters: Of all sites tested for FC, TWB on Chorro Creek had the highest bacteria concentrations of all of the sites, but the flows were relatively low or non-existent during times of typical elevated bacteria in the bay. PAS had the highest bacteria concentrations of the bay shoreline sites. Water quality in the bay south of the Embarcadero and outside of the main channel was degraded compared to that of the mouth of the bay and the channel along the Embarcadero during the flood tide. Data from six of the seven shellfish lease sample sites did not meet the criteria for a *Conditionally Approved* classification, suggesting that these areas should continue to be classified as *Prohibited*.
- Creek waters: Comparing *E. coli* to the fecal coliform criteria for safe recreational contact, four of seven sites failed the STV criteria and three of seven failed the geomean criteria. Chorro and lower Warden had infrequent bacteria exceedances, but the tributaries to Chorro had frequent issues.

303(D) ASSESSMENT FOR SEDIMENT, PATHOGENS AND NUTRIENTS

Project background: The 303(d) status of the waterbodies in Morro Bay and its watershed are as follows:

- Chorro Creek (category 4a): Impaired for *E. coli*, fecal coliform, nutrients and sediment
- Los Osos Creek (category 5): Impaired for fecal coliform, DO, nitrates, nutrients and sediment
- Warden Creek (category 5): Impaired for fecal coliform, DO and nitrates
- Pennington Creek (category 5): Impaired for fecal coliform
- Chumash Creek (category 5): Impaired for fecal coliform
- San Luisito Creek (category 5): Impaired for fecal coliform
- Dairy Creek (category 4a): Impaired for fecal coliform and DO
- Morro Bay (category 5): Impaired for DO, pathogens and sediment

The categories refer to their classification status on the state's Integrated Report. The categories applicable to the watershed and estuary are as follows:

- Category 4a: A state-developed TMDL has been approved by EPA or a TMDL has been established by EPA for any segment-pollutant combination
- Category 5: Available data and/or information indicate that at least one designated use is not being support or is threatened, and a TMDL is needed.

Expected project benefits: MBNEP monitoring provides long-term ambient data to assist the CCRWQB in assessing 303(d) progress. The sites, methodologies, frequency and monitoring equipment were selected to ensure that the data generated would support the assessment effort. The 303(d) list is reviewed periodically. Previously it was on a biennial basis, but more recently there have been delays in the process due to a backlog of data. The MBNEP spent the past year submitting historical data to the CCRWQCB via the California Environmental Data Exchange Network (CEDEN). MBNEP data is crucial to the 303(d) assessment process as it provides some of the only data from the watershed and estuary.

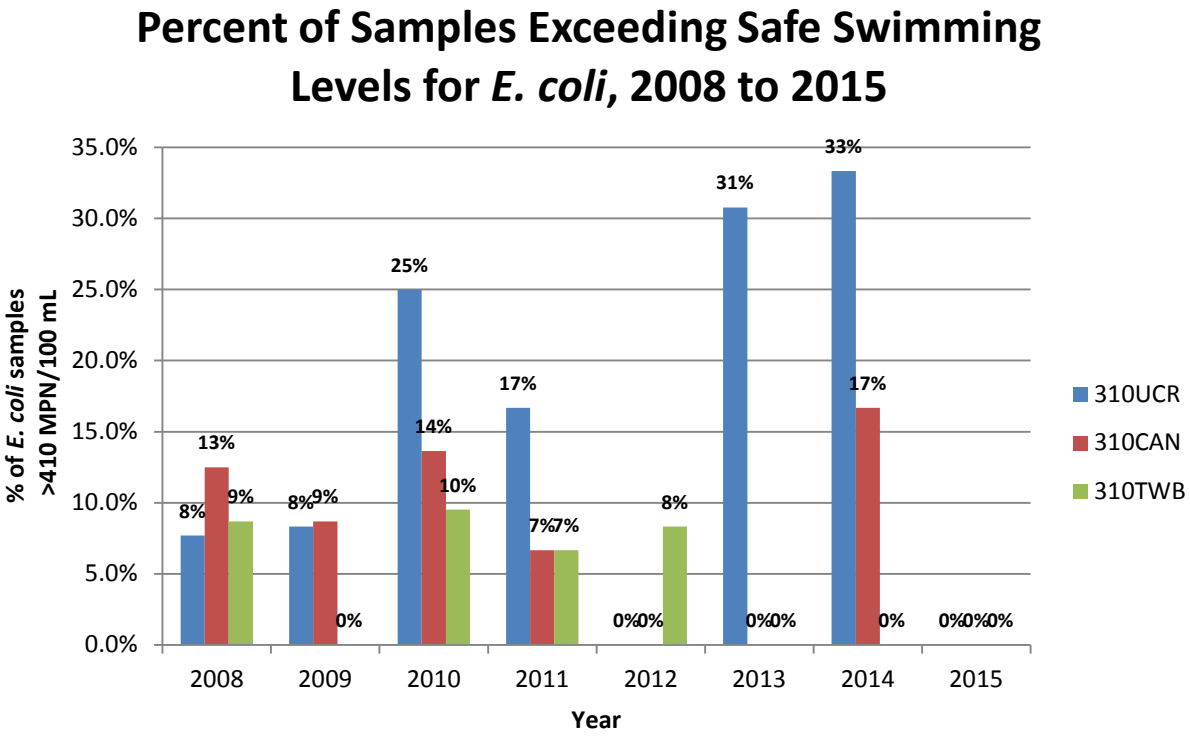
Data to assess 303(d) status is contained throughout this report. This section will bring together that data and introduce some additional data to support this effort.

CHORRO CREEK

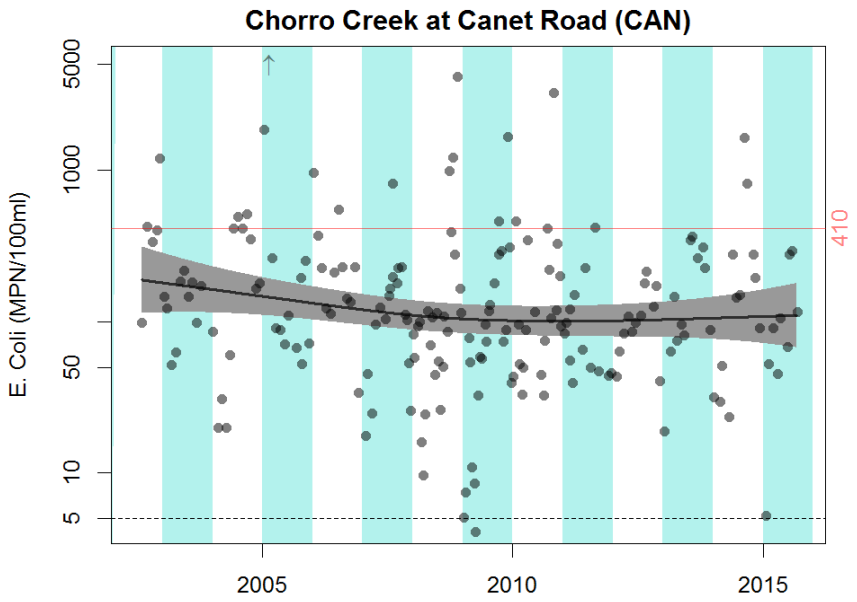
Chorro Creek is listed for *E. coli*, fecal coliform, nutrients and sediment. As the MBNEP does not conduct fecal coliform monitoring, this analyte will not be discussed.

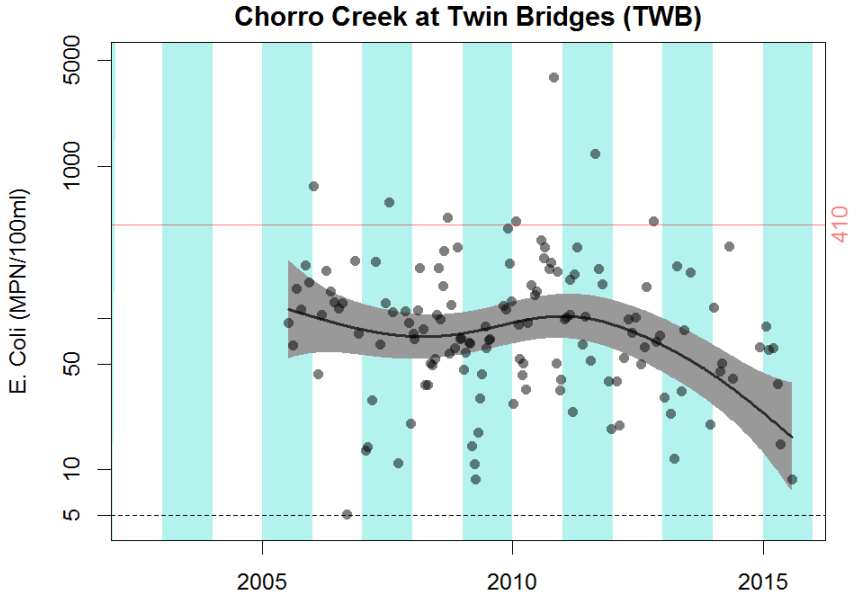
Bacteria

Chorro Creek has minimal issues with *E. coli*. The following graph illustrates the *E. coli* data relative to the 410 MPN/100 mL STV criteria from the 2012 EPA guidance. While exceedances were more common at UCR and CAN, the percent of exceedances at most downstream site (TWB) of the STV criteria are below 10% for the eight years assessed.



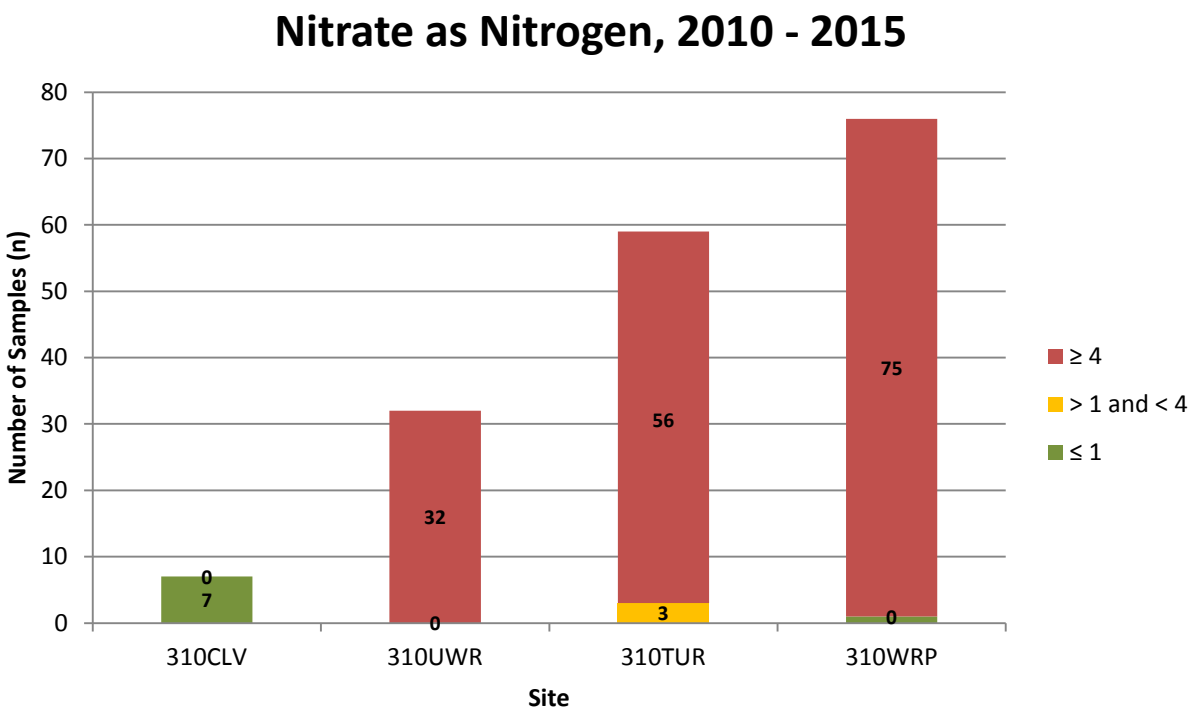
The following plots show the long-term trends of *E. coli* data at the three sites. The smooth curve is a spline smooth with degrees of freedom (df ≈ 7.8) chosen by cross-validation. The grayed area is the error band for the data. The up arrows represent values that were greater than 5,000 MPN/100 mL. At all both sites, the data shows a stable or decreasing trend that falls within the 95% confidence interval represented by the error band.



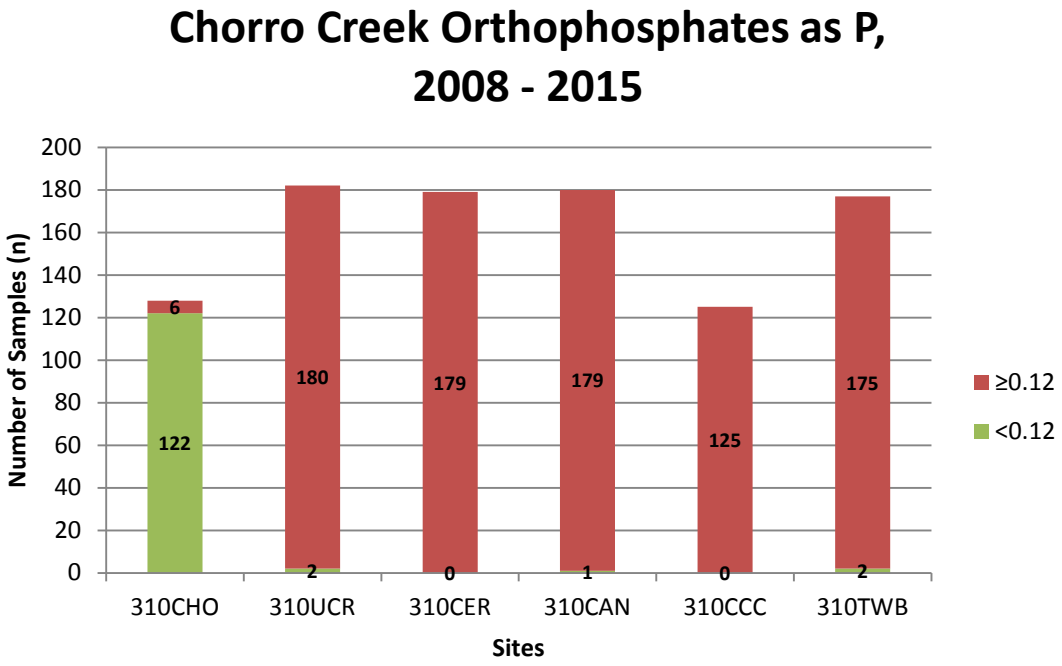


Nutrients

Following an upgrade of the CMC WWTP, improvements in nitrates were detected. Orthophosphates were unaffected by the plant upgrade. Using data from 2008 to 2015, the results were categorized into results that were less than or equal to 1 mg/L, greater than 1 and less than 4 mg/L, and greater than or equal to 4 mg/L of NO_3-N. The impact of the CMC WWTP is clearly illustrated in this data.



Orthophosphate as P data was similar assessed, with data combined into less than 0.12 mg/L as P and greater than or equal to 0.12 mg/L as P. As with the nitrate data, the impact of the CMC WWTP is evident in the data.

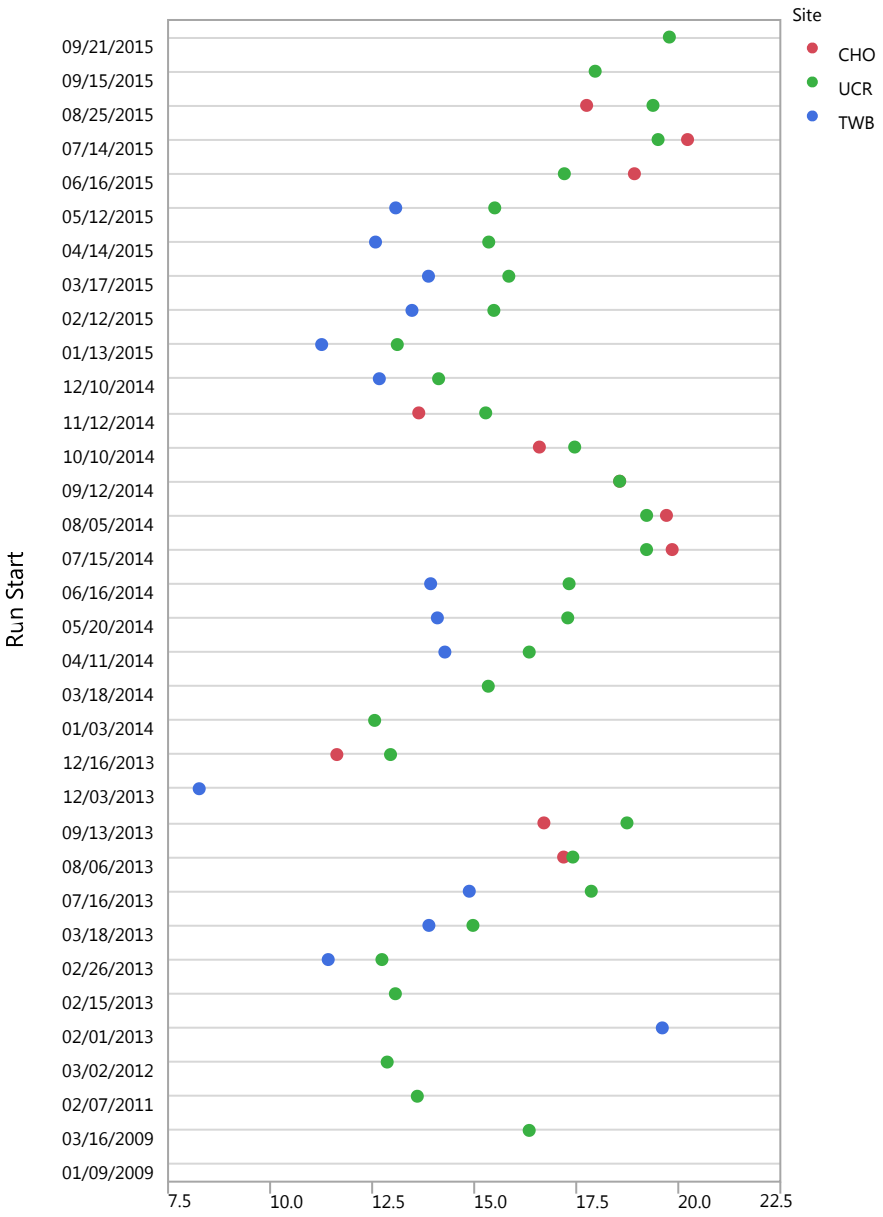


Dissolved Oxygen

Although Chorro Creek is not listed for DO, the parameter is of interest in relation to nutrient pollution. While DO concentration and percent saturation data are included in the Chorro Creek section of this report, some additional analysis on Minisonde continuous monitoring data is presented in this section for DO and temperature.

The MBNEP has two Minisonde meters for simultaneous deployment. Whenever adequate water is present, UCR and TWB were monitored approximately monthly. During years of lower than average rainfall, TWB goes dry in the summer and fall. If this is the case, then monitoring took place at CHO and UCR.

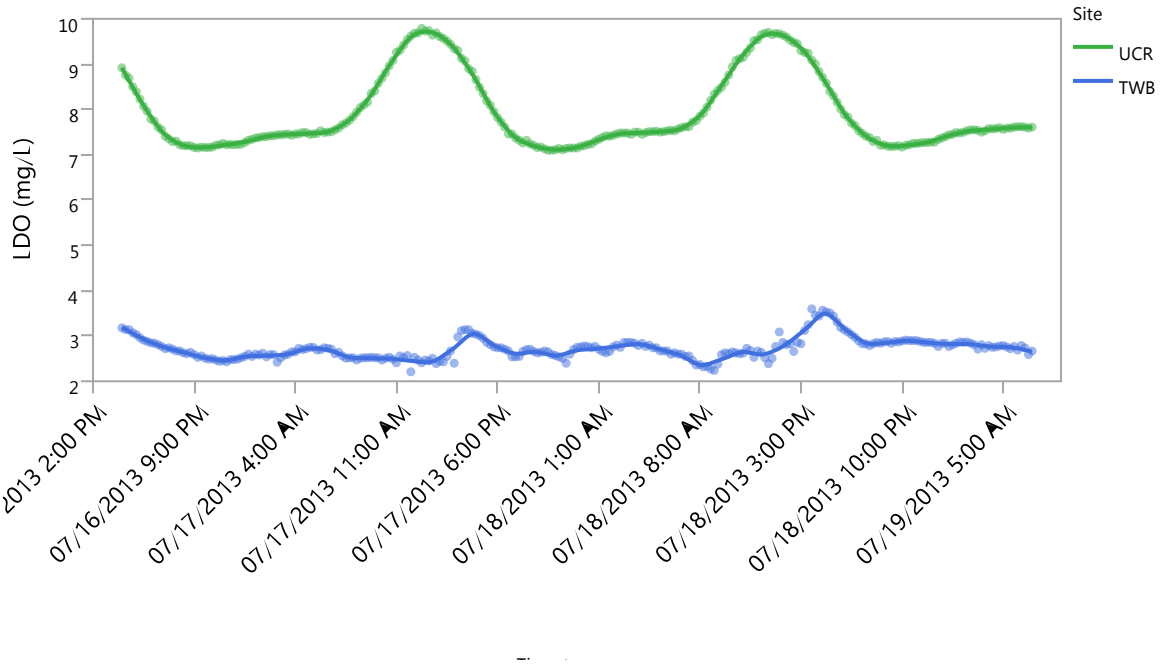
The following graphic provides an overview of the data by plotting the mean of DO data from each sampling run for each site on Chorro Creek (CHO, UCR and TWB). Of the eight runs with paired data from CHO and UCR, for seven of them CHO has higher mean DO levels than UCR. Of the eleven runs with paired data from UCR and TWB, ten have a higher mean DO concentration at UCR than at TWB. For the 14 Minisonde runs at TWB, four had mean DO values below 7 mg/L. For the ten runs at UCR and CHO, none of them had mean values less than 7 mg/L.



Analysis provided statistically significant evidence that the mean DO is not the same at all three Chorro sites (p-value = 0.0006). In particular, the mean DO at TWB is statistically significantly lower than the mean DO at UCR and CHO (p-value = 0.0005 and 0.0034, respectively). The mean DO is between 0.84 and 2.83 mg/L higher at UCR than TWB and between 0.74 and 3.70 mg/L higher at CHO than TWB, with 95% confidence.

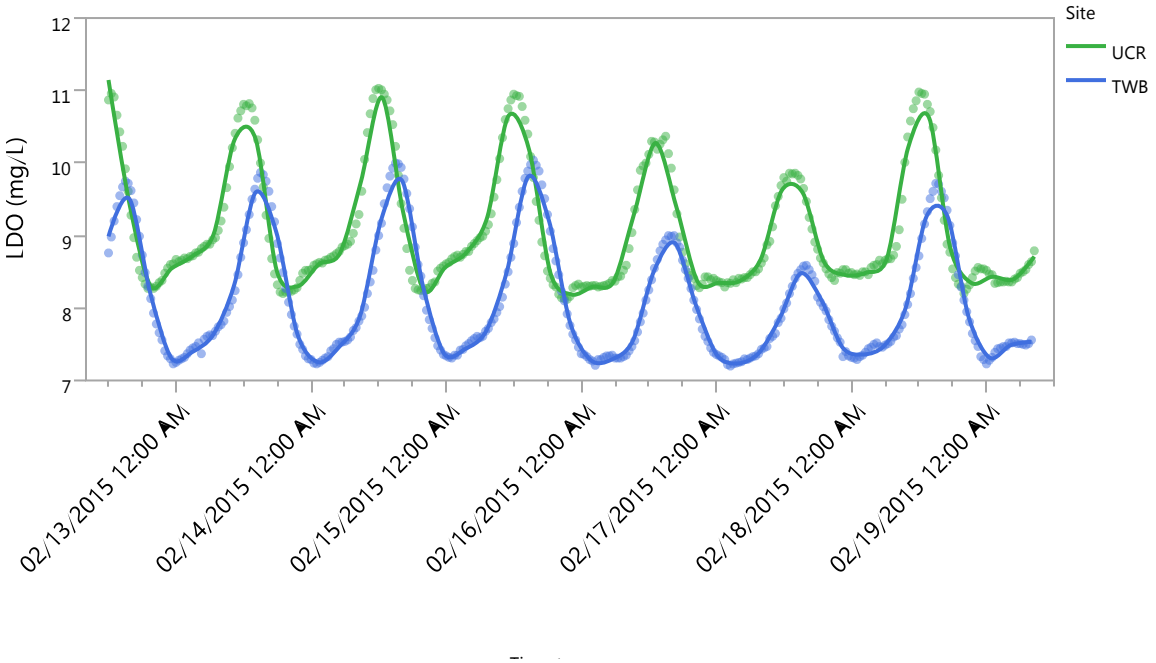
Hydrological conditions likely played a large role in the low DO concentrations at TWB. When water levels drop too low, flows go subsurface underneath the bridge where gravel and sand have built up over time. The creek emerges downstream of the bridge and continues to flow down to the bay. When these conditions exist, the DO levels drop fairly low (typically less than 5 mg/L) downstream of the bridge. During years impacted by drought, TWB flows can drop in the late spring. UCR and CHO did not experience any extended periods of depressed DO concentrations. The following graph shows typical

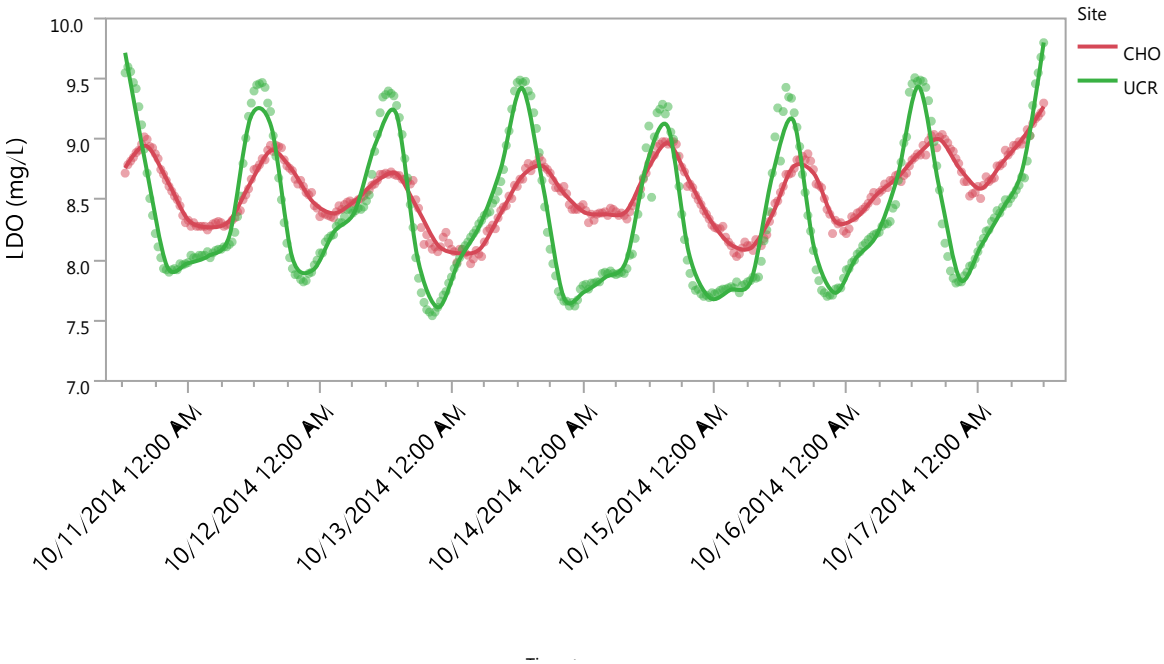
data from when the creek goes subsurface under the bridge and the meter is deployed downstream of the bridge to monitor the water after it returns to the surface.



In general, for the times assessed, DO did not drop below desired levels at any time at CHO or UCR. At TWB, levels dropped below 7 mg/L during summertime runs, likely the result of flow going subsurface under the bridge. Following these subsurface flow conditions, the creek soon went dry in the summers of 2013, 2014 and 2015.

For comparison, the following runs are from the wet season when no DO issues were detected. The first graph is for UCR and TWB in February 2015, and the second graph is for CHO and UCR in October 2014.

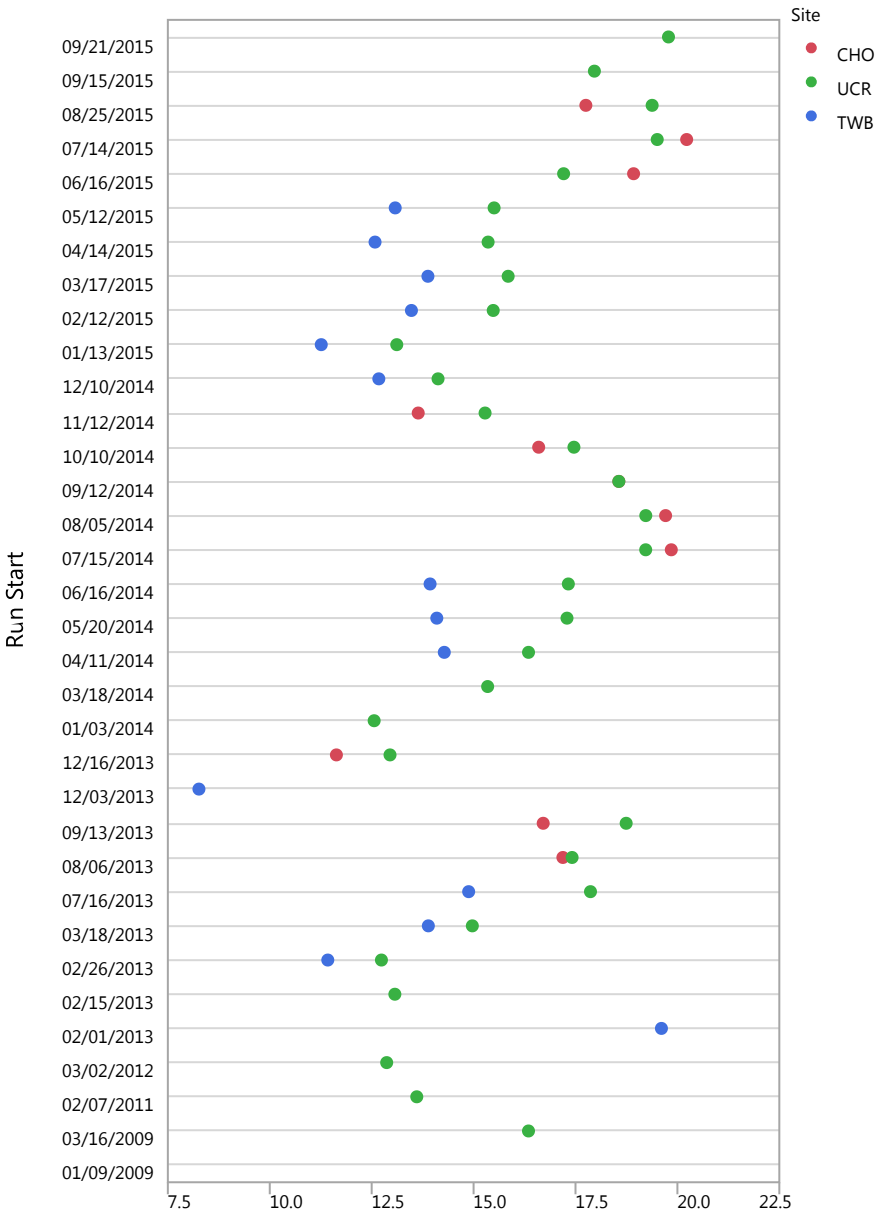




Water Temperature

The following graphic provides an overview of the Minisonde temperature data from CHO, UCR and TWB data by plotting the mean of water temperature from each sampling run for each site. Of the nine runs with paired data at CHO and UCR, four of them have a higher mean temperature at CHO than UCR, and the other five have a higher mean temperature at UCR than CHO. For the 12 runs with paired data at UCR and TWB, all 12 of them had higher mean temperatures at UCR than TWB.

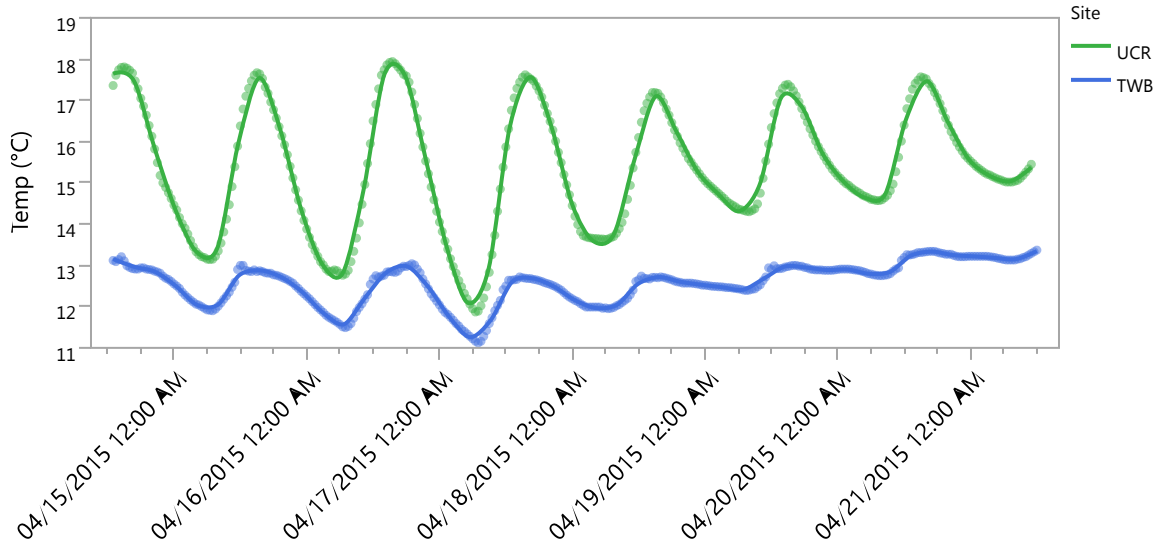
Between March 2009 and September 2015, there were a total of 33 data runs for collecting continuous monitoring data. Of those run, four at UCR and four at CHO had periods of time when temperatures exceed 21 °C.

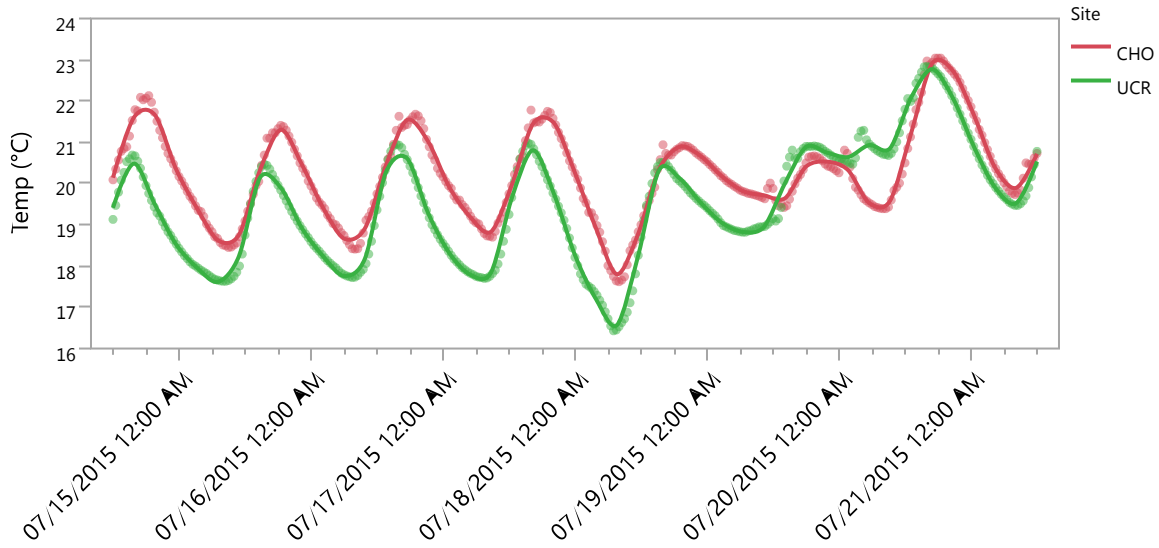


There is statistically significant evidence that the mean temperature is not the same at all three Chorro sites (p-value = 0.0001). In particular, the mean temperature at TWB is statistically significantly lower than the mean temperature at UCR and CHO, (p-value < 0.0001 and 0.0007, respectively). The mean temperature is between 1.48 and 2.93 °C warmer at UCR and between 0.79 and 2.88 °C warmer at CHO compared to TWB, with 95% confidence.

CHO had days with maximum temperatures in the diurnal cycle above 21 °C in July 2014, August 2014, June 2015 and July 2015. This occurred on 23 out of 29 days of deployment. In those same time periods, UCR temperatures exceeded 21 °C on 13 out of 36 days of deployment.

The following runs are typical data from the wet and dry seasons. The first graph is for UCR and TWB in April 2015, a time of year when temperatures are typically less than 21 °C. The second graph is for CHO and UCR in July 2015, from the dry season when elevated temperatures tend to occur.





Sediment

Chorro Creek impairment by sediment is detailed in the TMDL assessment section of this report. The results presented indicated that assessing an average annual load was complicated given the variability in sediment loading data depending on the sizes of storm events. The Streambed Sediment Impairment Indicators indicated potential issues on the two Chorro sites. At TWB, with four of the 13 categories in the 'high priority for 303(d) listing category and five of the 13 categories in the 'low priority for 303(d)

listing category.' At CER, four of the 13 categories are high priority for listing and three of the 13 are low priority for listing.

Conclusions for Chorro Creek

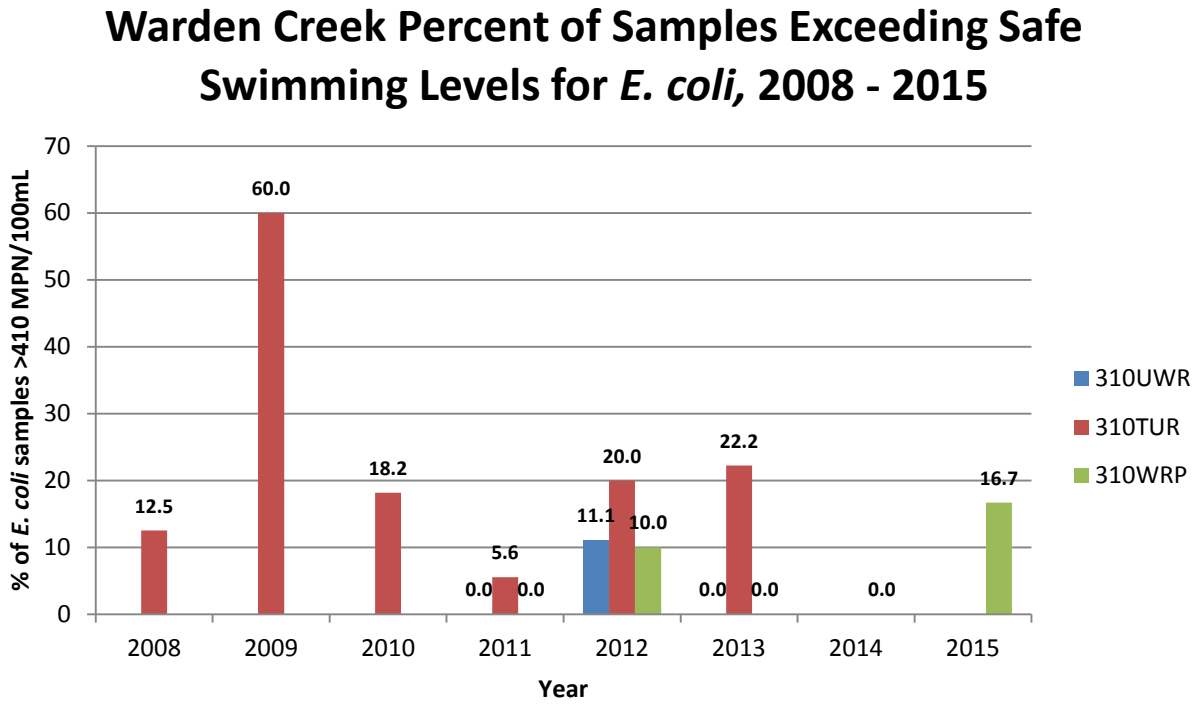
The creek has minimal issues with *E. coli,* in particular related to the elevated levels typically measured in its tributaries. Nitrates and orthophosphates are elevated above the level of concern at points downstream of the CMC WWTP. Of the continuous monitoring data, three runs out of 14 at TWB had sustained DO levels less than 7 mg/L, however these were from times when the creek went sub-surface at the bridge. There were no instances of depressed DO at UCR (out of 30 runs) and CHO (out of eight runs). Continuous monitoring data for water temperatures had infrequent occurrences of temperatures greater than 21 °C. This occurred in four out of 31 runs at UCR, four out of ten runs at CHO, and none of the 14 runs at TWB. Sediment impairment indicators showed potential issues at both monitoring sites.

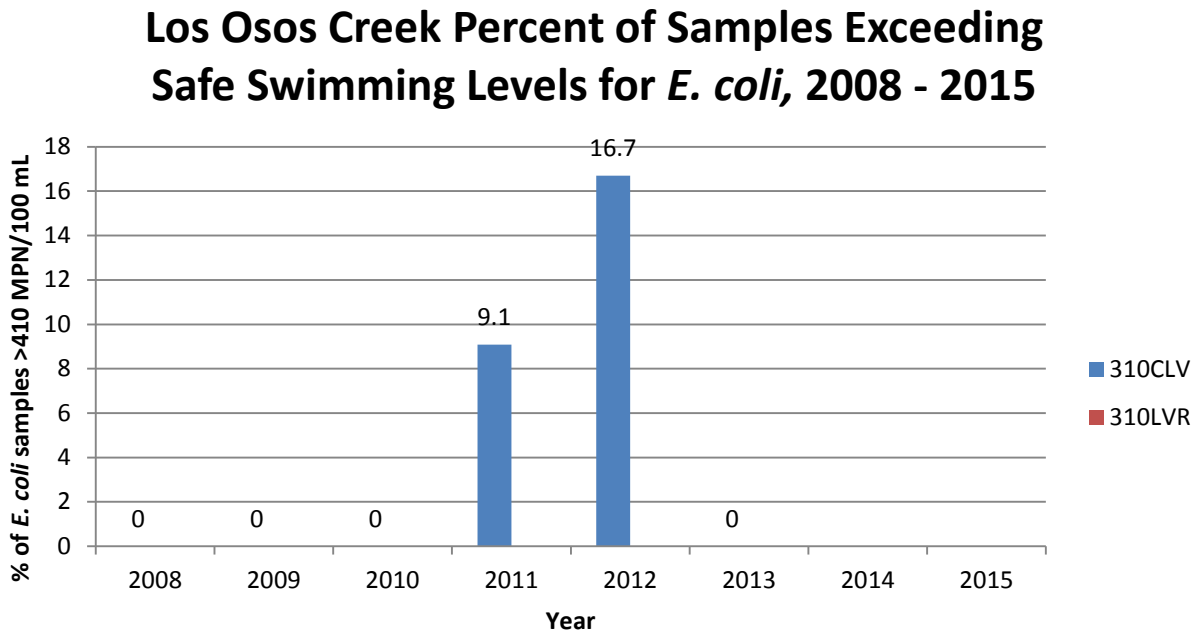
Los Osos and Warden Creeks

Los Osos Creek is listed as impaired for fecal coliform, DO, nitrates, nutrients and sediment. Warden Creek is impaired for fecal coliform, DO and nitrates.

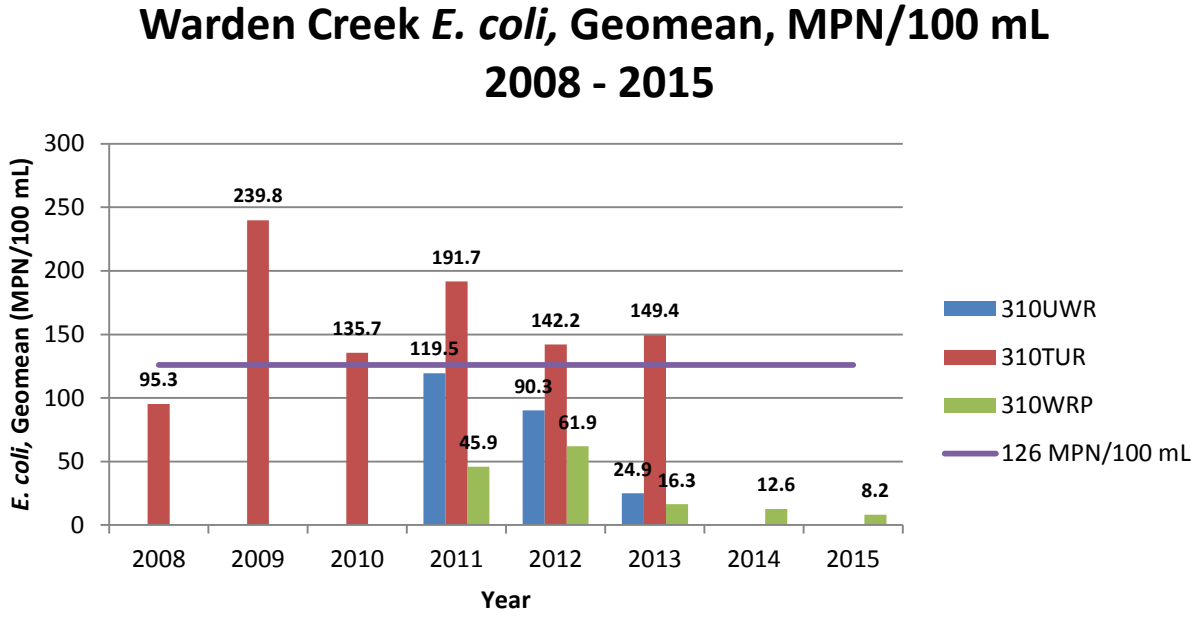
Bacteria

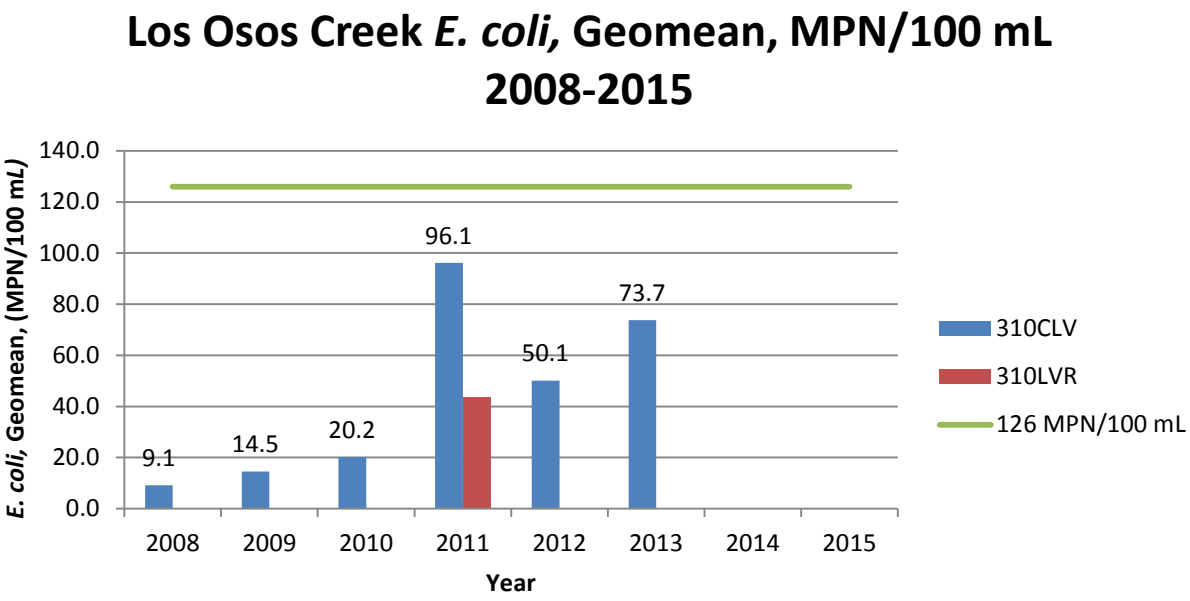
While the MBNEP monitors for *E. coli* rather than fecal coliform, this data provides some indication of frequency of elevated bacterial concentrations. The following graphs depict the *E. coli* data from 2008 through 2015 as a percent exceedance of 410 MPN/100 mL on Warden Creek and Los Osos Creek.





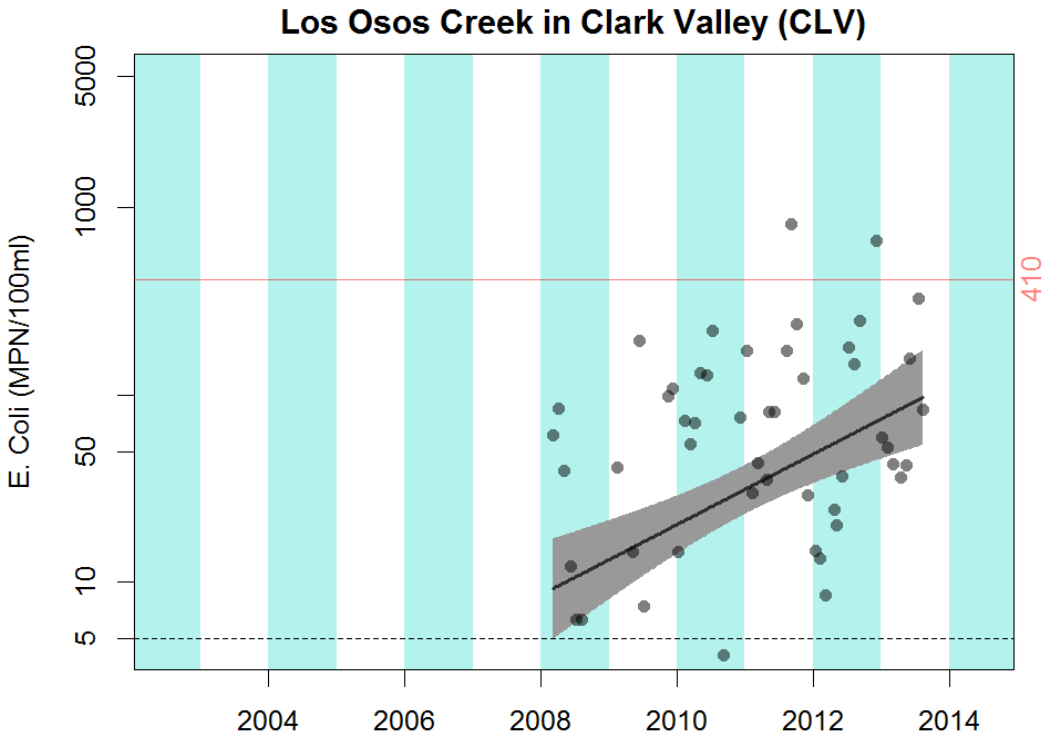
The following graph depicts the geomean of the *E. coli* data as compared to 126 MPN/100 mL for Warden Creek and Los Osos Creek.

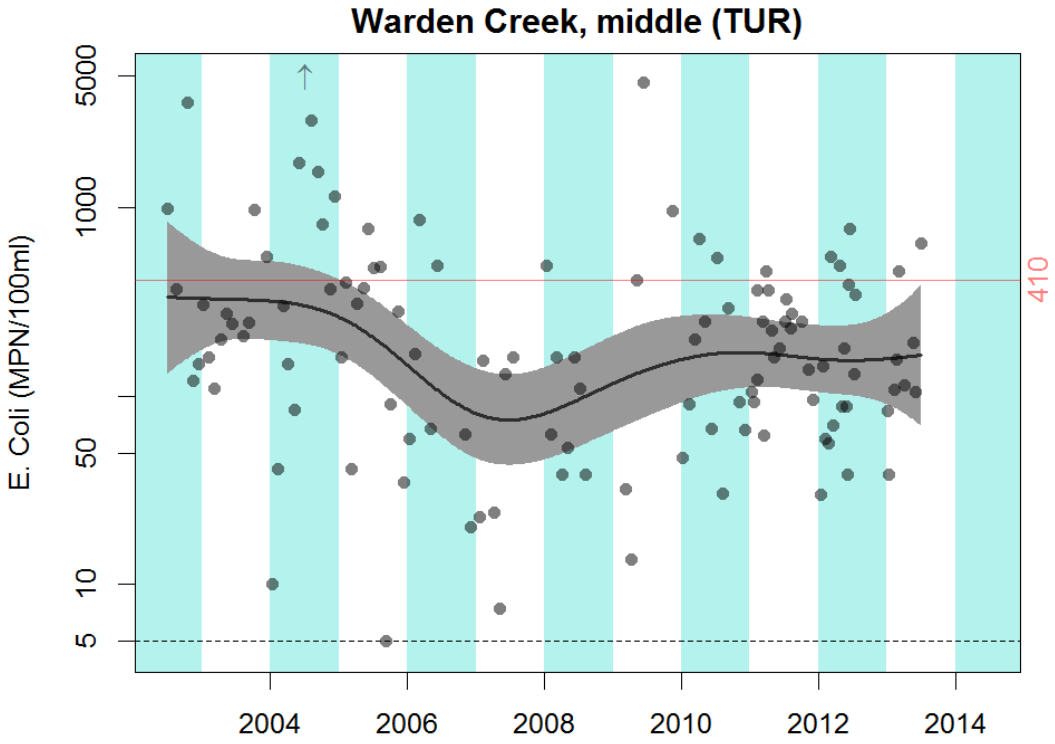




The following plots show the long-term trends of *E. coli* data at the three sites. The smooth curve is a spline smooth with degrees of freedom (df ≈ 7.8) chosen by cross-validation. The model does not contain a seasonality term. The grayed area is the error band for the data. The smooth line is meant to summarize the mean bacteria level while the error band reflects the certainty of this trend (average) estimate. The up arrows represent values that were greater than 5,000 MPN/100 mL.

The data from Los Osos Creek indicates an increasing trend that still falls below the 410 MPN/100 mL level of concern. The data from Warden Creek indicates more frequent exceedances and with the wide error band, it is not possible to determine the direction of the trend. Due to lower than average rainfalls, additional monitoring could not take place at either of these sites during 2015.



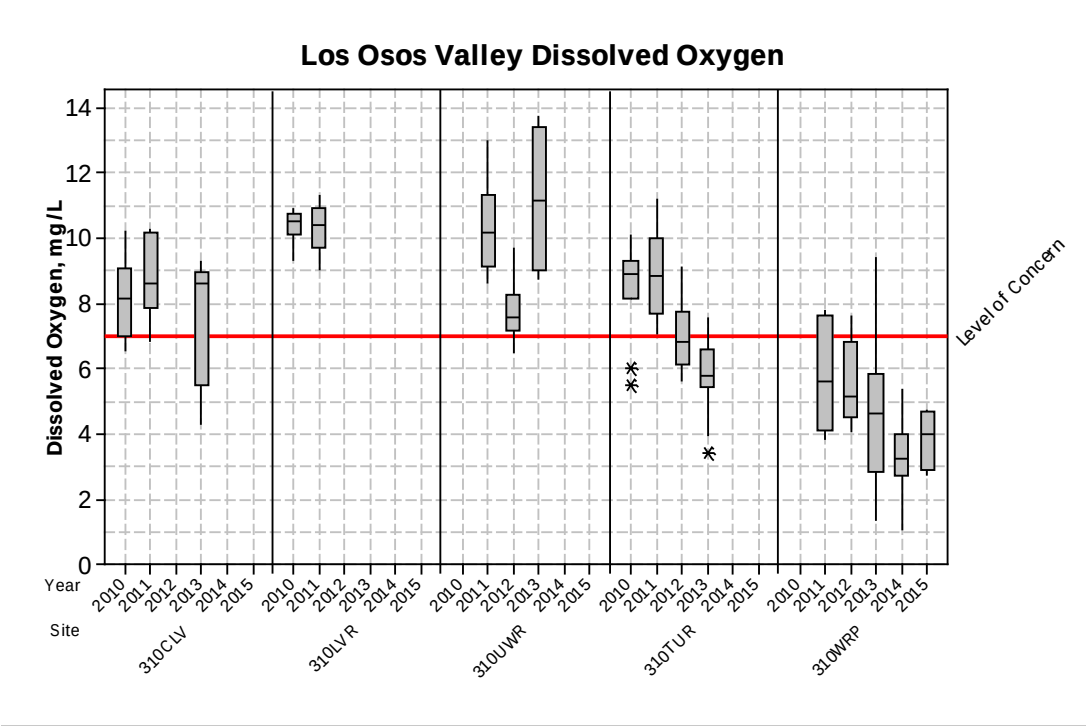


Dissolved Oxygen

The following graph shows the DO concentration data at three sites on Warden Creek and CLV on Los Osos Creek. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values.

Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk. The Central Coast Basin Plan set a regulatory standard that states that at no time shall DO concentrations fall below 7.0 mg/L.

Time of day has a significant impact on DO levels. Monitoring at the three Warden Creek sites consistently occurred on the same day, i.e., the monitoring team would visit all three sites within a two-hour period. The site in Clark Valley on Los Osos Creek, CLV, has minimal exceedances of the 7 mg/L standard. TUR and WRP had frequence exceedances of the standard.



The following tables provide a breakdown of the DO values by year and wet season/dry season for the applicable Basin Plan standards. For the CLV site on Los Osos Creek, the appropriate criterion for comparison is 7 mg/L for DO concentration. Flow of adequate levels for monitoring did not occur during 2015 at CLV.

CLV	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	7.5	7.3	8.2	8.7	-	7.7	-	-
Wet season average	9.7	6.8	8.5	9.9	-	9.1	-	-
Dry season average	6.6	8.1	7.9	8.0	-	6.6	-	-
Range	4.4	4.3	3.7	3.5	-	5.0	-	-
n	7	8	12	10	-	7	-	-
# exceedance for wet season	0	2	2	0	-	0	-	-
# exceedance for dry season	4	1	1	2	-	2	-	-
% exceedance for entire year	57.1	37.5	25.0	20.0	-	28.6	-	-
Median	6.8	7.4	8.1	8.6	-	8.6	-	-

For the sites on Warden Creek, the appropriate criteria is median DO % saturation falling below 85% saturation. Flow adequate for monitoring did not occur at UWR and TUR in 2015.

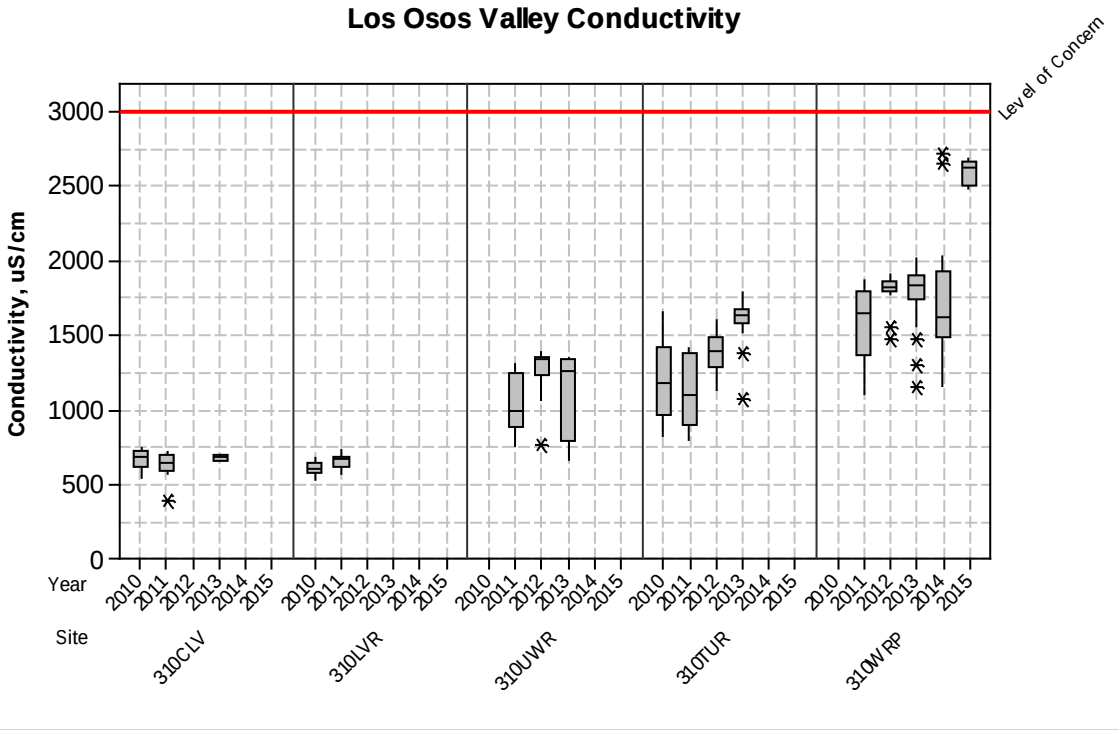
UWR	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	-	-	-	103.7	75.7	103.3	-	-
Wet season average	-	-	-	97.0	76.7	103.3	-	-
Dry season average	-	-	-	118.7	74.1	-	-	-
Range	-	-	-	55.8	22.3	43.2	-	-
n	-	-	-	13	15	4	-	-
# exceedance for wet season	-	-	-	2	8	1	-	-
# exceedance for dry season	-	-	-	0	6	-	-	-
% exceedance for entire year	-	-	-	15.4	93.3	25.0	-	-
Median	-	-	-	98.8	75.1	103.5	-	-

TUR	2008	2009	2010	2011	2012	2013	2014	2015
Annual average	74.7	60.6	83.2	85.2	66.1	55.9	-	-
Wet season average	74.5	62.0	89.9	86.3	70.2	57.8	-	-
Dry season average	75.6*	56.4*	76.6	82.8	60.9	53.1	-	-
Range	37.3	32.4	43.6	44.9	25.7	35.6	-	-
n	5	4	12	13	16	20	-	-
# exceedance for wet season	3	3	2	3	9	12	-	-
# exceedance for dry season	1	1	5	3	7	8	-	-
% exceedance for entire year	80.0	100.0	58.3	46.2	100.0	100.0	-	-
Median	75.6	56.95	83.8	85.9	65.5	56.3	-	-

WRP	2008	2009	2010	2011	2012	2013	2014	2015
Annual average				54.9	51.7	44.5	30.6	37.3
Wet season average				65.1	56.9	48.4	30.4	37.3
Dry season average				47.3	45.0	39.5	32.5	-
Range				35.2	25.7	70.1	40.9	22.5
n				7	16	32	17	5
# exceedance for wet season				3	9	18	15	5
# exceedance for dry season				3	7	14	2	0
% exceedance for entire year				85.7	100.0	100.0	100.0	100.0
Median				54.8	49.1	43.3	29.8	36.0

Conductivity

While the creeks in the Los Osos Valley are not listed for conductivity, the historical data set indicates elevated levels. The following graph illustrates the mean conductivity levels by year at UWR, TUR and WRP (on Warden Creek) and at CLV (on Los Osos Creek) from 2008 through June 2014. Average conductivity levels at all three sites on Warden Creek are consistently in the "Increasing Problems" range listed in the Basin Plan standards (750 to 3,000 uS/cm), but do not exceed 3,000 uS/cm where the problem would be considered '"Severe."

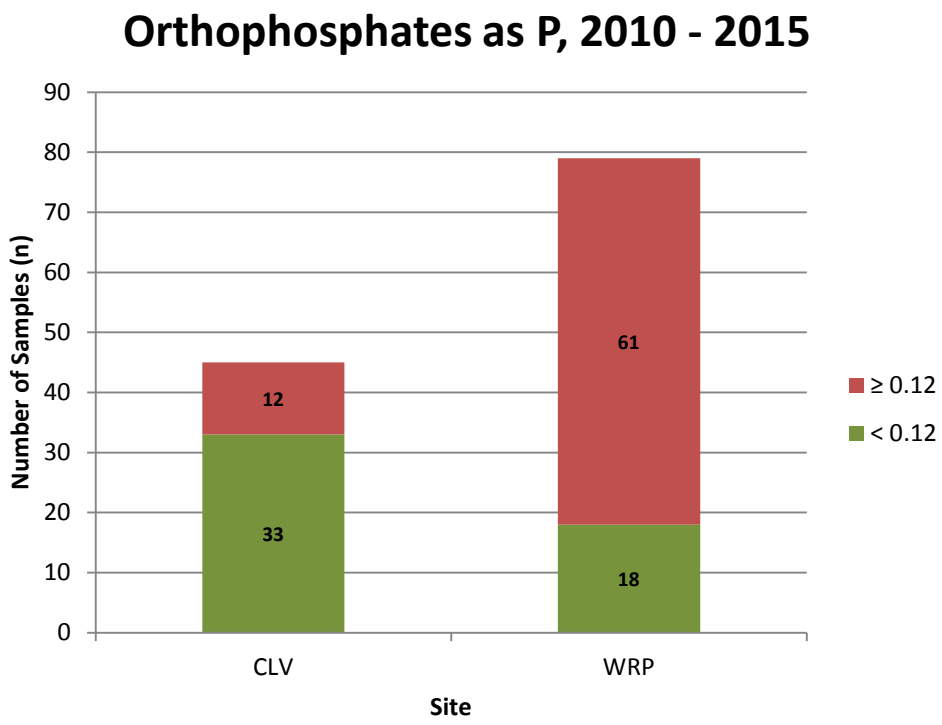


Nutrients

The MBNEP measured orthophosphates as P and nitrates as N during each water quality field visit. Samples were collected by staff and trained volunteers. Samples from CLV were analyzed at the MBNEP office using chemical test kits or colorimeters.

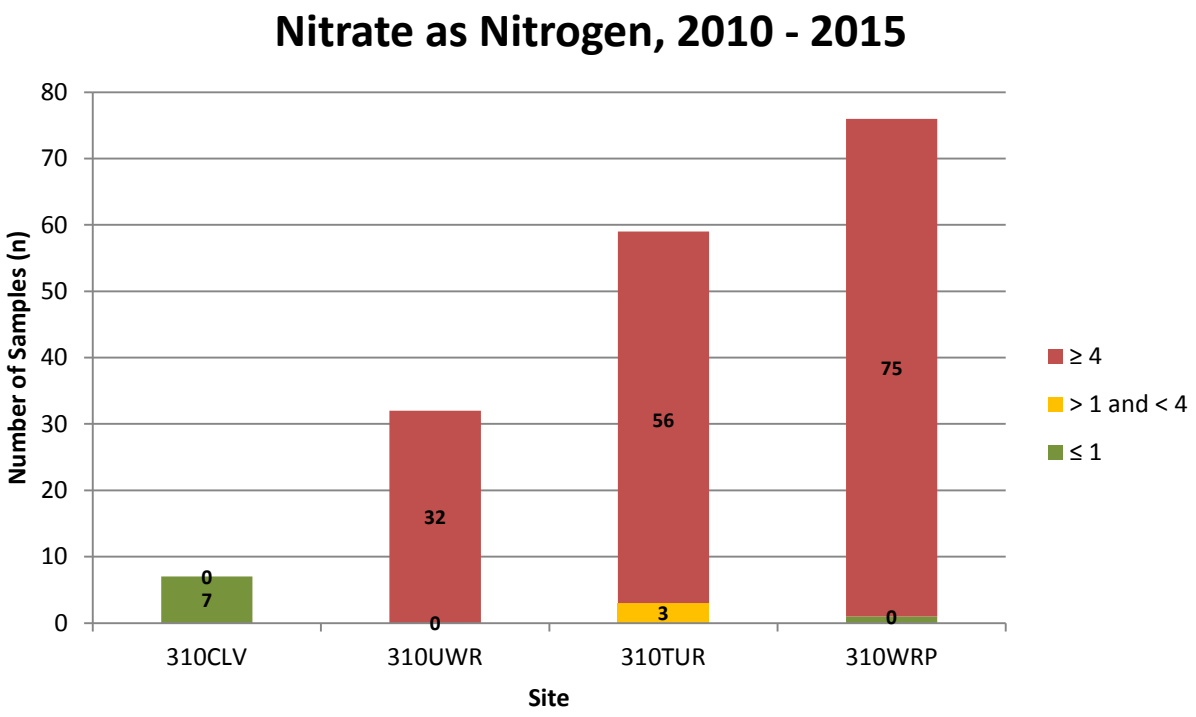
The MBNEP also collected samples which were sent to a certified laboratory for nutrient analysis. The following graphs contain the lab-generated nutrient data for sites UWR, WRP, TUR and LVR from 2010 through 2015. Due to lower than average annual rainfall, LVR did not have measurable surface flows during 2012, 2013, 2014 and 2015. Measurable surface flows were not present at UWR or TUR in 2014 or 2015.

For orthophosphates, the following bar graph illustrates the number of samples with orthophosphate as P concentrations in two categories: less than 0.12 mg/L (shown in green) and greater than or equal to 0.12 mg/L (shown in red). Site WRP Is located on Warden Creek and orthophosphate analysis was conducted by a certified lab. Site CLV is located on Los Osos Creek, and the orthophosphate data was collected using a colorimeter.

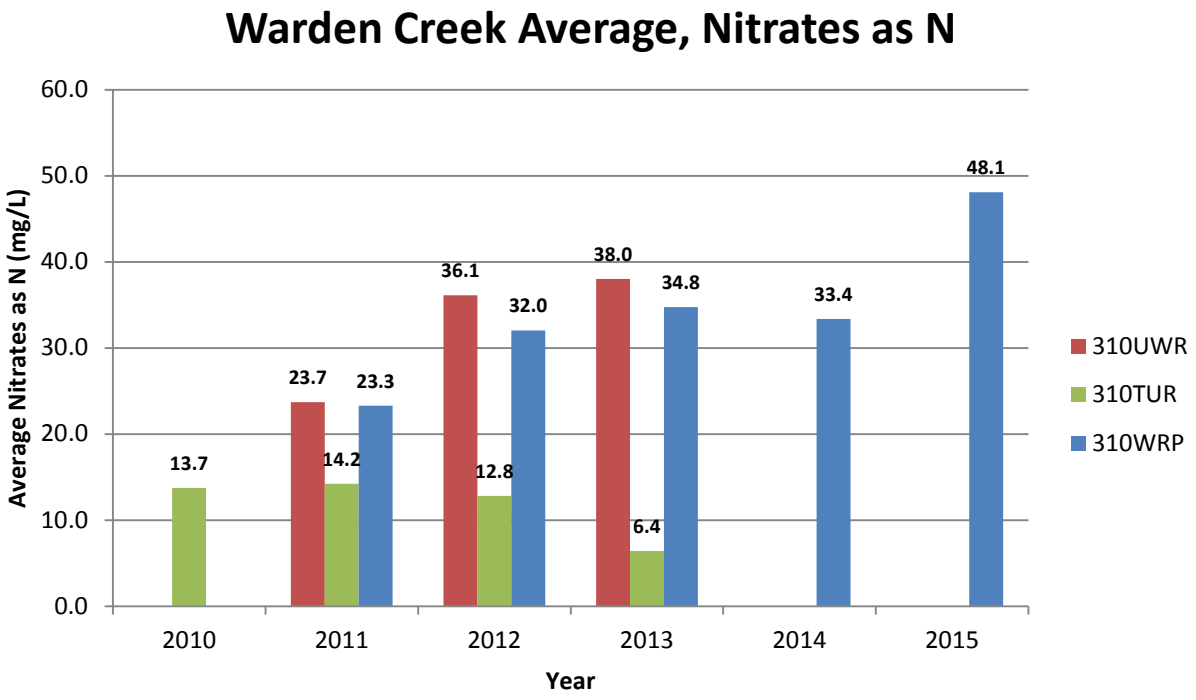


The CCRWQCB 303(d) Listing Guidance Value for nitrates as nitrogen is 1.0 mg/L to be protective of aquatic life and 10 mg/L to be protective of human health.

The following plot shows the number of nitrate as nitrogen samples in each of three categories: less than or equal to 1 mg/L (shown in green), greater than 1 and less than 4 mg/L (shown in yellow), and greater than or equal to 4 mg/L (shown in red). The data is lab-generated analysis for UWR, TUR and WRP on Warden Creek. The data from CLV included in the graph was generated using a HACH colorimeter during 2013. All seven results were less than 1 mg/L. From 2010 through 2012, CLV was monitored 22 times for nitrates using a LaMotte 3354 nitrate as N kit and all results were less than 1 mg/L. While this data can only be considered screening level data, it indicates a long-running trend of minimal nitrate concentrations at the site.



The average nitrate concentrations for the three sites on Warden Creek from 2010 through 2015 are illustrated in the following graph. All data used in this analysis was from a certified laboratory.



Sediment

MBNEP sediment monitoring efforts are focused in the Chorro Valley, so the program does not have adequate data to assess sediment progress in the Los Osos subwatershed.

Conclusions for Los Osos and Warden Creeks

Los Osos and Warden Creeks have minimal issues with *E. coli*. TUR more frequently has elevated levels. Analysis indicated frequent issues with DO at TUR and WRP. Conductivity on Warden Creek is consistently in the "Increasing Problems" range but never in the "Severe" range (> 3,000 uS/cm). Warden has frequent exceedances of the nitrate drinking water standard.

PENNINGTON CREEK

Impairments on Pennington Creek are related to fecal coliform. As the MBENP monitors for *E. coli*, all analysis will address this analyte.

Bacteria

The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) of 410 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

The following table contains the number of bacteria samples collected each year at the sites and the number and percent of samples that exceeded the STV criteria of 410 MPN/100 mL.

APN	2008	2009	2010	2011	2012	2013	2014	2015
n	0	0	0	0	1	10	10	7
> 410 MPN/100 mL	-	-	-	-	0	0	1	2
% exceedance	-	-	-	-	0	0	10.0	28.6

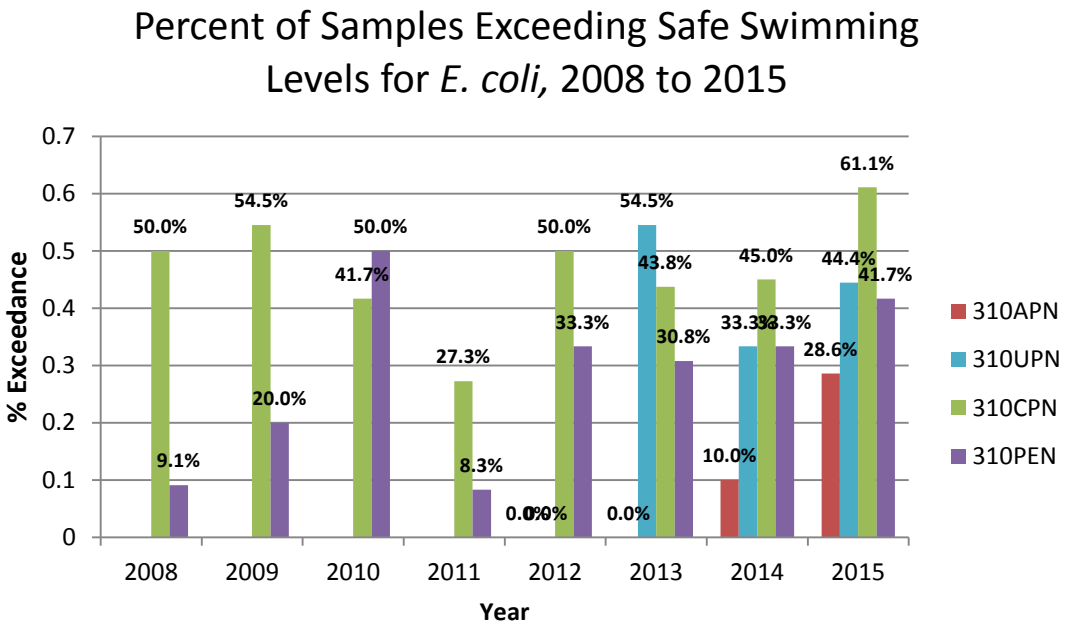
UPN	2008	2009	2010	2011	2012	2013	2014	2015
n	0	0	0	0	1	11	17	18
> 410 MPN/100 mL	-	-	-	-	0	6	8	8
% exceedance	-	-	-	-	0.0	54.5	47.1	44.4

CPN	2008	2009	2010	2011	2012	2013	2014	2015
n	12	11	11	11	12	16	20	18
> 410 MPN/100 mL	6	6	5	3	6	7	9	11
% exceedance	50.0	54.5	41.7	27.3	50.0	43.8	45.0	61.1

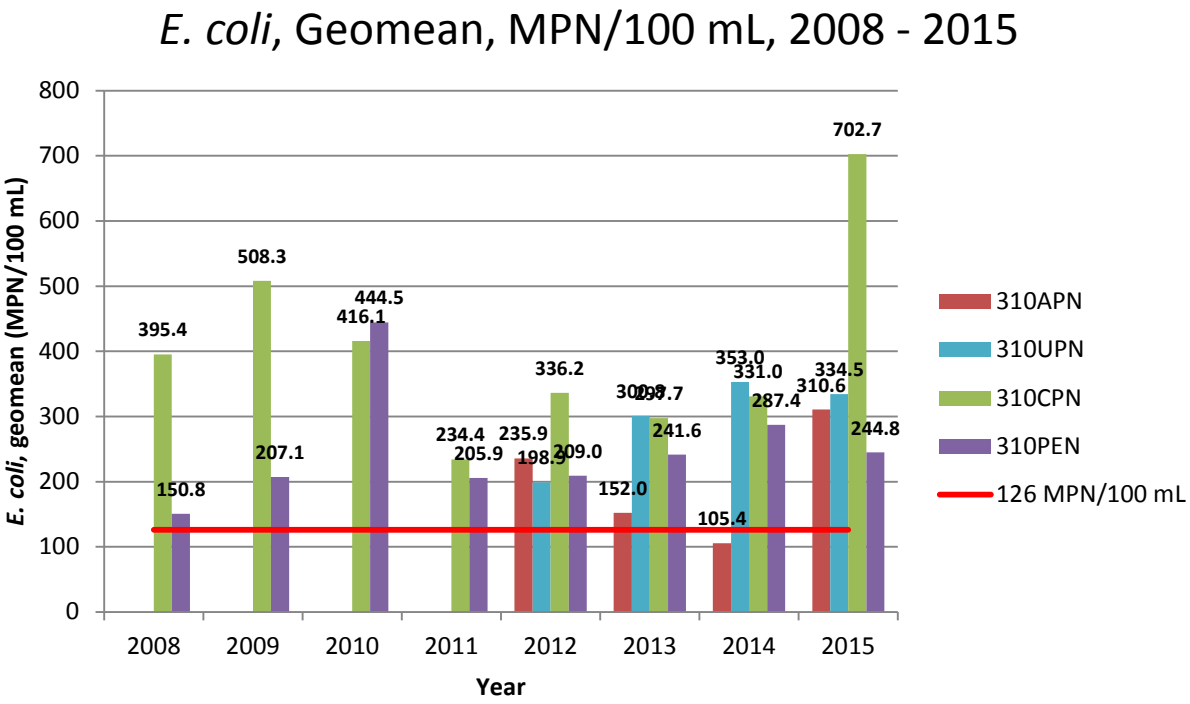
310PEN	2008	2009	2010	2011	2012	2013	2014	2015†
n	11	10	12	12	12	13	12	12
> 410 MPN/100 mL	1	2	6	1	4	4	4	5
% exceedance	9.1	20.0	50.0	8.3	33.3	30.8	33.3	41.7

2015 values include January to September.

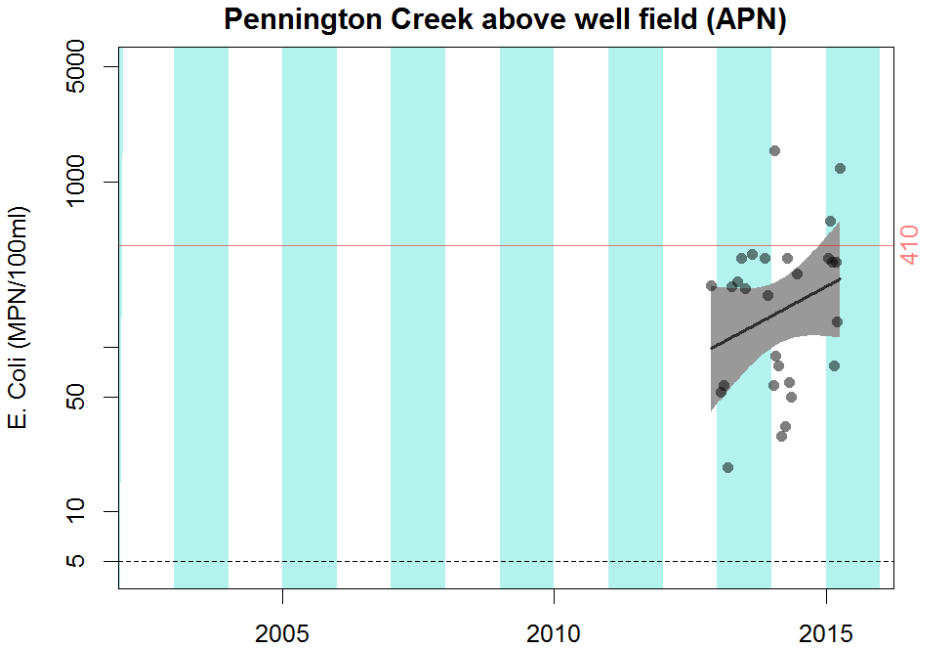
The following graph illustrates the percent of bacteria samples that exceeded the STV criteria of 410 MPN/100 mL.

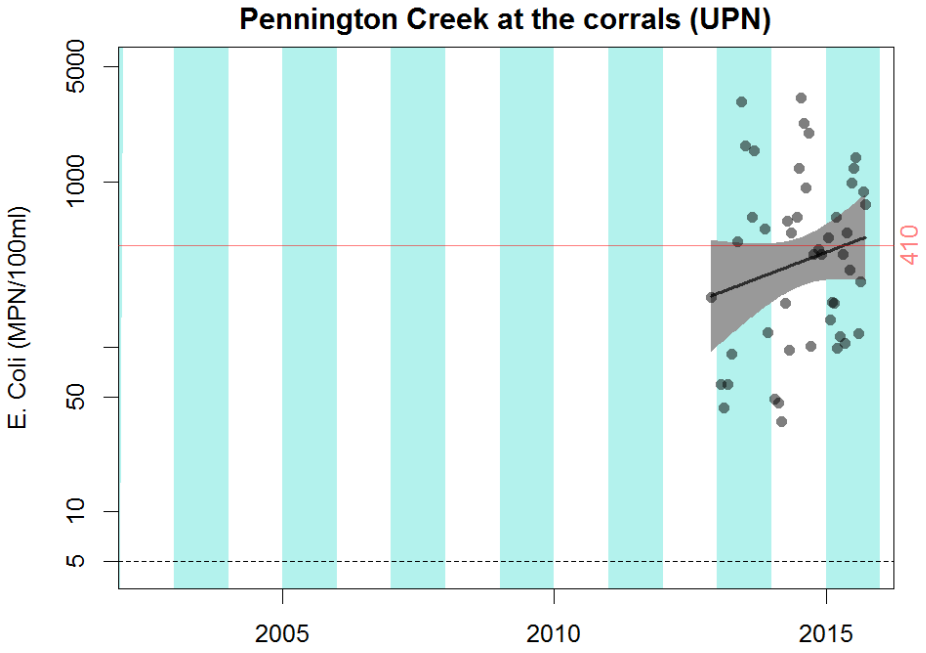


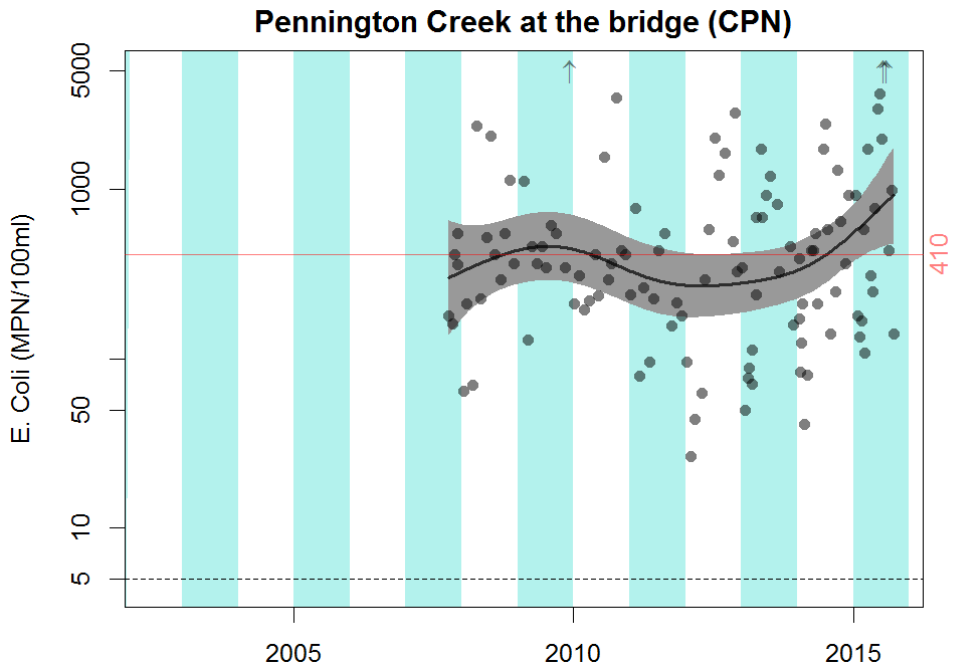
The following graph illustrates the geomean of the *E. coli* data from Pennington Creek from January 2008 through September 2015. The red line represents the regulatory criteria of 126 MPN/100 mL for the geomean of the data.

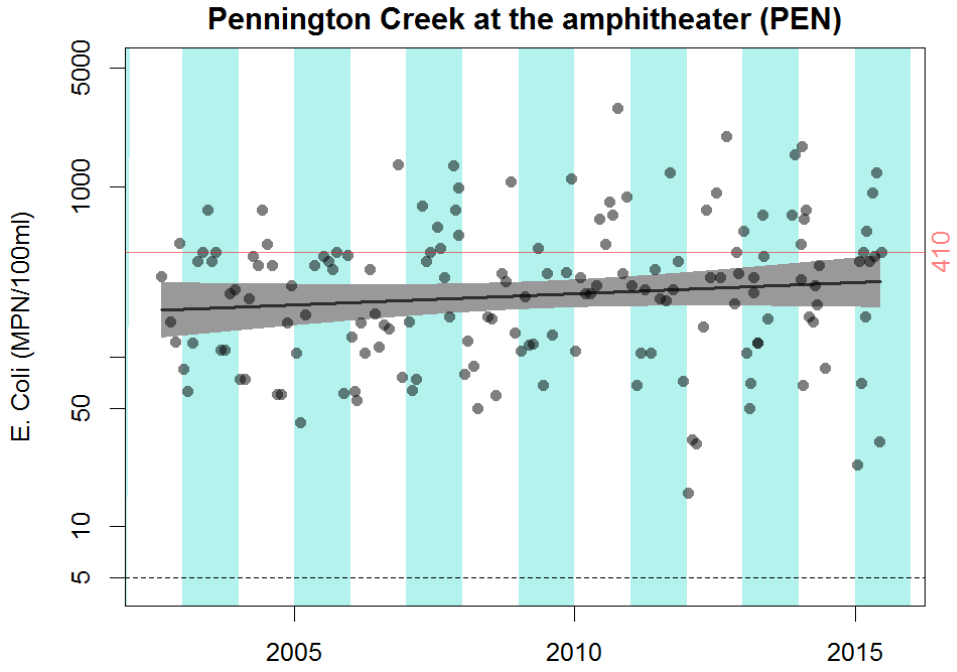


The following graphs plot the *E. coli* data over time and include smoothing splines as well as error bands. The model used has no seasonality term and uses arrows to indicate values over 5,000 MPN/100 mL. The smooth line summarizes the mean bacteria level and the error band reflects the certainty of the trend estimate. The bands can be considered as a 95% confidence interval for the mean bacteria level at any point in time. Monitoring at APN and UPN has not been long running enough to develop a trend. Data from CPN and PEN indicated a relatively flat trend that consistently hovered around the 410 MPN/100 mL STV criteria.

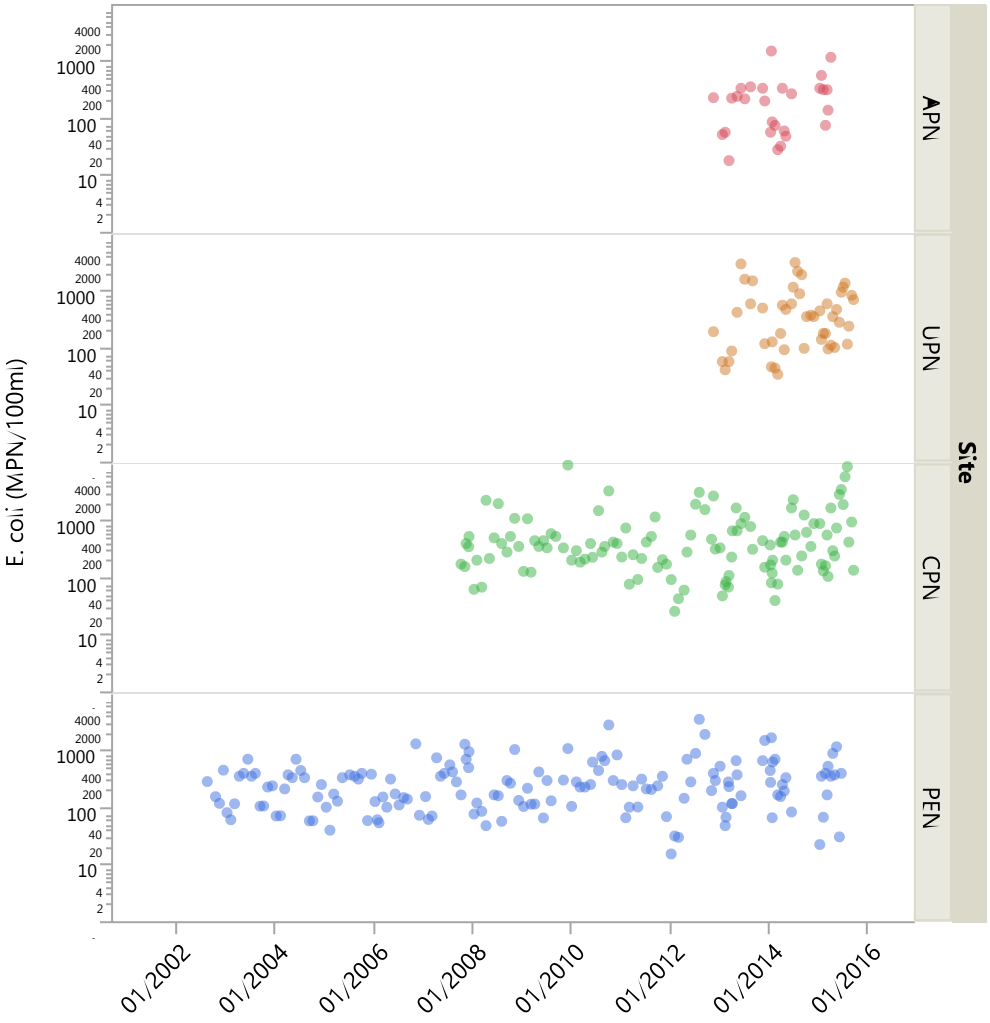




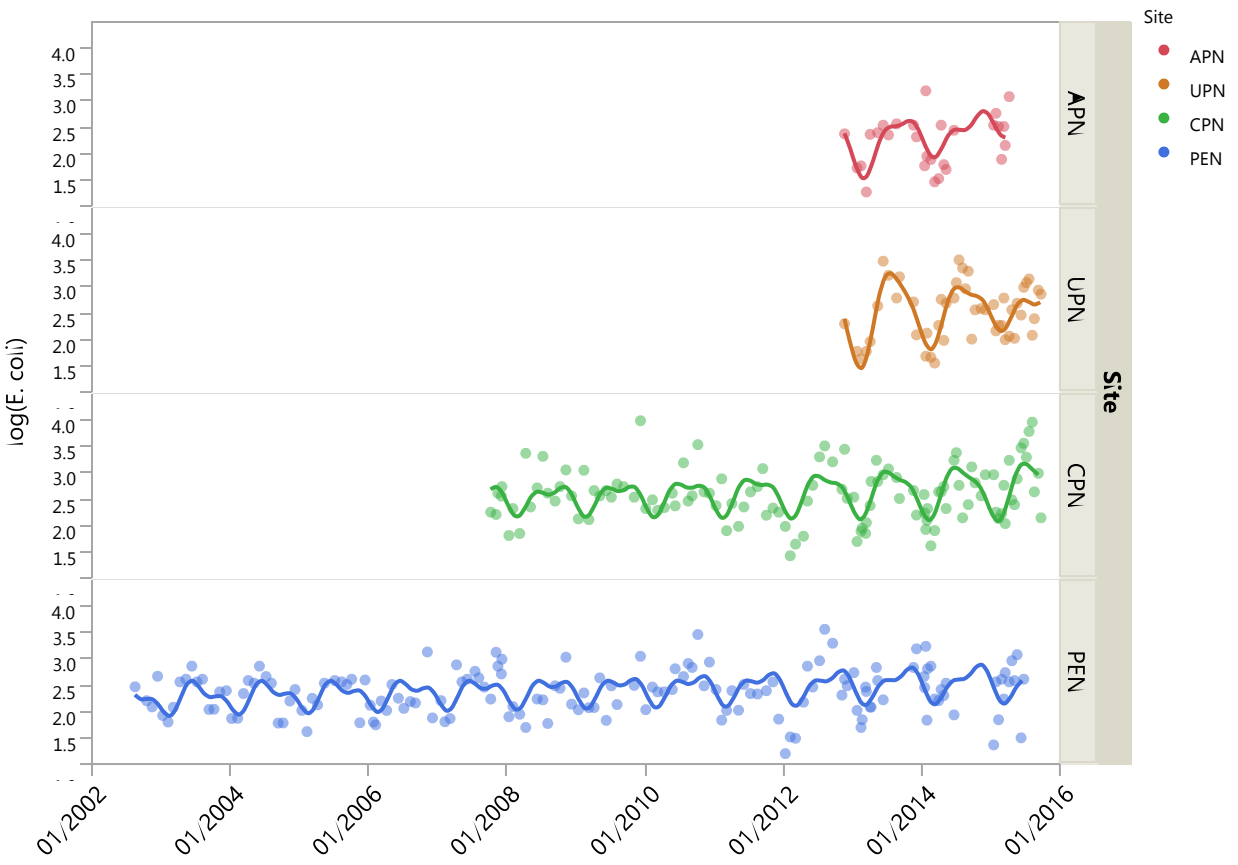




An assessment was conducted to get a sense of the long-term trend at the four sites. The graph provides an overview of the data for each site.

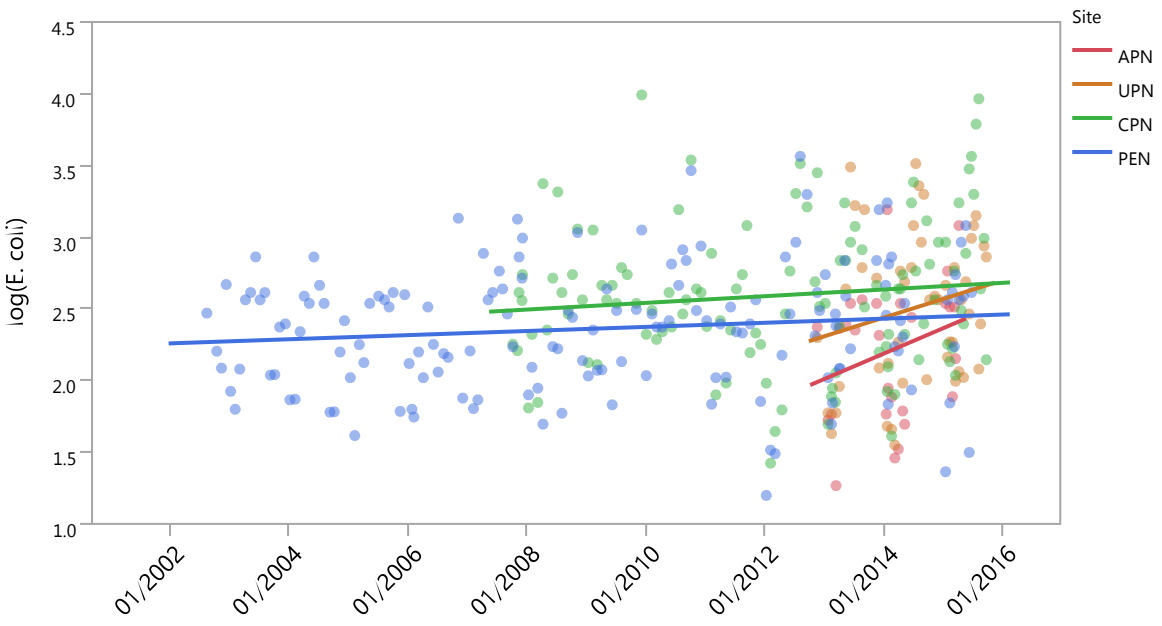


A model was also run to test the differences across the sites. A semi-annual seasonal sin/cos model was run to test for different temporal swings across the sites. The following plot illustrates the model. This model accounts for approximately 40% of the variation in the *E. coli* counts.

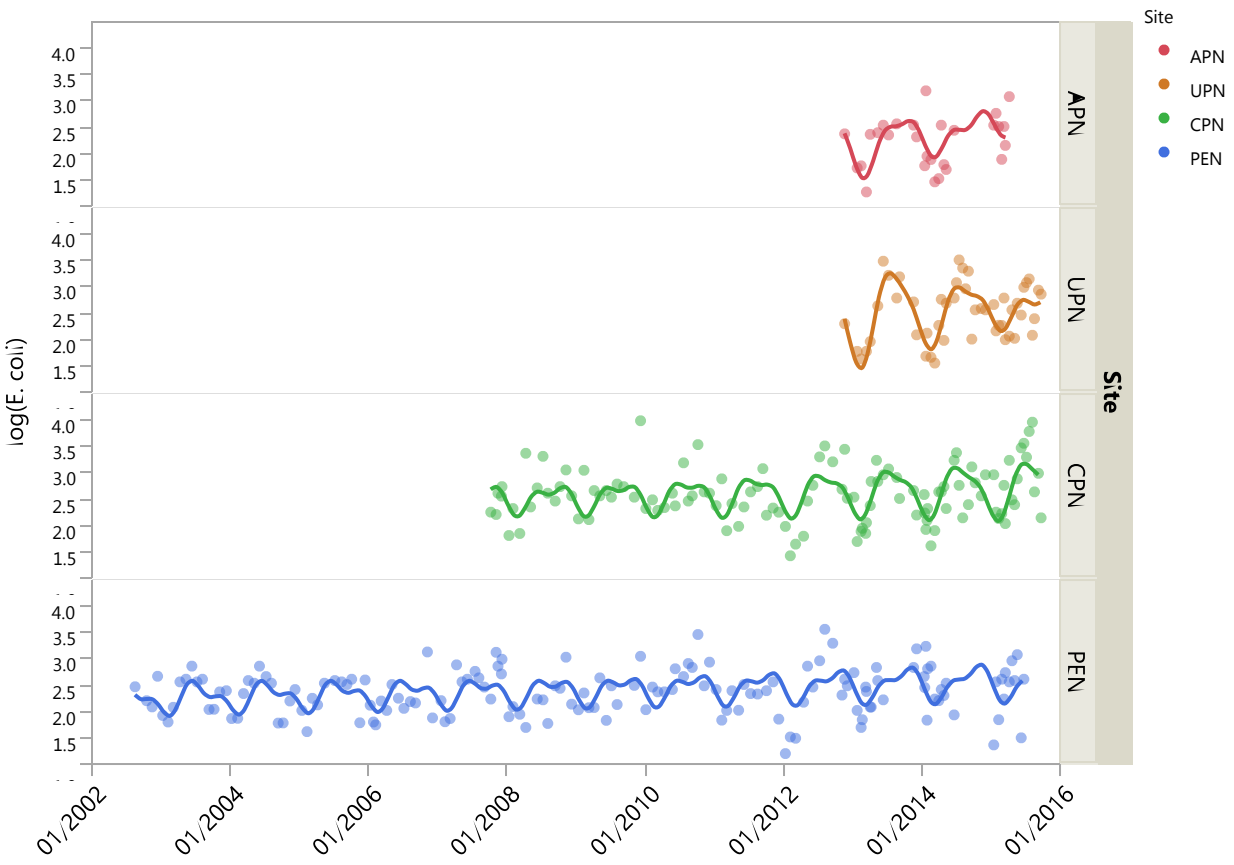


There is moderate evidence that the mean log (*E. coli*) is not the same across all sites. In particular, CPN has significantly higher counts than the overall average (p-value = 0.0256) and is significantly higher than PEN (p-value = 0.0266). Empirically, the counts at CPN and PEN are higher than those upstream (APN and UPN), but because sample sizes upstream are substantially lower, the differences cannot be declared statistically significant.

The following graph displays the observed *E. coli* counts on the log scale. The plot shows the apparent difference in the general trend over time with APN and UPN showing trends in *E. coli* abundance that are growing at faster rates (steeper) than at CPN and PEN. These observed differences are not, however, statistically significant (p-value = 0.6989). Again, additional data is needed to further assess the trend.



There is evidence that the amplitude of the variation is not constant over time across the sites (p-value = 0.0038). In particular, there is evidence that the amplitude at CPN is growing (p-value = 0.0210). Empirically, the amplitude at UPN appears to be radically dropping, but due to the short series length, this reduction in variability is not statistically significant (p-value = 0.1337).



Conclusions for Pennington Creek

All four of the Pennington Creek sites have frequent instances of elevated *E. coli* concentrations that exceed EPA's 2012 criteria. Additional analysis of relative bacteria levels is needed, and additional data collection and analysis will be conducted in 2016.

Chumash Creek

Due to intermittent flows, minimal data was collected on Chumash Creek. No analysis will be included in this report.

San Luisito Creek

Impairments on San Luisito Creek are related to fecal coliform. As the MBENP monitors for *E. coli*, all analysis will address this analyte.

Bacteria

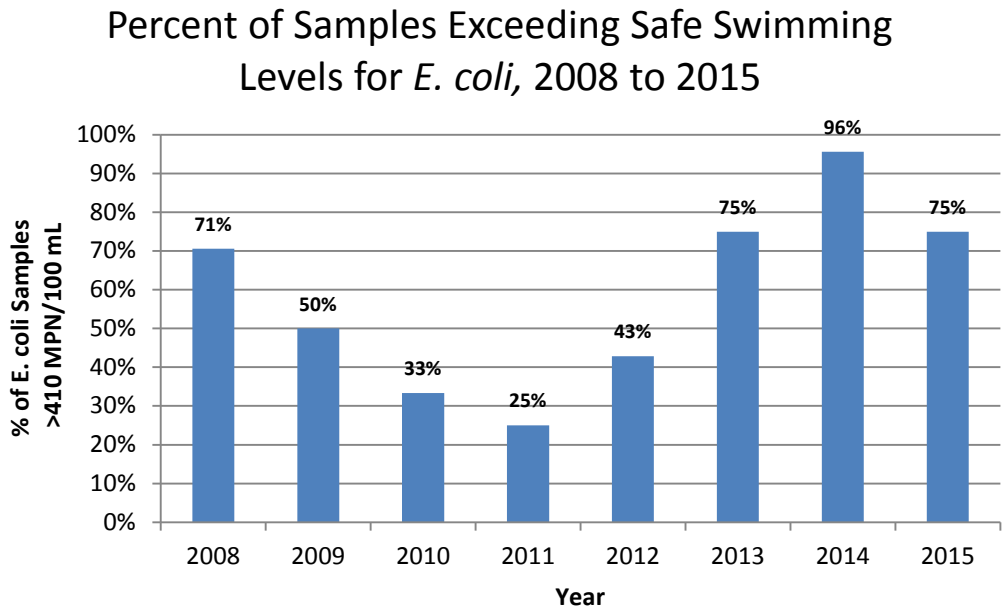
The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) is 410 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

The following table contains the number of bacteria samples collected each year at the sites and the number of samples that exceeded the STV criteria of 410 MPN/100 mL.

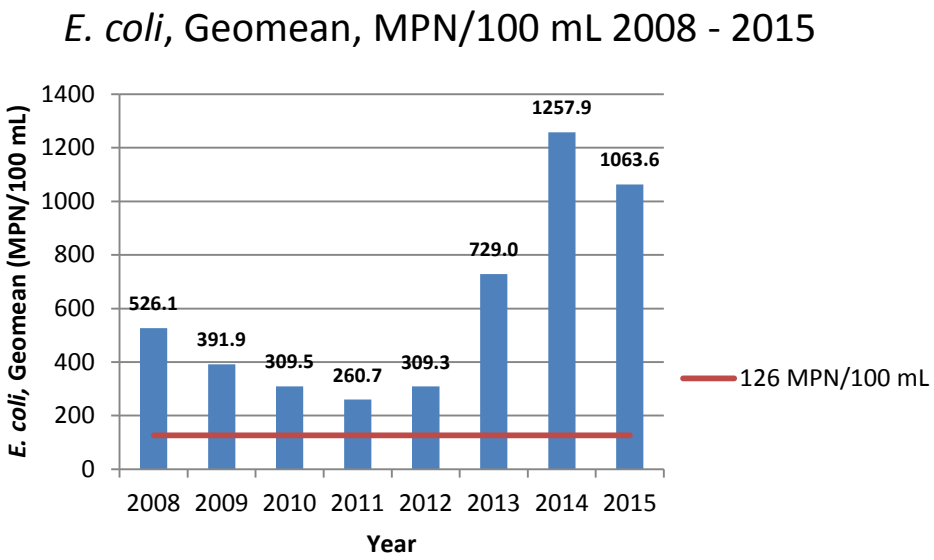
	2008	2009	2010	2011	2012	2013	2014	2015
SLU n	17	24	24	23	14	25	23	12
SLU %Exceed	64	16	33	29	39	38	95	75

2015 values include January to September 2015.

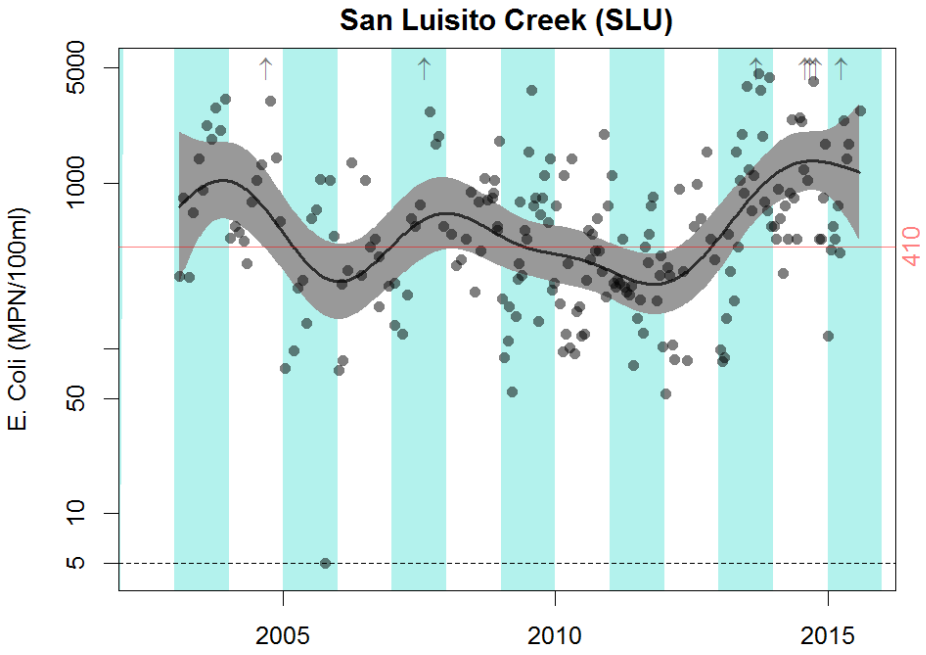
The following graph illustrates the percent of bacteria samples that exceeded the STV criteria of 410 MPN/100 mL.



The following graph illustrates the geomean of the *E. coli* data from January 2008 through September 2015. The red line represents the regulatory criteria of 126 MPN/100 mL for the geomean of the data.



The following graph plots the *E. coli* data over time and include smoothing splines as well as error bands. The model used has no seasonality term and uses arrows to indicate values over 5,000 MPN/100 mL. The smooth line summarizes the mean bacteria level and the error band reflects the certainty of the trend estimate. The bands can be considered as a 95% confidence interval for the mean bacteria level at any point in time. The analysis indicates a more recent upward trend in the data.



Conclusions for San Luisito Creek

San Luisito Creek *E. coli* data has frequent exceedances of the EPA recreational criteria and an upward trend line.

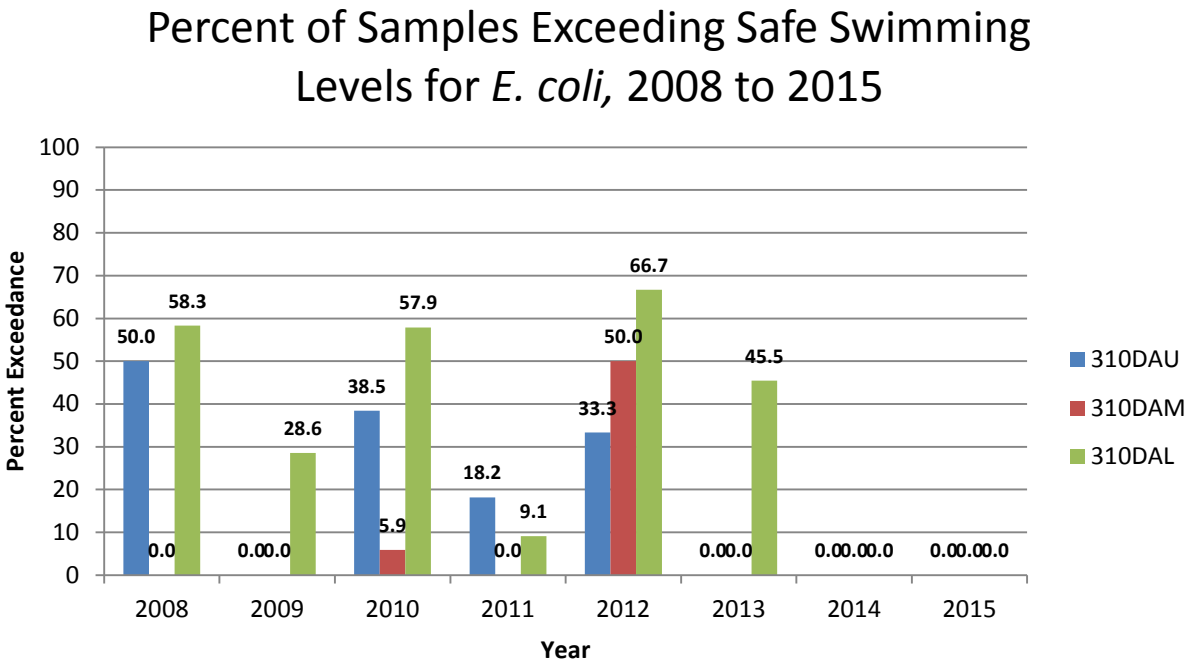
DAIRY CREEK

Impairments on Dairy Creek are related to fecal coliform and DO.

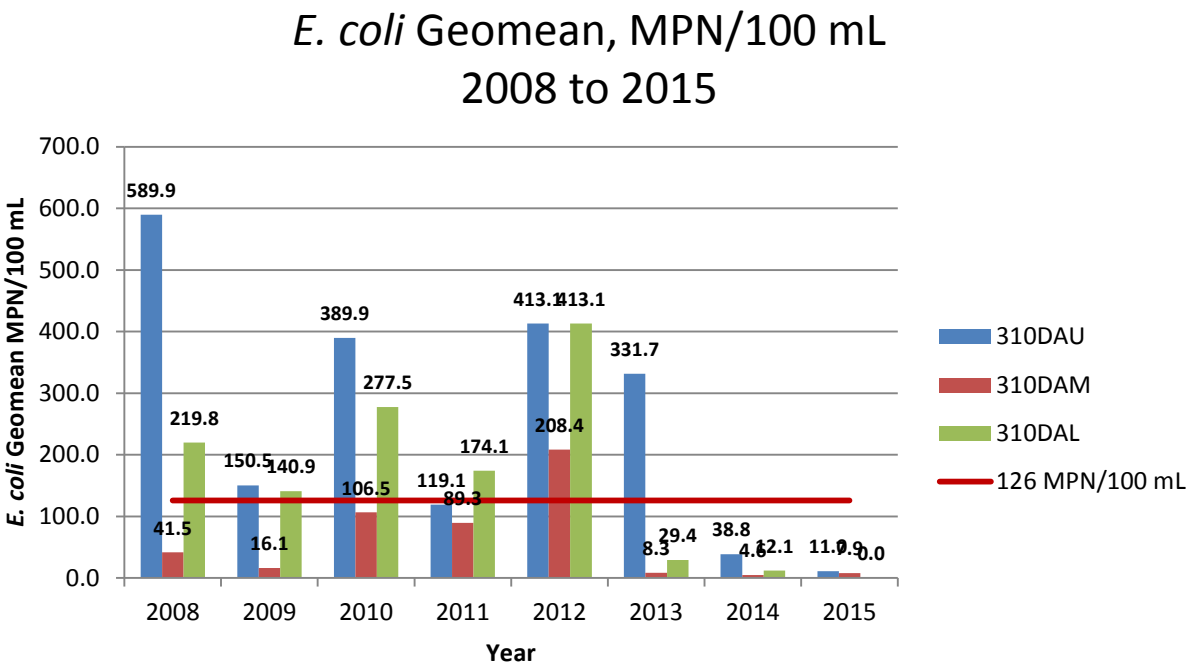
Bacteria

As the MBNEP monitors for *E. coli*, all analysis will address this analyte. The regulatory criteria for comparison are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For freshwater, the geomean of the *E. coli* data should be less than 126 MPN/100 mL and the statistical threshold value (STV) is 410 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

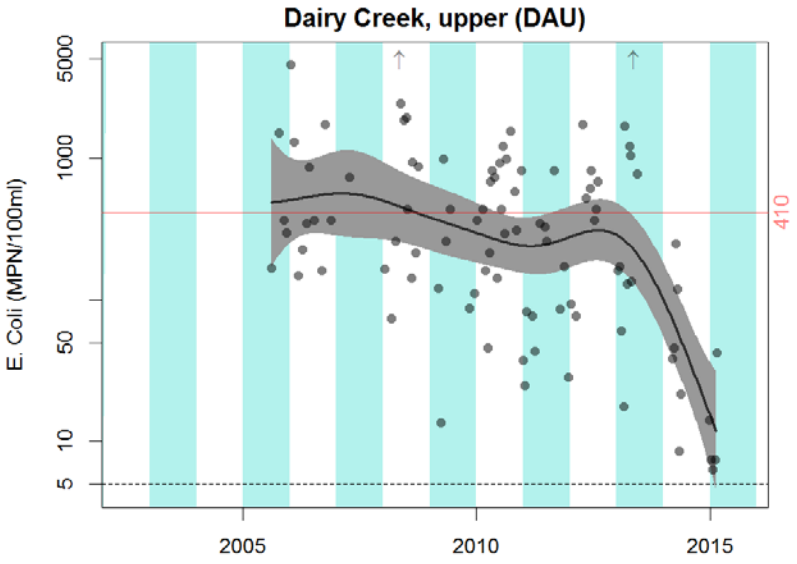
The following graph depicts the % of samples that exceeded the 410 MPN/100 mL recreational contact standard for *E. coli* each year.

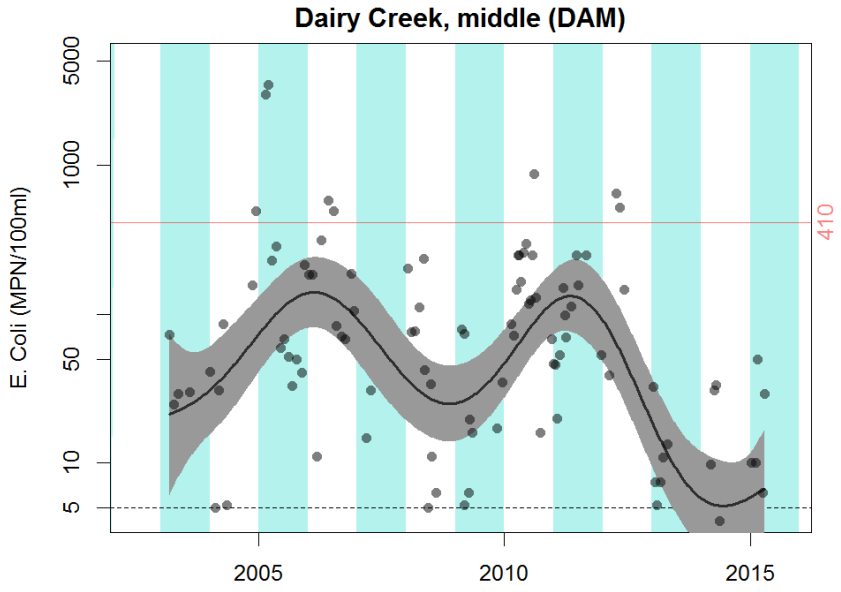


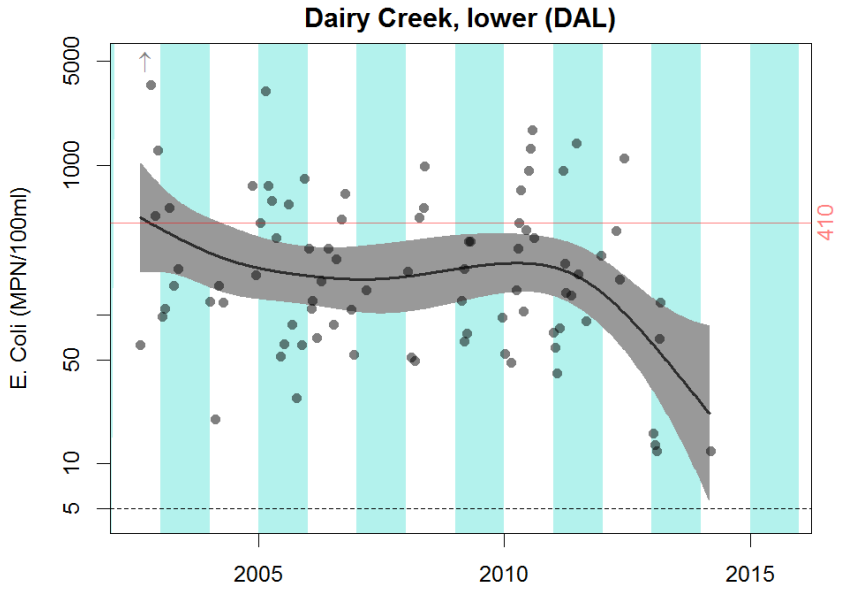
The following graph illustrates the geomean of the *E. coli* data on Dairy Creek from January 2008 through September 2015.



The following graphs plot the *E. coli* data over time and include smoothing splines as well as error bands. The model used has no seasonality term and uses arrows to indicate values over 5,000 MPN/100 mL. The smooth line summarizes the mean bacteria level and the error band reflects the certainty of the trend estimate. The bands can be considered as a 95% confidence interval for the mean bacteria level at any point in time. The analysis at all three sites indicated a recent downward trend in *E. coli.*







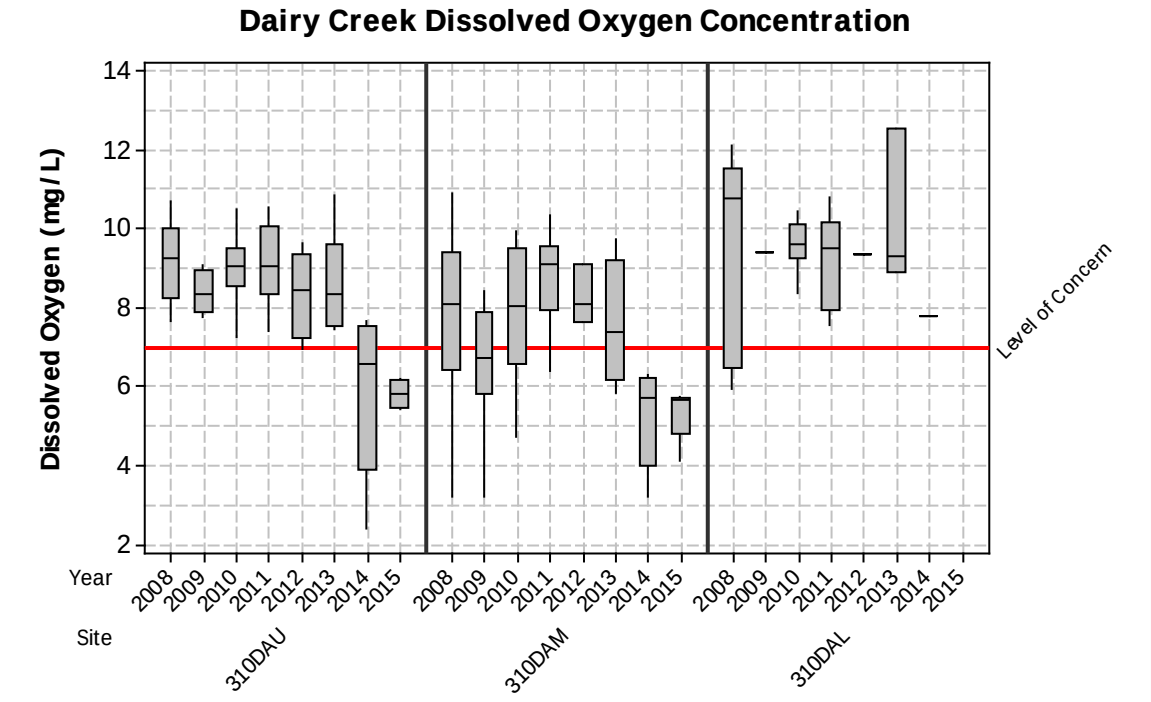
Dissolved Oxygen

DO impairment has also been measured on Dairy Creek. The following tables provide an overview of the dissolved oxygen data, following a format recently adopted by the CCRWQCB in their own analysis of impaired waterbodies. In this analysis, the dry season encompasses May to October and the wet season includes November through April.

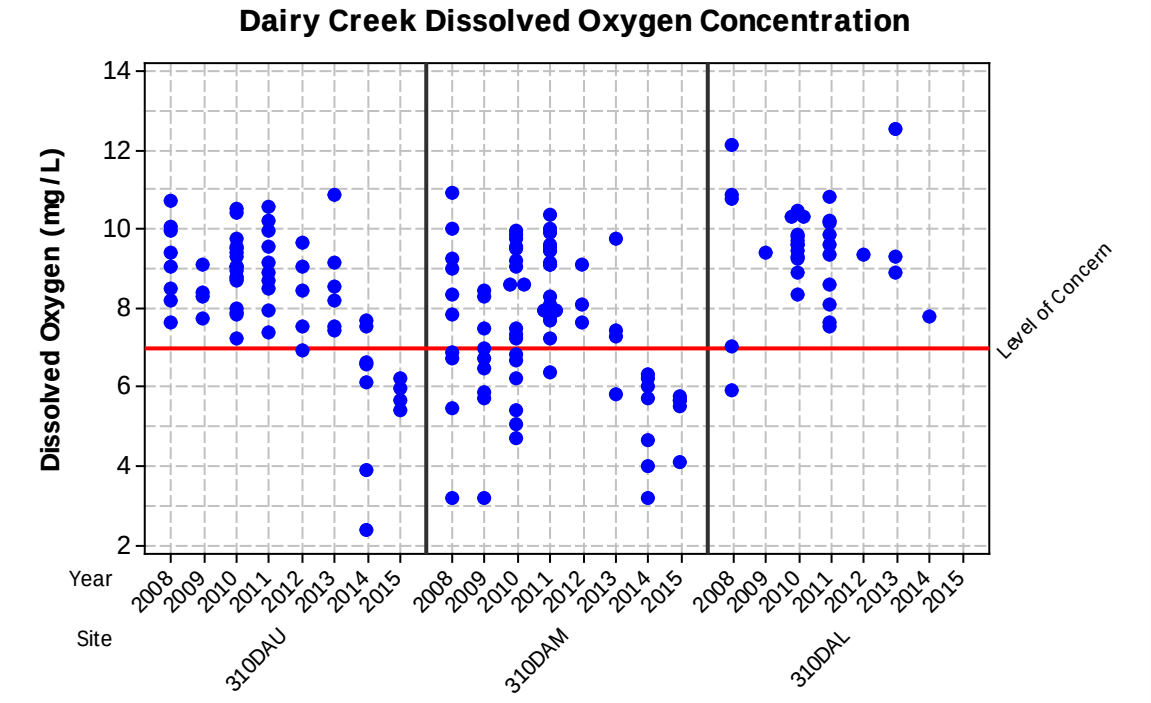
DAU	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	9.2	8.4	9.0	9.1	8.3	8.6	5.9	5.8
Dry Season Average	8.6	-	8.6	8.9	7.6	-	3.1	-
Wet Season Average	10.2	8.4	9.5	9.5	9.4	8.6	6.9	5.8
Range	3.1	1.4	3.3	3.2	2.7	3.4	5.3	0.8
n	8.0	4.0	18	10	5	6	7	4
# Exceedance for Wet Season	0	0	0	0	0	0	3	4
# Exceedance for Dry Season	0	0	0	0	1	-	2	-
%Exceedance for Entire Year	0	0	0	0	20	0	63	100

DAM	2008	2009	2010	2011	2012	2013	2014	2015
Annual Average	7.8	6.6	7.8	8.7	8.3	7.3	5.2	5.3
Dry Season Average	5.9	4.4	6.7	8.1	-	-	3.6	-
Wet Season Average	9.0	7.2	8.9	9.3	8.3	7.3	5.8	5.3
Range	7.7	5.3	5.2	4.0	1.5	4.0	3.1	1.7
n	10	9	18	18	3	5	7	5
# Exceedance for Wet Season	1	3	1	0	0	2	5	5
# Exceedance for Dry Season	3	2	5	1	-	-	2	-
%Exceedance for Entire Year	40	56	3	6	0	40	100	100

The following plot shows the mean DO concentrations for each year, with the results grouped by site. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk. The Central Coast Basin Plan regulatory standard that states that at no time shall DO concentrations fall below 7.0 mg/L, represented by the red line.



The following plot presents the same data presented in scatter plot form.



Conclusions for Dairy Creek

Drought conditions and lack of surface flows have likely contributed to DO exceedances at Dairy Creek in the past few years.

Although recent data from all three sites indicated a downward trend, minimal data was collected in recent years due to drought conditions. STV and geomean criteria were frequently exceeded.

MORRO BAY

The Morro Bay estuary is impaired for DO, pathogens and sediment.

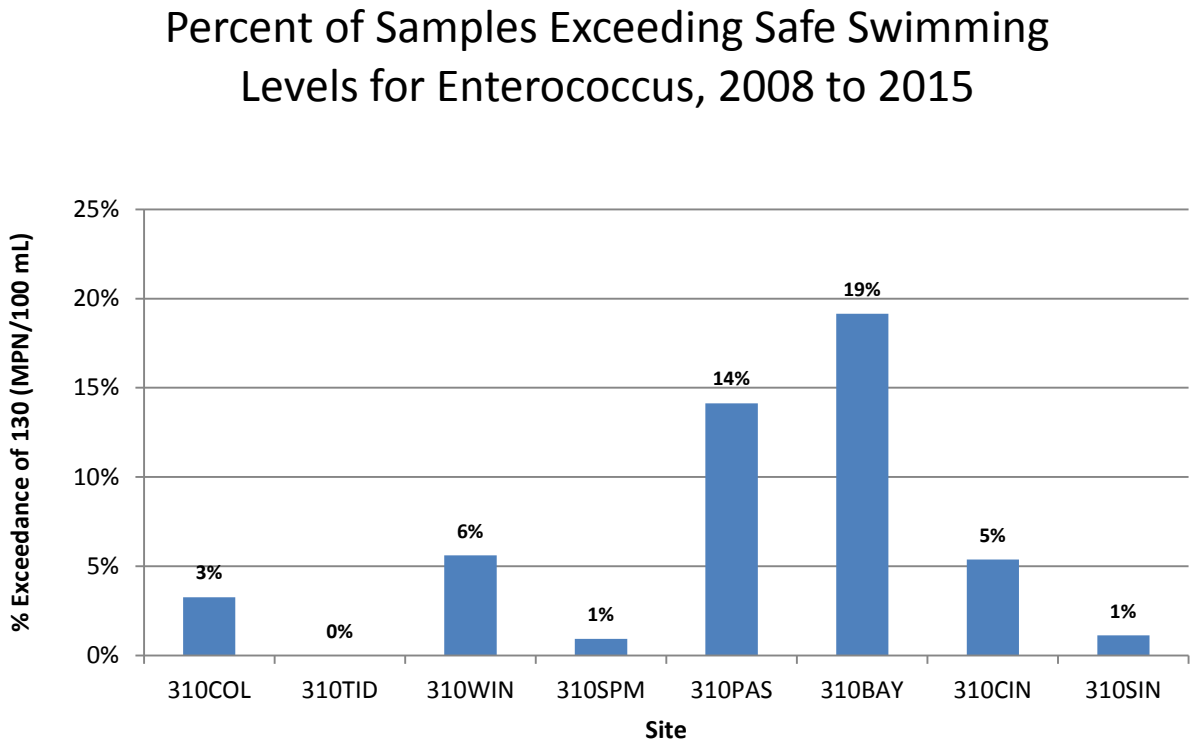
Bacteria

The regulatory criteria for bay bacteria analysis are the recommended standards in EPA's *2012 Recreational Water Quality Criteria*. For marine waters, the geomean of the enterococcus data should be less than 35 MPN/100 mL and the statistical threshold value (STV) is 130 MPN/100 mL, which approximates the 90th percentile of the water quality distribution and is the value that should not be exceeded by more than 10% of the samples.

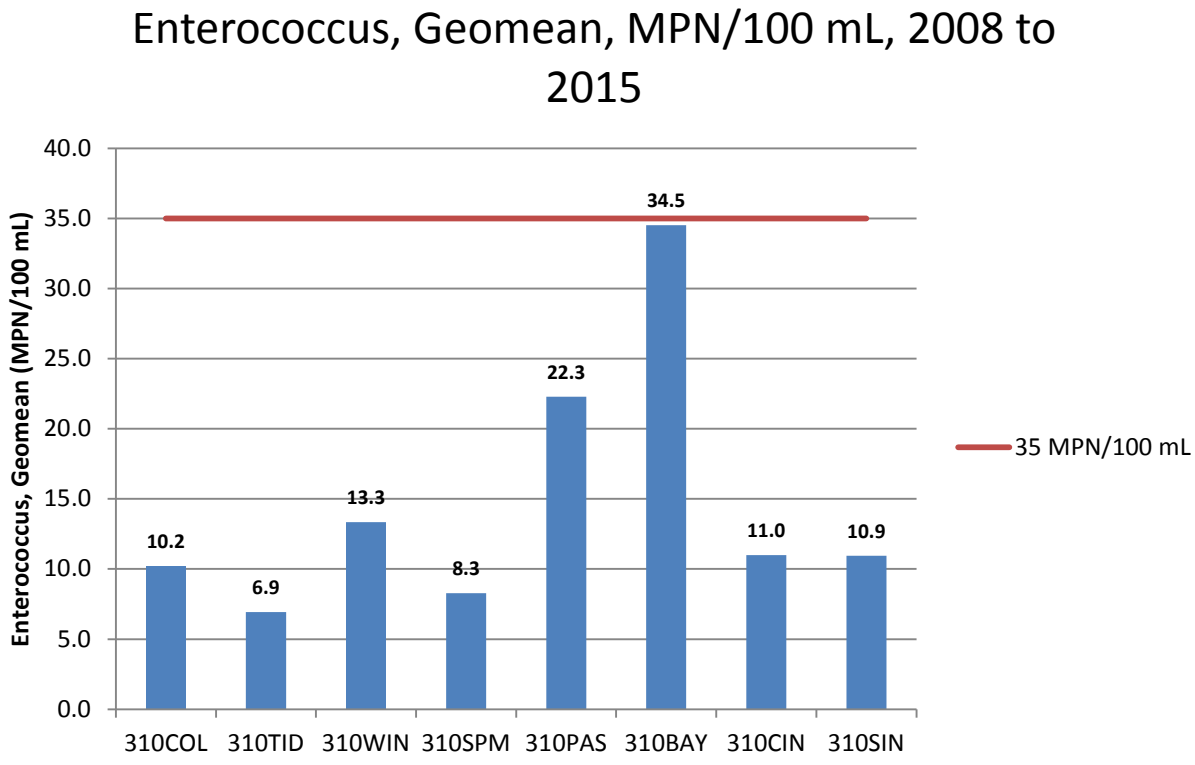
The following table contains the number of *Enterococcus* spp. samples collected at the sites from January 2008 through September 2015.

Site Code	Site Description	Number of Samples (n)	Number of Exceedances of 130 MPN/100 mL	Percent of Samples Exceeding
COL	Coleman Beach	92	3	3%
TID	Tidelands Park	93	0	0%
WIN	Windy Cove	107	6	6%
SPM	State Park Marina	107	1	1%
PAS	Pasadena Point	92	13	14%
BAY	Baywood Pier	94	18	19%
CIN	Cuesta Inlet	93	5	5%
SIN	Sharks Inlet	89	1	1%

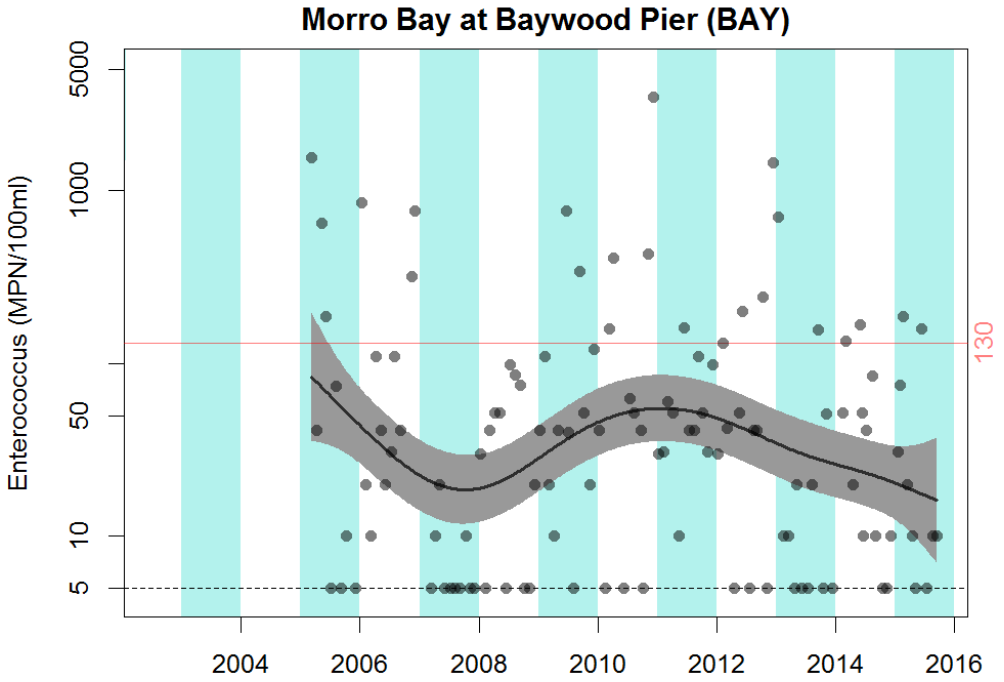
The following graph shows the percent of samples that exceeded the 130 MPN/100 mL regulatory standard for safe recreational contact for *Enterococcus* spp. in marine waters. This analysis is for data from January 2008 through September 2015.

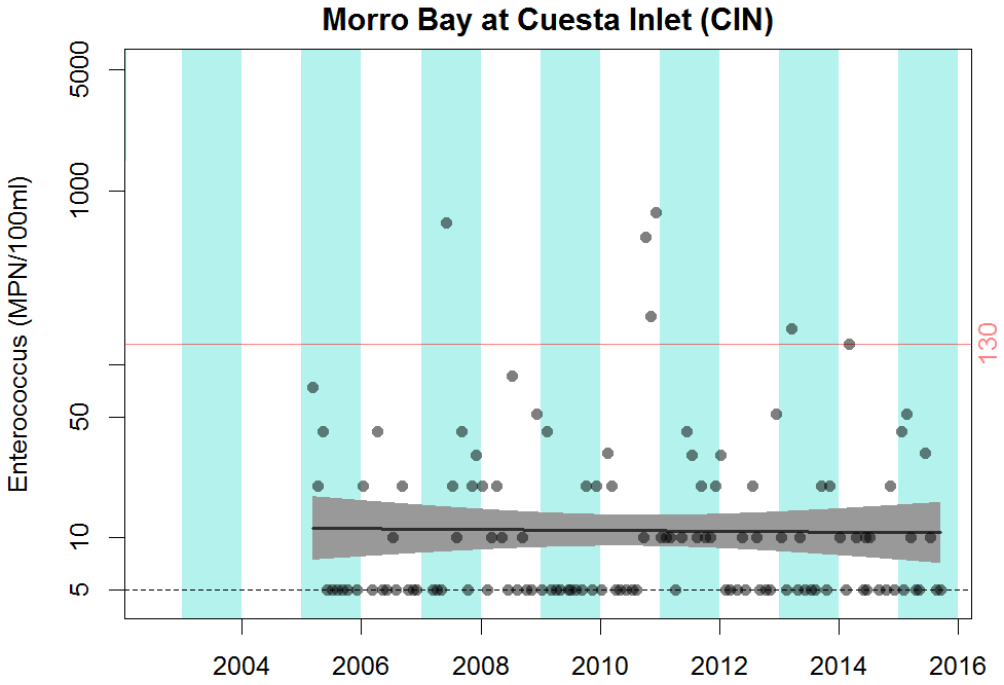


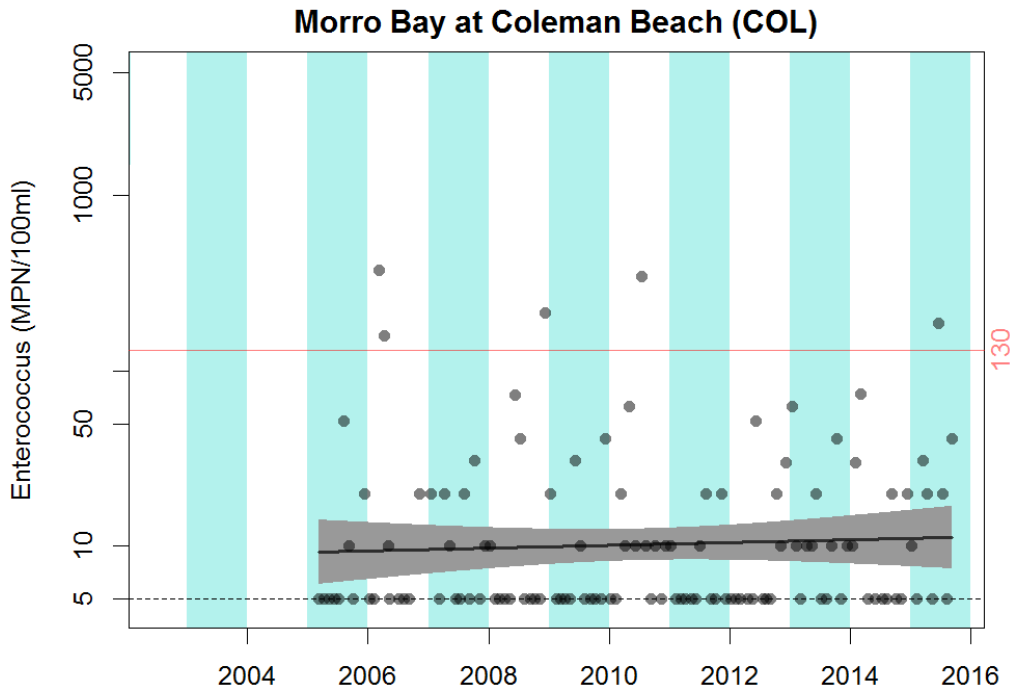
The following graph illustrates the geomean of the *Enterococcus spp.* data from January 2008 through September 2015 for each site.

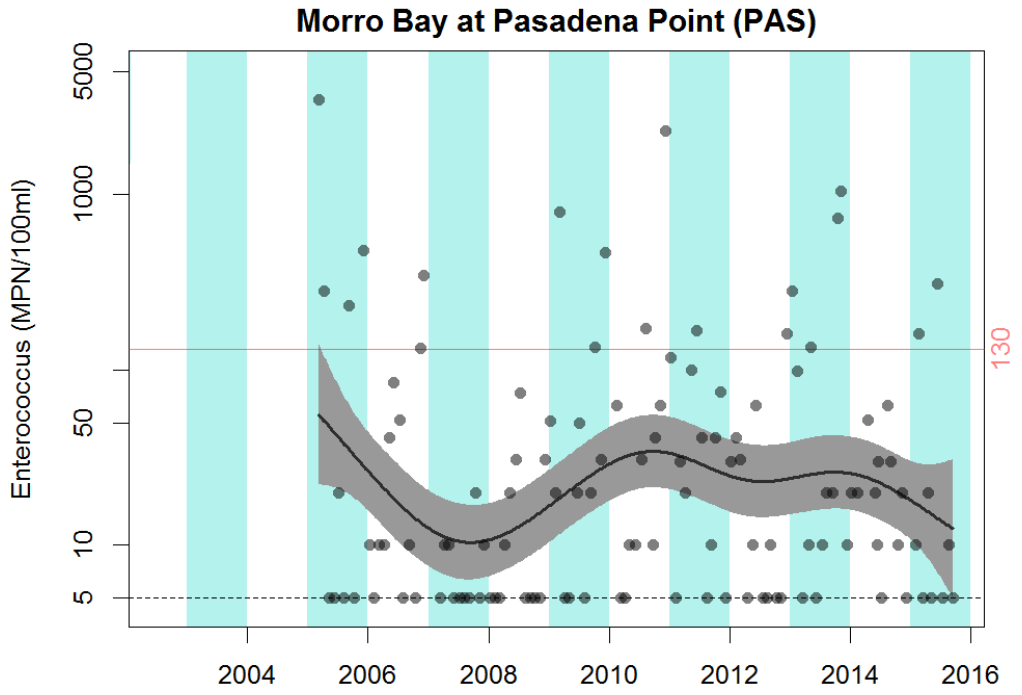


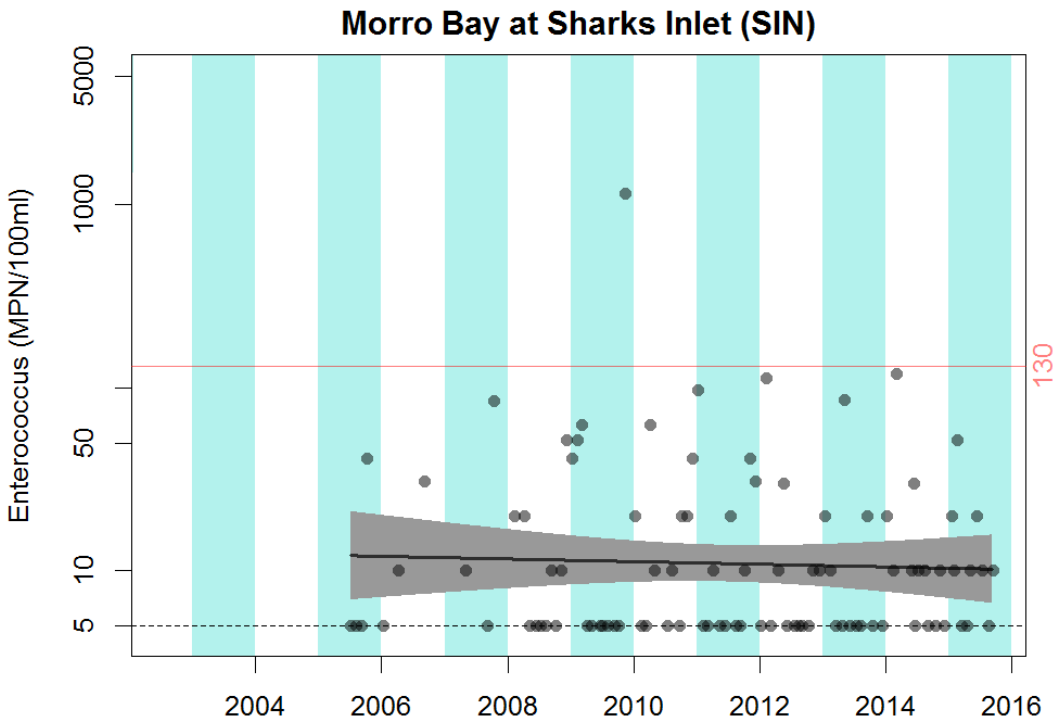
The following graphs plot the enterococcus data over time and include smoothing splines as well as error bands. The model used has no seasonality term and uses arrows to indicate values over 5,000 MPN/100 mL. The smooth line summarizes the mean bacteria level and the error band reflects the certainty of the trend estimate. The bands can be considered as a 95% confidence interval for the mean bacteria level at any point in time.

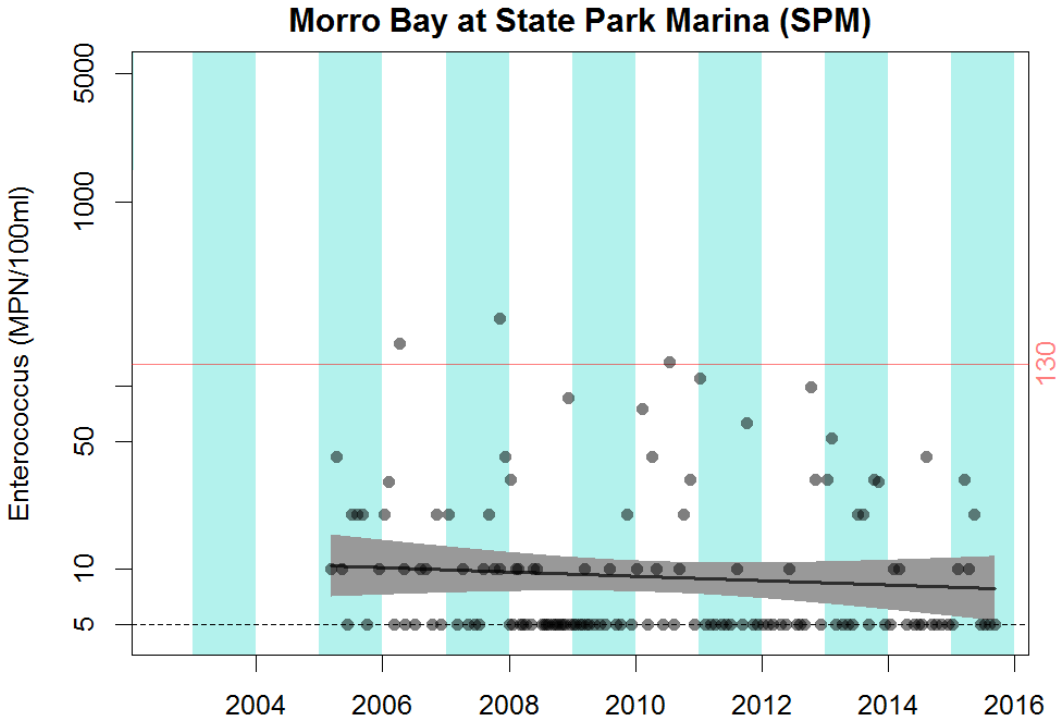


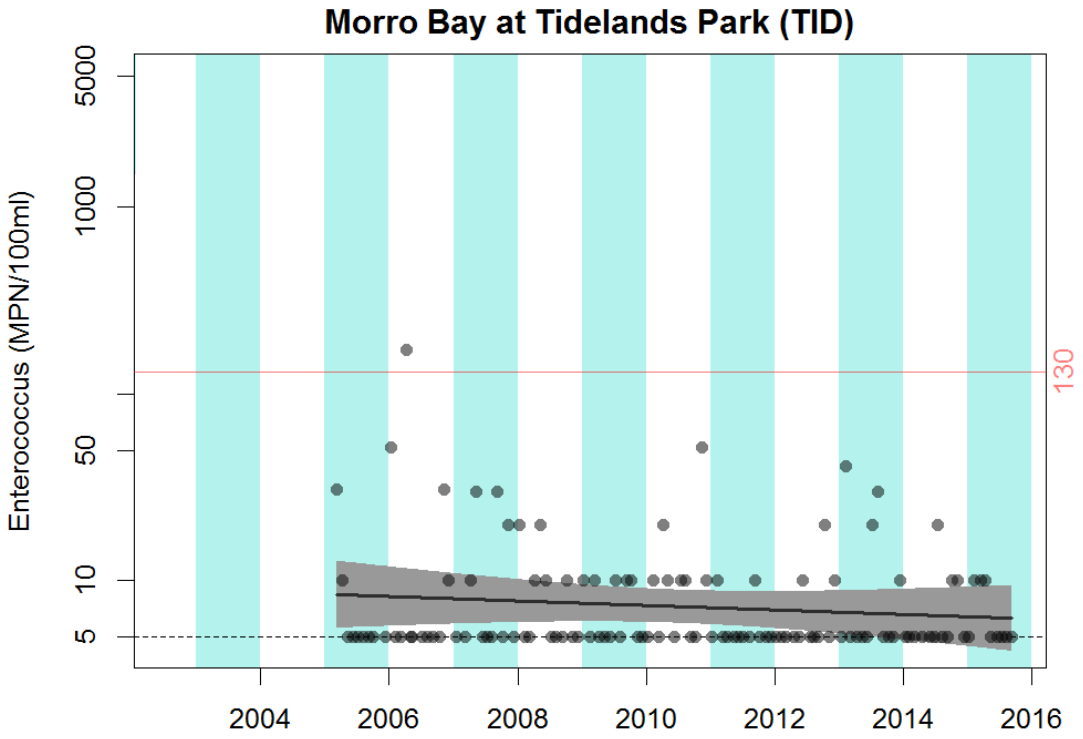


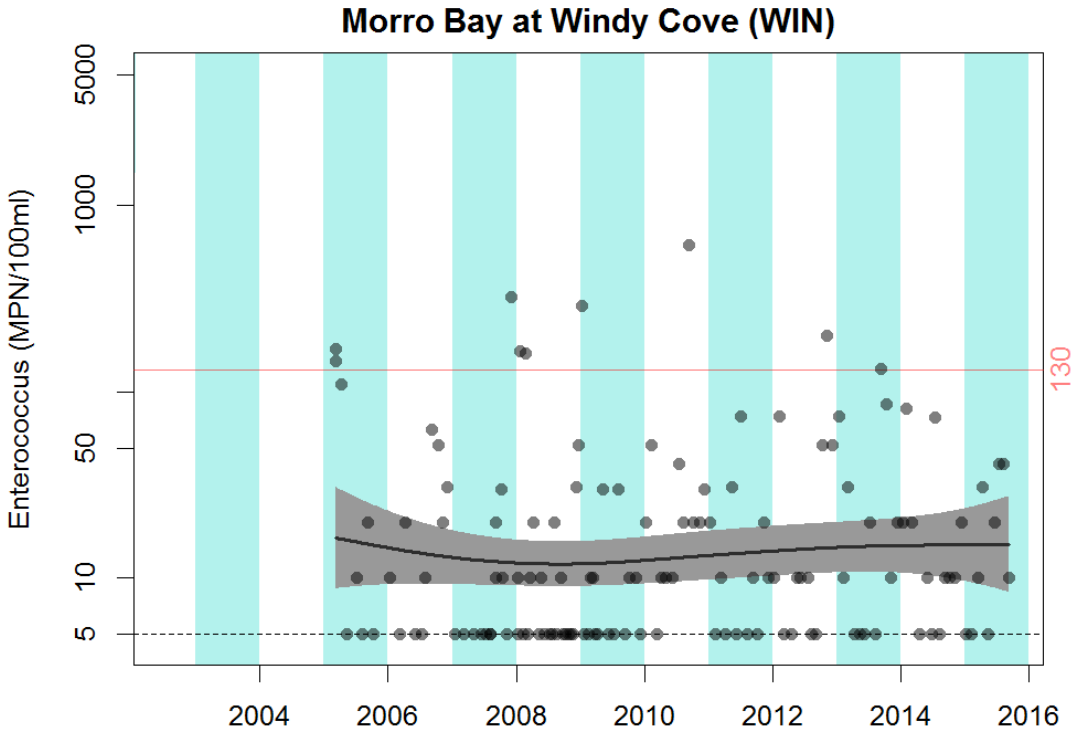

Morro Bay at Coleman Beach (COL)
Enterococcus (MPN/100ml)
5000
1000
50
10
5
130
2004
2006
2008
2010
2012
2014
2016


Morro Bay at Pasadena Point (PAS)
Enterococcus (MPN/100ml)
5000
1000
50
10
5
130
2004
2006
2008
2010
2012
2014
2016

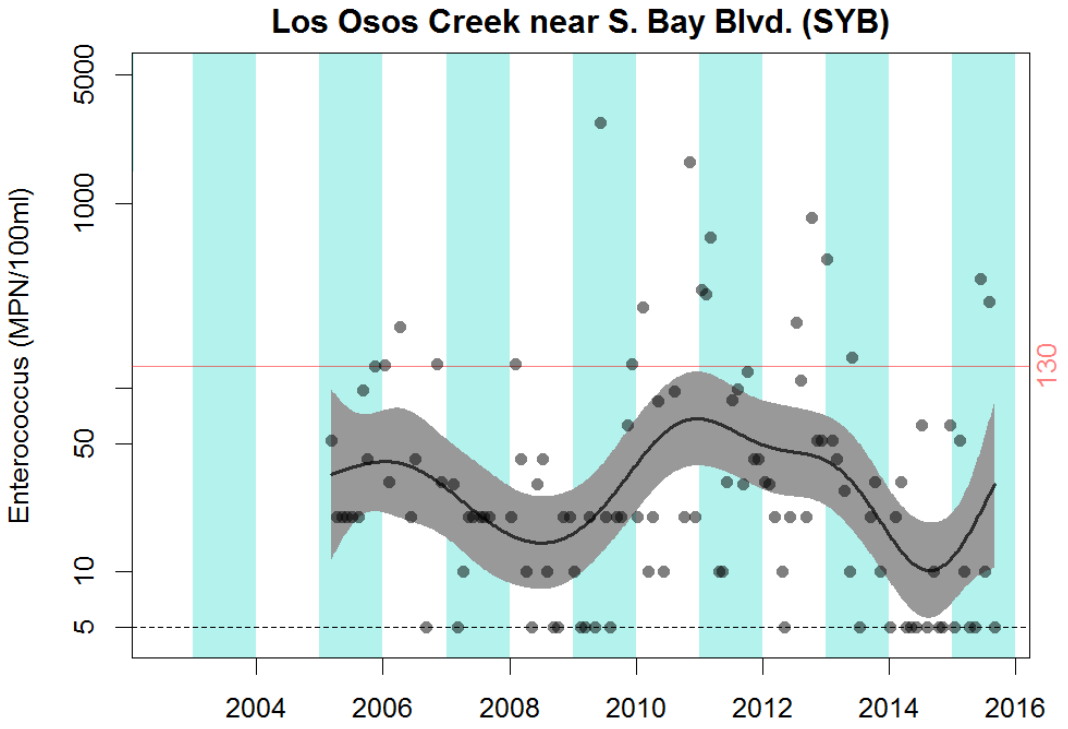

Morro Bay at Sharks Inlet (SIN)
Enterococcus (MPN/100ml)
5000
1000
50
10
5
130
2004
2006
2008
2010
2012
2014
2016

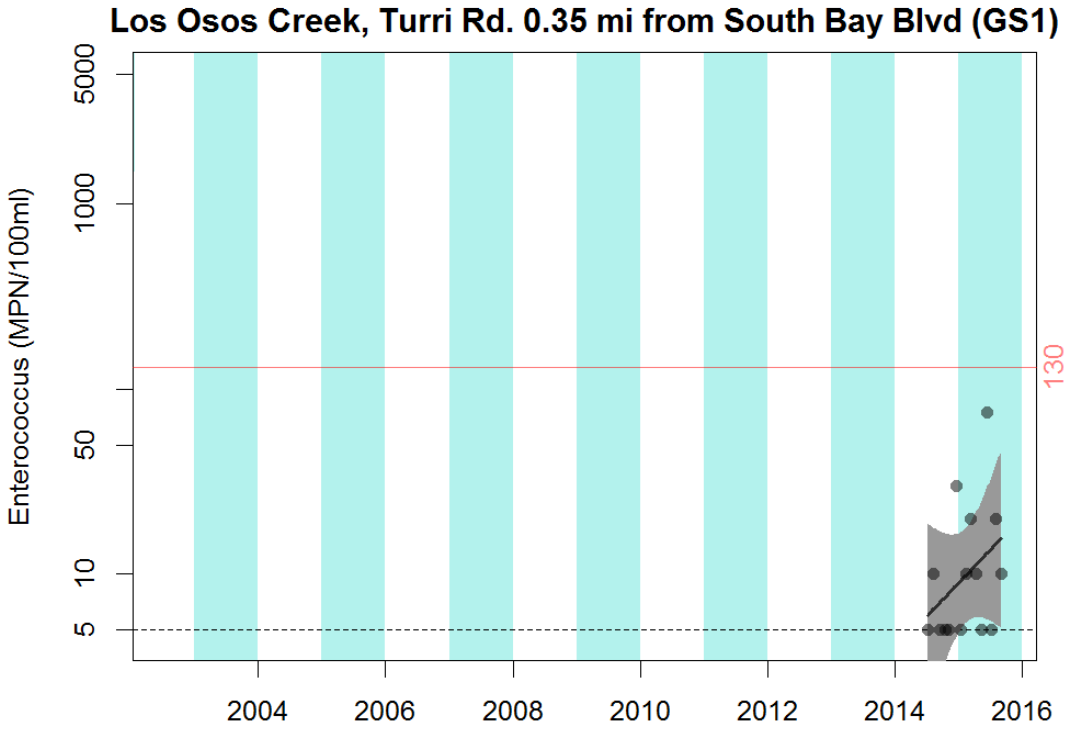

Morro Bay at State Park Marina (SPM)
Enterococcus (MPN/100ml)
5000
1000
50
10
5
130
2004
2006
2008
2010
2012
2014
2016





The following plots are for the enterococcus trend on Los Osos Creek near South Bay Boulevard (SYB) and at a site slightly downstream from SYB (GS1). This creek site is tidally-influenced, so the site is treated as a marine site and monitored for enterococcus.


Los Osos Creek near S. Bay Blvd. (SYB)
Enterococcus (MPN/100ml)
5000
1000
50
10
5
130
2004
2006
2008
2010
2012
2014
2016


Los Osos Creek, Turri Rd. 0.35 mi from South Bay Blvd (GS1)
Enterococcus (MPN/100ml)
5000
1000
50
10
5
130
2004
2006
2008
2010
2012
2014
2016

Dissolved Oxygen

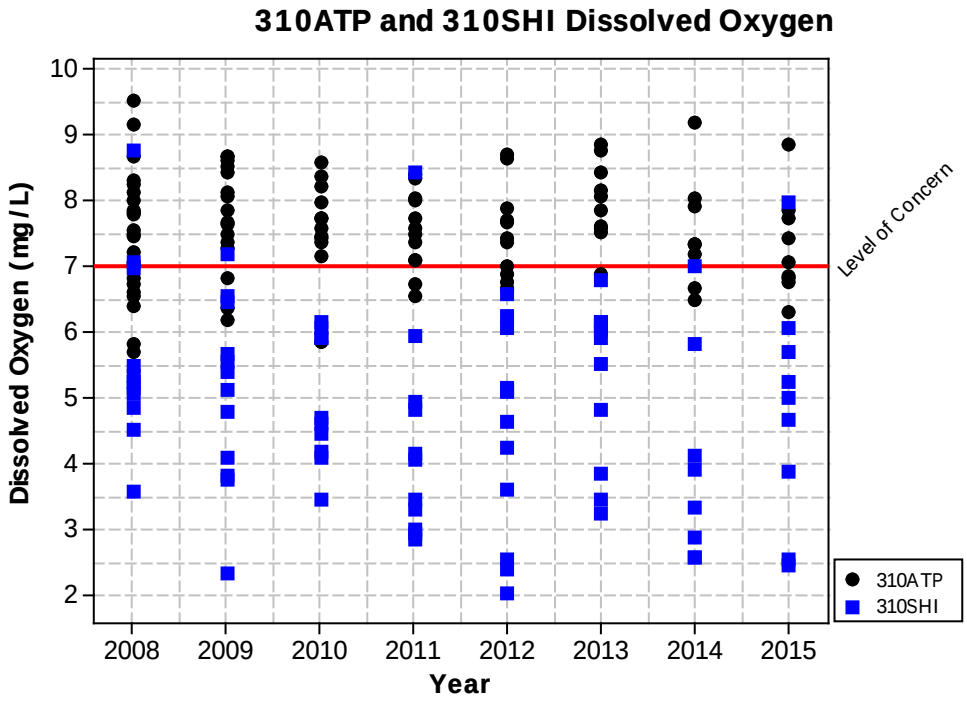
The bay DO data collected by the MBNEP is early morning readings collected at seven sites on a monthly basis. The Central Coast Region Basin Plan states that bay DO concentrations must remain above 7 mg/L to be protective of marine aquatic life.

The following table shows the number of readings taken at each site by year. The table also shows the number and percent of samples that exceeded the 7 mg/L regulatory standard that is protective of marine habitat.

Site	2008	2009	2010	2011	2012	2013	2014	2015	Sample Size	# of exceedances < 7 mg/L	% of Exceedances < 7 mg/L
ATP	22	15	12	12	12	11	8	9	101	26	26%
SPO	13	12	12	12	12	11	8	9	89	32	36%
LO2	13	12	12	12	12	11	8	8	88	29	33%
PSP	13	12	12	12	12	11	8	9	89	29	33%
CHI	11	12	10	11	12	10	9	9	84	67	80%
CSI	11	12	10	11	12	10	9	9	84	79	94%
SHI	11	12	10	11	12	10	8	9	83	77	93%

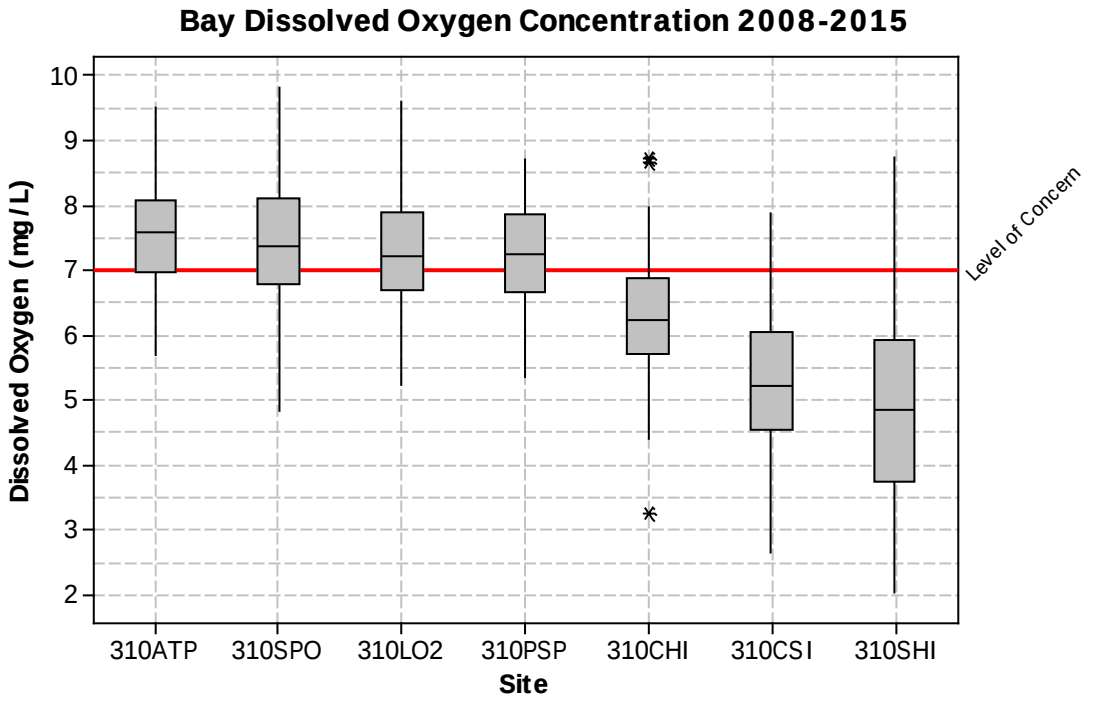
**2015 data includes January through September.*

The following figure is a scatter plot of surface level DO levels at two sites, Tidelands Park (ATP) and Sharks Inlet (SHI). The red line indicates the Basin Plan DO standard of 7 mg/L that is protective of marine life. The southernmost site of Sharks Inlet (shown in blue) exhibits DO levels that tended to remain in the 5 to 6 mg/L range. In comparison, the front bay site at Tidelands Park (shown in black) consistently had levels above 7 mg/L.

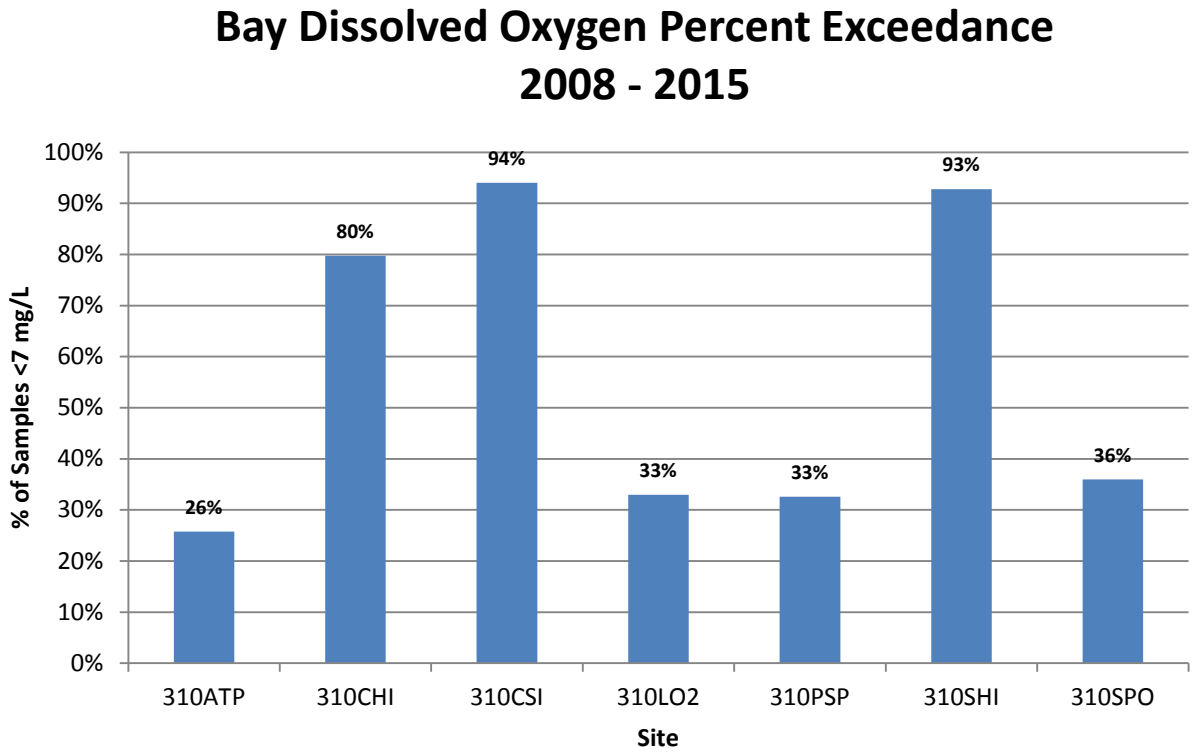


The next figure indicates the median DO levels at each of the sites. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk.

The red line indicates the Basin Plan DO standard of 7 mg/L that is protective of marine life. The data show the expected trend of higher DO levels along the main channel where more tidal flushing occurs (sites ATP, SPO, LO2 and PSP) and lower DO levels in the shallow back bay areas (sites CHI, CSI, SHI). Concentrations below 7 mg/L were regularly observed in the front bay sites in the summer time and year-round in the back bay sites. The low DO levels in the back bay could be a naturally-occurring phenomenon due to a lack of tidal flushing.



The following bar graph shows the percent of monitoring events where DO concentrations were below 7 mg/L.



Conclusions for Morro Bay

Bacteria in Morro Bay consistently met recreational criteria at all sites except BAY and PAS. Bay DO criteria were most often violated at the back bay sites – CHI, CSI and SHI.

CHORRO VALLEY FLOW STUDY

Project background: Limited water resources are a pressing issue in the area. To address this challenge, the MBNEP partnered with Trout Unlimited (TU) on a flow study in the Chorro Valley. The project has these major phases:

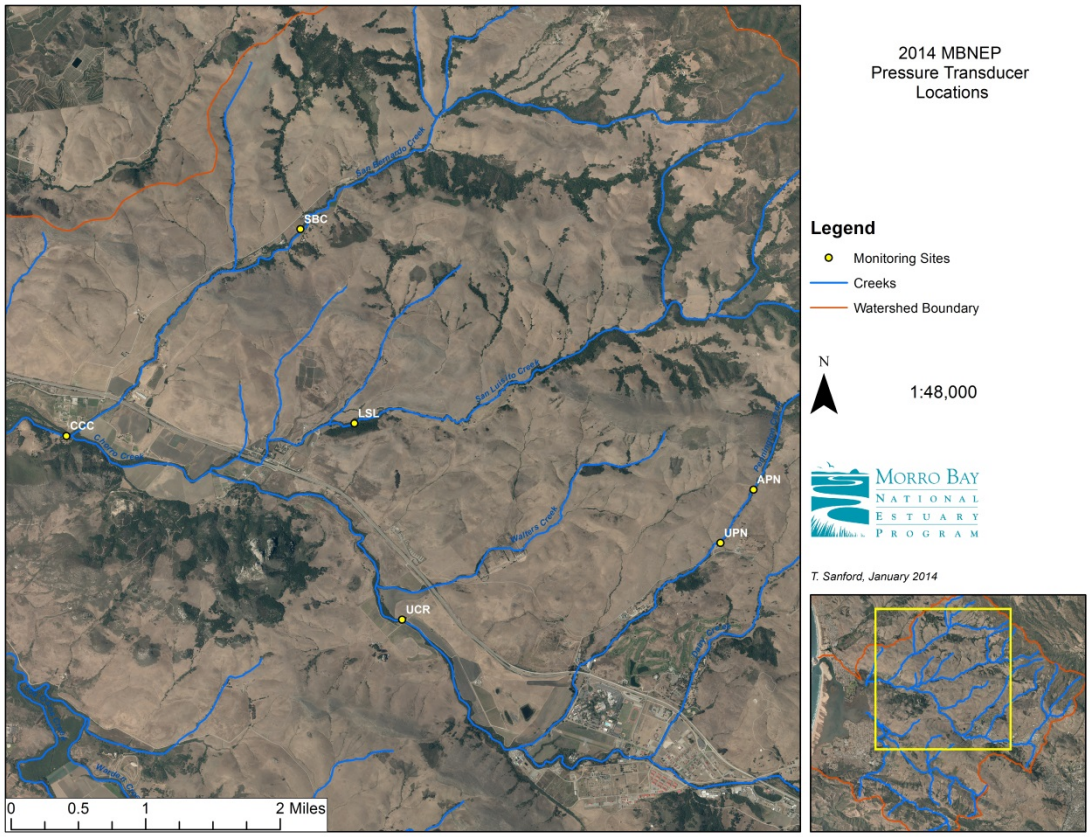
- Collect discharge data from throughout the Chorro Valley.
- Foster relationships with landowners to assist in gathering water use and water needs data.
- Create a water balance, which incorporates water needs and water supply information.
- Develop initial designs for a water conservation project in the Chorro Valley.

The MBNEP monitoring program has been involved with the first step of this project.

Expected project benefits: The primary goal of the project was to understand water supply and demand in the Chorro Valley in order to work with landowners and others to create a sustainable plan for water management.

Existing data: The MBNEP has been collecting discharge data throughout the watershed since 2002.

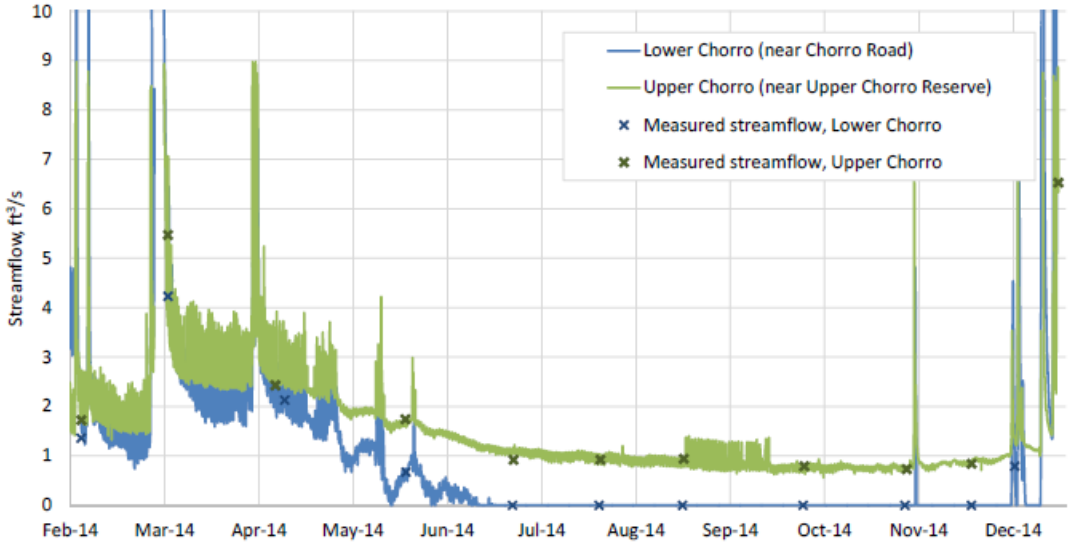
IEP activities: A network of six pressure transducers has been established which continuously collect water depth measurements. Two were installed on Pennington Creek in the fall of 2012, and four were installed on Chorro Creek, San Luisito Creek and San Bernardo Creek in the fall of 2013. MBNEP staff visit the sites monthly to measure discharge, download water depth data from pressure transducers, and collect a staff gauge measurement from the site.



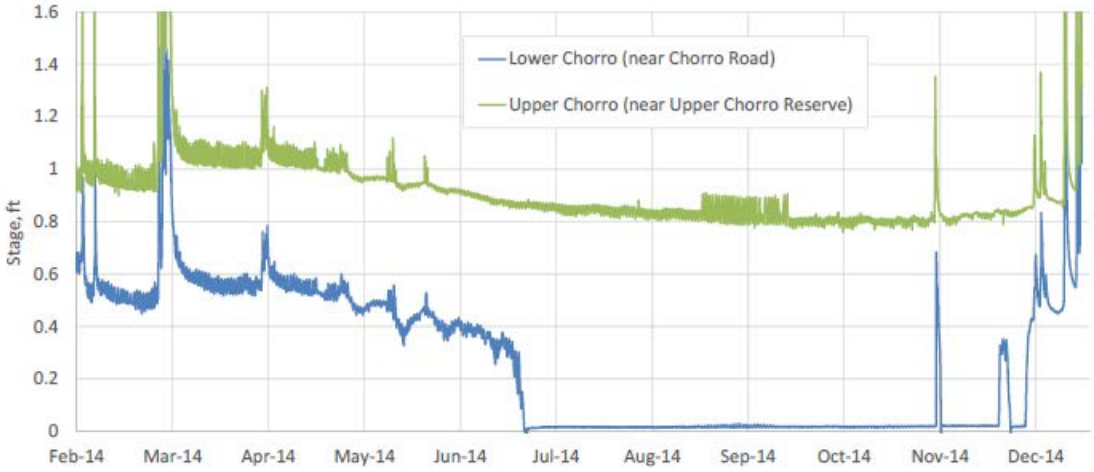
IEP data analysis: The data is being provided to the Center for Ecosystem Management and Restoration (CEMAR), a consulting firm specializing in water conservation projects throughout the state. In early 2015, CEMAR developed results and analysis with data collected to date from the gauging sites. Summary plots of streamflow as well as CEMAR's analysis are summarized here.

Chorro Creek

Two gauges were installed along mainstem Chorro Creek. The upstream gauge is at the top of the Chorro Creek Ecological Reserve on Cal Poly's vineyard property (site code UCR). Approximately 3.5 miles downstream from there, a second gauge was installed at Chorro Creek Road (site code CCC). The stations began collecting data in November of 2013. Following the last large storm in February 2014, streamflow at both gauges began a steady decline. Flows at CCC became intermittent in June 2014, while flow at UCR remained above 0.6 cfs throughout the summer.



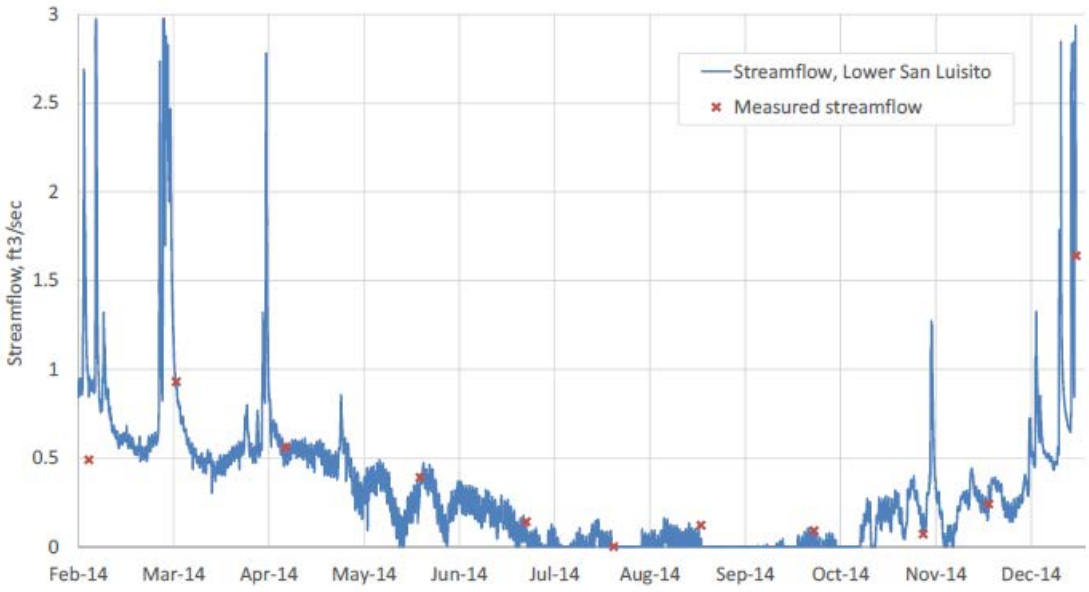
The stage data illustrates the effects of upstream flow releases on water levels throughout the creek. Water levels at UCR demonstrate a daily fluctuation through February, March and April where streamflow rises for a portion of the day and then quickly recedes to baseline levels. These fluctuations do not appear to occur in May, June or July, but then resume again in parts of August and September. These releases cause the streamflow to increase by 1 cfs relative to baseline conditions. In February, March and April, these increases in flow propagate downstream to the CCC gauge as well, causing a rise of 0.8 cfs each day when releases occur. Stage data indicate that the water released in August and September 2014 did not reach the CCC gauge, as apparent in the following graph.



San Luisito Creek

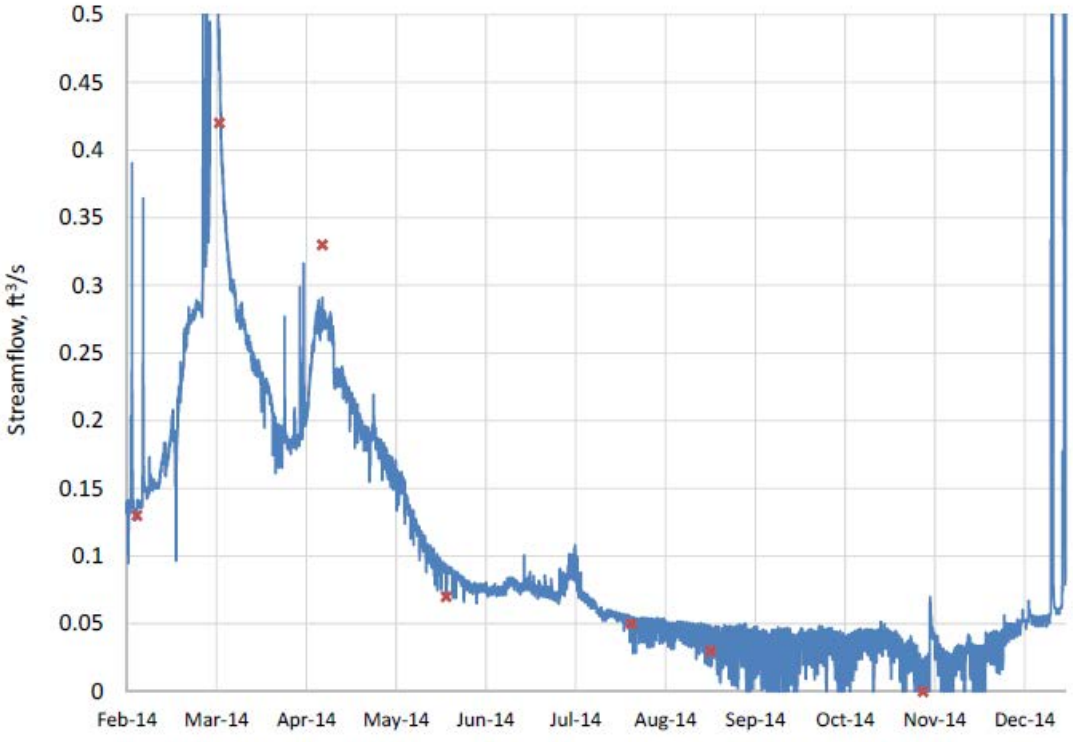
Streamflow records at the San Luisito gauge (code LSL) show a mostly steady recession toward intermittence from the final rain events of the 2014 rain year (late March and April 2014) until the stream becomes intermittent in July. Streamflow receded especially quickly in May and returned to near previous levels, but this fluctuation may not be due to upstream water uses but rather to warm weather. In fact, in the first half of May there were two periods with air temperatures in the high 80s

and low 90s. The resumption of very low streamflow of August and September prior to any substantial storms may have been due to cooler temperatures or overcast conditions.



San Bernardo Creek

Streamflow recorded at the San Bernardo Creek gauge shows irregular changes in streamflow throughout most of the study period. In April and May 2014, water levels receded quickly and returned to previous levels on some days but not on others. In August and early September, streamflow drops suddenly twice per day; and later in September there are drops once a day. The abrupt nature of the changes in streamflow suggests that the fluctuations are not due to natural processes but rather as a result of upstream water management. Due to the minimal flows at these times, the diversion rates are fairly low. Water storage to replace this diversion is likely to have a measurable benefit on flow. This tributary is considered to have high potential for water storage projects that would have a positive impact on streamflows.



Conclusions: The data emphasizes the impacts of the drought on dry season surface waters. Monitoring will continue to help identify potential projects that would help maintain dry season flows.

To develop a water balance, CEMAR gathered data to assess the water supply and water needs for the Chorro Valley. Their analysis estimates 12,170 acre-ft of discharge from Chorro Creek each year. Based on land use maps, remote sensing and registered water rights, CEMAR estimated the total human water needs as 1,451 ac-ft of water annually. While this supply versus needs picture looks optimistic, many human water activities take place in the dry season when rainfall and therefore discharge are limited. Thus the shortfall must be made up through stored water, groundwater extraction, direction surface flow diversion, etc. CEMAR's remote sensing analysis shows that there is not sufficient water storage available within the watershed to meet human water needs during the dry season. Targeted streamflow improvement projects can reduce the impact of human water diversions in the dry season.

As part of the Chorro Valley Flow Study, a project was developed in the valley to address water supply issues. The Estuary Program partnered with TU, the California Conservation Corps, Sierra Watershed Progressive and the San Luis Coastal Unified School District to create a project at the Rancho El Chorro Outdoor School, which is an outdoor environmental education campus. Pennington Creek runs through the center of campus. A Drought Response Outreach Program for Schools (DROPS) grant was recently awarded to these partners to design and implement Low-Impact Development on the campus to direct stormwater into constructed wetlands. Along with providing educational opportunities, the project goals include improving the water quality and quantity in Pennington Creek. The Estuary Program will continue to conduct monitoring on this site to determine impacts from the project.

Pennington Creek, Rainwater Catchment Project

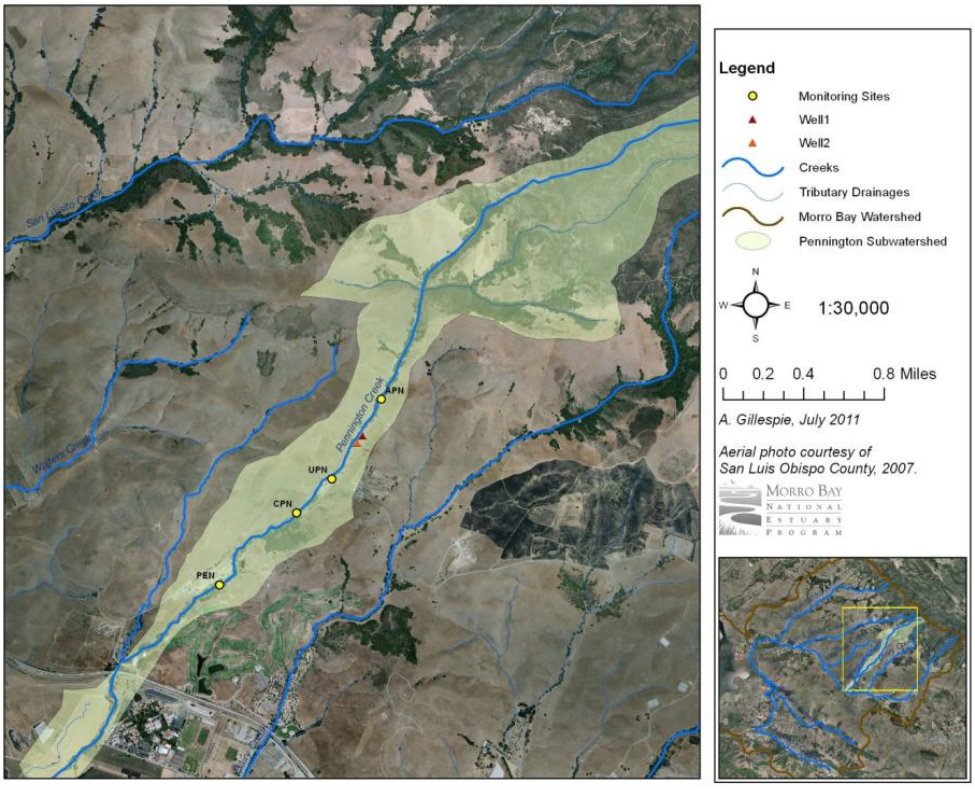
Project background: The MBNEP partnered with the California Conservation Corps (CCC) to win funds from NOAA and the California Department of Fish and Wildlife for water conservation efforts. A

rainwater catchment system was designed for the Beef Center facility on Cal Poly, San Luis Obispo property. This is a working cattle operation where faculty and students work with cattle to train the ranchers of the future. The project installed rain gutters, piping, filters and four 74,000-gallon storage tanks. Rainwater from roof tops is captured during storms and stored in the tanks. For four months of the year (July to October), Cal Poly will stop pumping two nearby riparian wells and instead use water from the tanks to supply cattle troughs. Pennington Creek runs through Cal Poly's property, and the wells that supply the Beef Center are immediately adjacent to the creek.

Expected project benefits: Pennington Creek contains high quality habitat for steelhead, but lack of water makes it difficult for fish to access. By keeping more water in the creek during the crucial time of year, areas of potential fish access are increased.

Existing data: The MBNEP has been monitoring discharge on Pennington Creek for two years at two sites on Pennington Creek. One is upstream of the well field, and one is downstream of the well field. This was pre-project data to document water levels in the creek prior to the use of the tanks from the rainwater catchment system.

IEP activities: Two pressure transducers were installed on Pennington Creek, one upstream of the well field (APN) and one downstream of the well field (UPN). They were installed in the fall of 2012. MBNEP staff visit the sites monthly to measure discharge, download water depth data from pressure transducers, and collect a staff gauge measurement from the site.

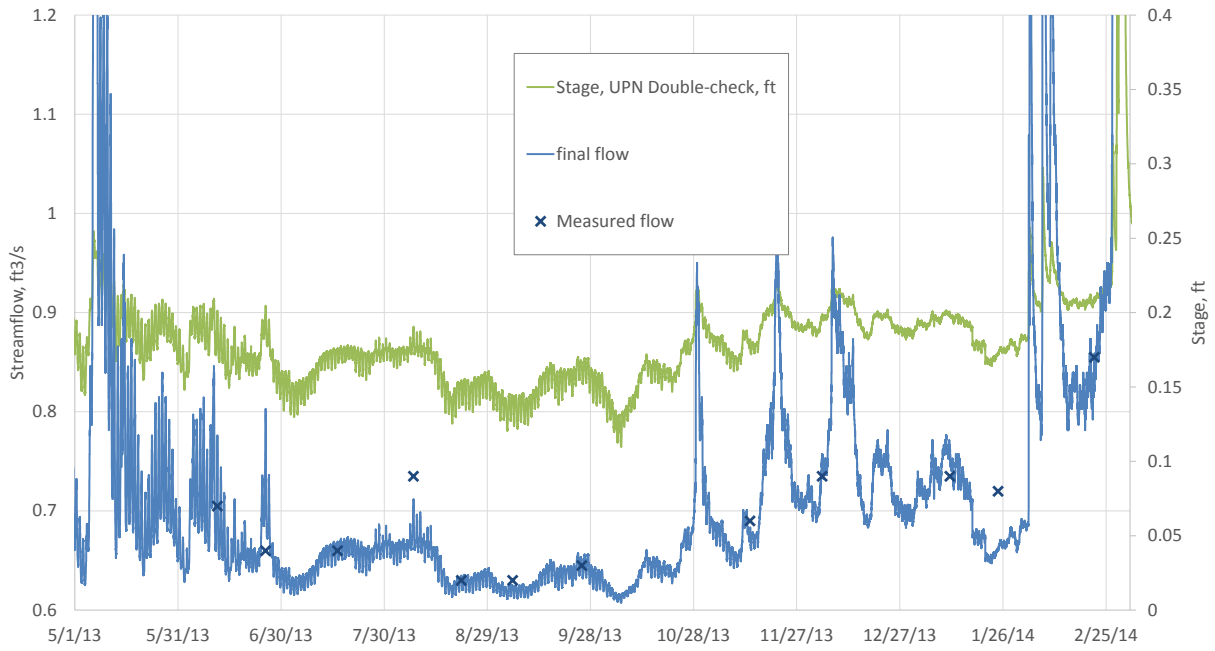


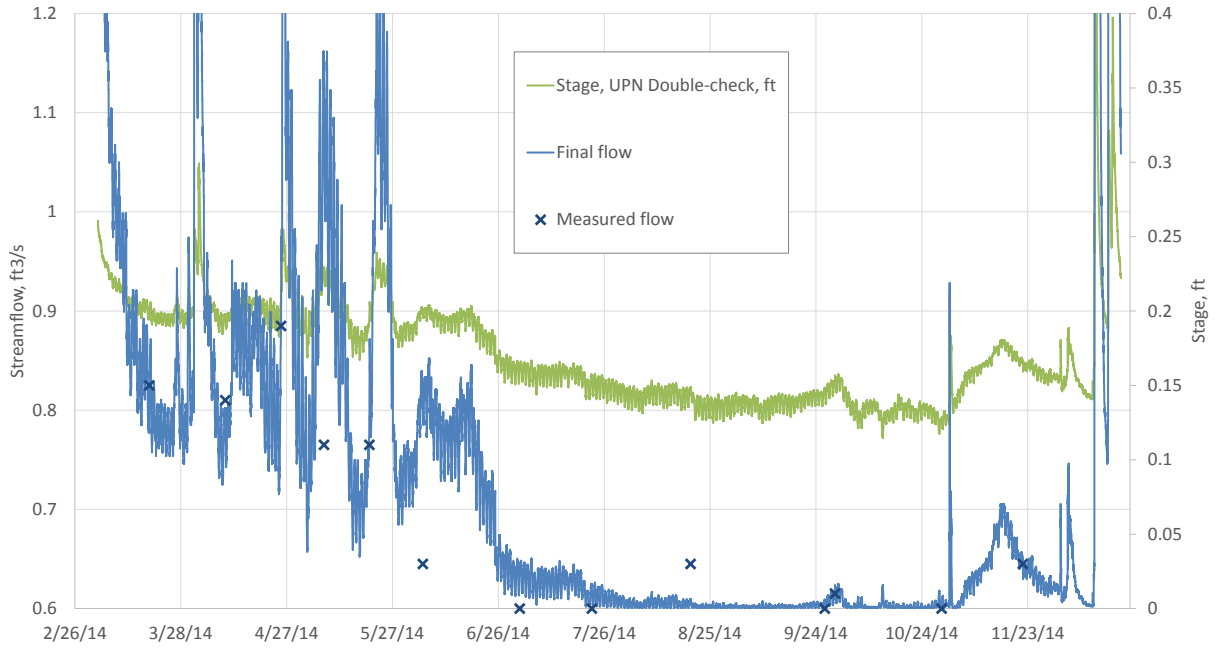
IEP data analysis: Due to lower than normal rainfall over the past three years, the tanks could not be utilized. The data currently being collected is considered to be pre-project data. Although the tanks were used minimally in the late summer and fall of 2015, the riparian wells also had to be used because the springs that normally feed the cattle troughs had gone dry. Thus, a season of post-project

data has not yet been collected that represents full usage of the rainwater catchment tanks when the wells are not in use. We will continue to collect data in hopes that the next rainy season will produce adequate water for the tanks to be used in the fall of 2016.

CEMAR was responsible for conducting the analysis on pre-project data, and some is included here.

CEMAR created two separate rating curves for the upper monitoring site, located upstream of the riparian wells. Data from the summer of 2013 through March 2014 was used to develop a rating curve representing that time period, and a separate rating curve was developed for March 2014 through November 2014. The calculated flow records for the two time periods are represented in the following graphs.





Conclusions: Unfortunately due to lower than average rainfalls, the rainwater catchment tanks have not yet been fully utilized. Thus, post-project data and analysis is not yet available. Post-project monitoring and analysis have been included in a proposal for Proposition 1 funding. The hope is that this grant is successful, which would enable this final phase of project monitoring and analysis to occur.

STORMWATER MANAGEMENT EFFORTS FOR LOCAL MUNICIPALITIES

Project background: The city of Morro Bay, community of Los Osos, and the county of San Luis Obispo are responsible for stormwater management in the areas surrounding the Morro Bay estuary. These management efforts include requirements for monitoring and assessing compliance with Wasteload Allocation and Attainment Plans. Portions of the MBNEP bacteria monitoring effort support the municipalities' stormwater management efforts. Data from eight bay sites and the most downstream sites on Los Osos and Chorro Creeks are of use to the municipalities.

Expected project benefits: Stormwater runoff is considered to be a substantial potential source of pollution to the Morro Bay estuary. The impacts of rainfall on bay bacteria levels have been documented by shellfish farmers and the CDPH, which regulates the safety of shellfish growing waters. Mandatory shellfish harvesting closure periods have been established following storms. Recently, during years of heavy rainfall, portions of the shellfish growing areas were under threat of closure due to consistently poor water quality. Stormwater management to reduce pollutants entering the bay will have positive impacts on the shellfish industry, on recreational bay use and tourism, and on marine wildlife.

Existing data: The MBNEP has been monitoring bacteria at eight locations on the bay shoreline since 2002. A site on lower Chorro Creek at Twin Bridges (TWB) and lower Los Osos Creek near S. Bay Boulevard (SYB) are also of interest for stormwater management efforts since the two creeks which drain into Morro Bay are substantial sources of bacteria to the bay. These ten sites are monitored

monthly. TWB is monitored for total coliform and *E. coli*, and the remaining nine sites are monitored for *E. coli* and enterococcus.

IEP activities: Monthly monitoring by the MBNEP at these ten sites will continue. Data is compiled and shared with the municipalities in an annual report to support their stormwater management effort.

IEP data analysis: The stormwater monitoring report includes an overview of data collected in the previous year, assessment of data related to EPA's recreational criteria, and a comparison of data to the regulatory standards for recreation and for shellfish growing waters contained in the Morro Bay Pathogen TMDL. This analysis is contained in a report titled *Stormwater Monitoring Report 2015* which was completed and distributed in September of 2015. It is available on the MBNEP website at www.mbnep.org.

LOS OSOS SHORELINE SEEPS

Project background: SLO County is heading up the construction of a wastewater treatment facility for the community of Los Osos. The community of nearly 14,000 currently operates primarily with individual septic systems which are impacting the underlying aquifer. The project is expected to be ready for the start-up phase in March of 2016, which includes a testing phase and readiness to accept wastewater flows. This is according to a project construction update issued by the county in November 2015.

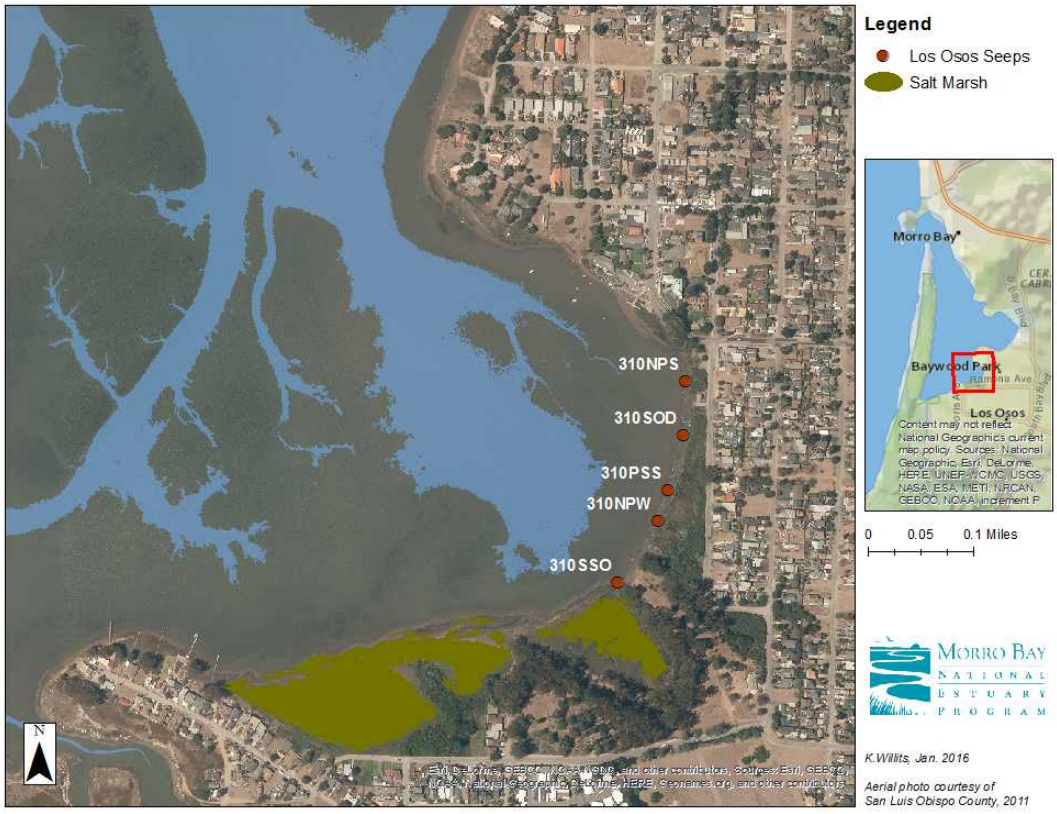
The shallow groundwater in the Los Osos area is thought to be impacted by septic systems. Historic data indicated elevated levels of bacteria and nitrates in these freshwater seeps.

Expected project benefits: When the Los Osos Wastewater Project comes online, the expected impacted to the estuary is a reduction in nutrient and bacteria inputs from the freshwater seeps that border the Los Osos shoreline.

Existing data: The Estuary Program has been collecting monthly samples for analysis of nitrate as nitrogen since April of 2014. The samples are analyzed by a certified lab. As part of their monitoring of shellfish growing leases, CDPH has been interested in bacteria inputs to the bay from these seeps and has been conducting fecal coliform monitoring for several years. The Estuary Program conducted monitoring of the seeps for *E. coli* from August 2005 to February 2007. *E. coli* concentrations greatly exceeded the results from nearby bay shoreline sites.

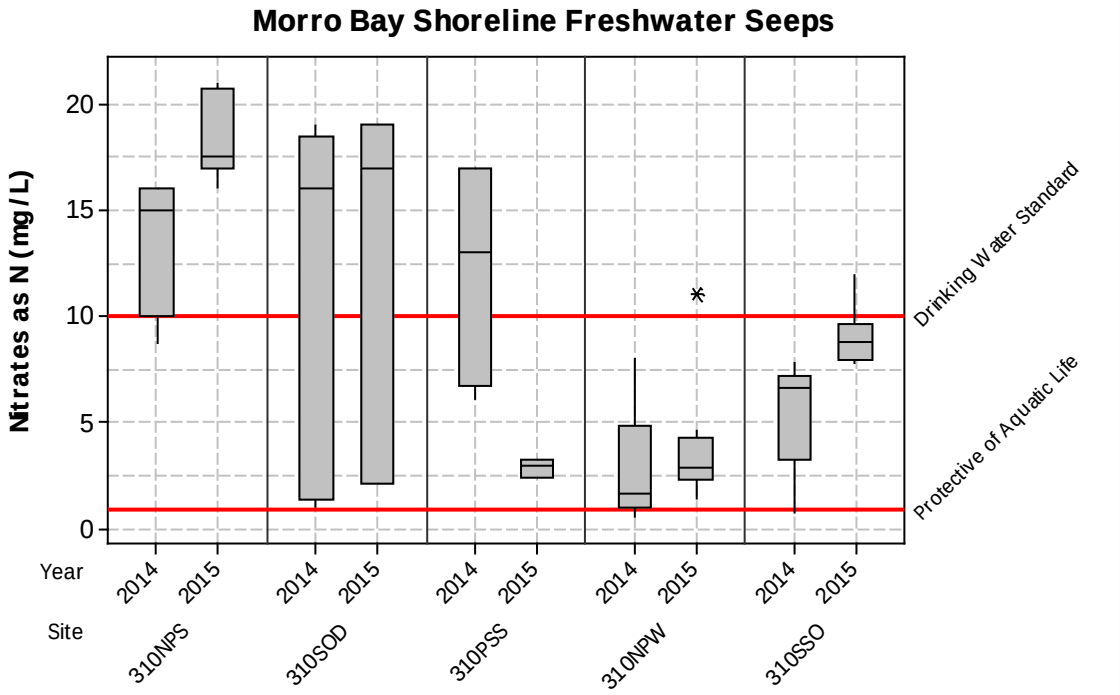
IEP activities: The Estuary Program has been conducting monthly monitoring of nitrate as nitrogen concentrations since April of 2014. During the dry season, the seeps frequently go dry.

The following map shows the locations of the bay shoreline monitoring sites.

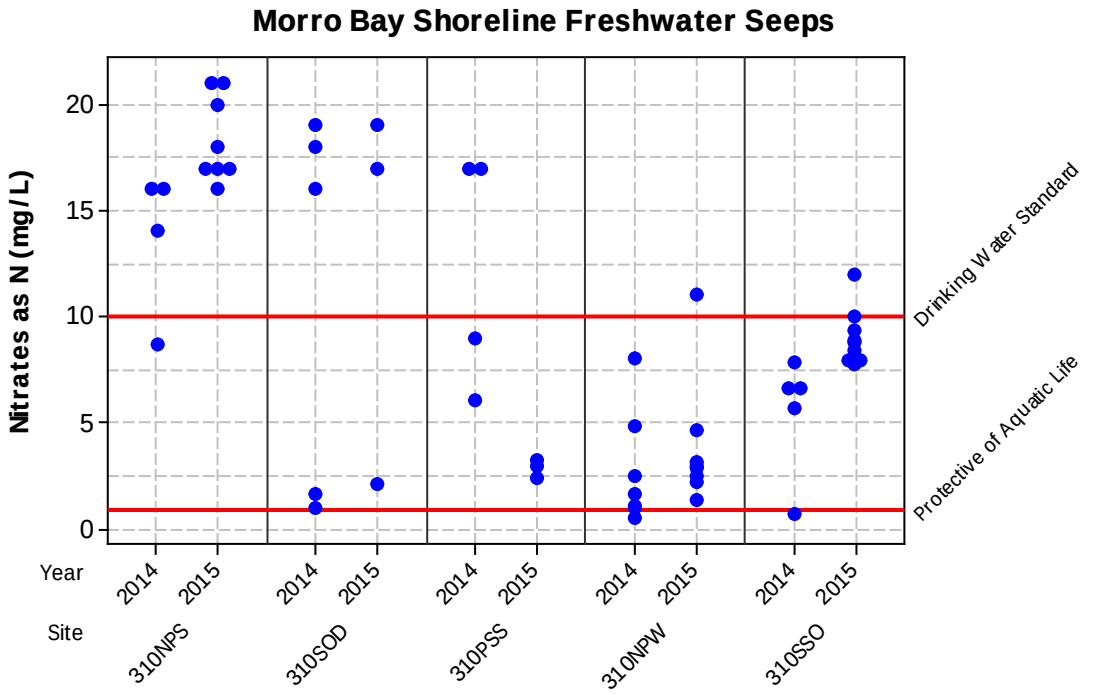


IEP data analysis: Monthly monitoring data form April 2014 through September 2015 is summarized in the following graph. The bar in the center of the box plots indicates the median of the data. The boxes define the first and third quartiles of the data, and the whiskers define the maximum and minimum values. Outliers are defined as values that are 1.5 times the interquartile range (Q3 – Q1) from the edge of the box and are indicated by an asterisk. The results are compared to the drinking water standard of 10 mg/L as N and 1 mg/L, which is the level protective of aquatic life.

All data summarized in these graphs is pre-project data.



The data for the same sites is also presented as a scatter plot to show the variability in the data.



Conclusions: Pre-project data indicates elevated nitrate as nitrogen concentrations. Monitoring will continue for at least a year after the Los Osos Wastewater Project comes on line in early 2016 to determine if the project has an impact on nitrate concentrations in bay shoreline sites.