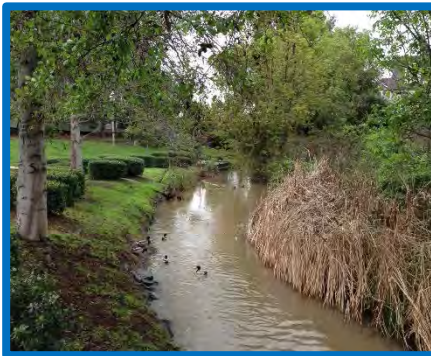


SAN MATEO CREEK PATHOGEN INDICATOR STRESSOR/SOURCE IDENTIFICATION

*Prepared in support of Provision C.8.d.i of
the Municipal Regional Permit
(NPDES Permit # CAS612008)*

Final Project Report



September 28, 2015

EXECUTIVE SUMMARY

This report presents the results and recommendations of the San Mateo Creek Pathogen Indicator Stressor/Source Identification (SSID) project. The project was conducted to address requirements in the San Francisco Bay Municipal Regional Permit (MRP) for discharges of stormwater runoff. Per MRP Provision C.8.d.i, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) has conducted two SSID projects that follow-up on creek status monitoring data that exceed trigger thresholds (the other SSID project addressed low dissolved oxygen in San Mateo Creek and was reported on separately). SSID projects are designed to identify and isolate potential sources and/or stressors associated with observed potential water quality impacts. Additional actions required by Provision C.8.d.i are to identify and evaluate the effectiveness of potential actions for controlling the cause(s) of the trigger stressor/source and to confirm that the problem was addressed.

Monitoring data collected in 2003 and 2012 at stations in San Mateo Creek showed fecal indicator bacteria (FIB) at densities exceeding water quality objectives (WQOs) for waters designated as having water contact recreation (REC-1) Beneficial Uses. During water years 2014 and 2015 SMCWPPP conducted a SSID project to address this potential water quality concern. Results of the SSID investigation suggest that FIB are present at densities exceeding REC-1 WQOs in San Mateo Creek reaches downstream of Sierra Drive. However, noncontact recreation (REC-2) Beneficial Use WQOs are not exceeded. Microbial source tracking (MST) techniques suggested that human sources are present year-round and dog sources are present during and shortly after wet weather. Many other potential sources of FIB are present in the watershed and likely contribute to the FIB densities measured at sampling stations. These include uncontrollable sources such as wildlife and natural bacterial growth in the creek bed and conveyance system.

A number of management actions designed specifically or opportunistically to control bacterial sources are currently planned or are being implemented by municipalities in the San Mateo Creek watershed. These include control measures for pet waste (signage and public education), trash reduction efforts that may reduce nuisance wildlife, programs to address homeless encampments, and several improvements to the sanitary sewer conveyance system in response to a Cease and Desist Order (CDO).

The City of San Mateo, Town of Hillsborough, San Mateo County, and SMCWPPP may wish to consider working together to increase public education and outreach targeting pet waste in the San Mateo Creek watershed. Potential examples include installation of additional cleanup signs, dog bag dispensers, and trash receptacles at creekside parks. Local municipalities should also continue the homeless elimination efforts begun through the HOPE strategy and HOT program. In addition, to help evaluate the effectiveness of current and planned control actions, SMCWPPP may wish to consider continuing to monitor FIB in San Mateo Creek via its MRP Creek Status monitoring program. However, even if human and dog sources are better controlled, results could still exceed WQOs due to uncontrollable sources such as wildlife and natural bacterial growth.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	I
TABLE OF CONTENTS	II
1.0 INTRODUCTION	1
1.1 PATHOGEN INDICATORS AND WATER QUALITY OBJECTIVES	1
2.0 STUDY AREA.....	5
2.1 PRIOR PATHOGEN INDICATOR MONITORING	7
2.1.1 2003 Monitoring	7
2.1.2 2012 Monitoring	8
3.0 SSID INVESTIGATION AND RESULTS	10
3.1 FIB MONITORING	10
3.1.1 Stations and Study Design	10
3.1.2 FIB Results.....	13
3.3 BACTEROIDALES MONITORING/MICROBIAL SOURCE TRACKING.....	17
4.0 POTENTIAL BACTERIA SOURCES AND ONGOING MANAGEMENT ACTIONS	18
4.1 LAND USE.....	18
4.2 PET WASTE	19
4.3 TRASH.....	21
4.4 WILDLIFE	21
4.5 WASTEWATER	21
4.5.1 Municipal Wastewater Treatment	21
4.5.2 Individual Sewage Disposal Systems	23
4.5.3 Direct Wastewater Sources.....	23
4.6 BACTERIA FATE AND TRANSPORT.....	23
5.0 DISCUSSION AND RECOMMENDATIONS.....	24
5.1 BACTERIAL EXTENT AND SOURCES.....	24
5.2 CURRENT AND PLANNED MANAGEMENT ACTIONS	25
5.3 RECOMMENDATIONS	25
6.0 REFERENCES.....	27

TABLES

Table 1. Bacteriological objectives and criteria for water recreation in freshwater.	4
Table 2. Pathogen indicator levels measured in San Mateo Creek.	9
Table 3. <i>E. coli</i> , enterococci, and Bacteroidales monitoring results, Gateway Park and De Anza Park, WY2014.	15
Table 4. Fecal coliform and <i>E. coli</i> densities measured in San Mateo Creek watershed on July 8, 2014 and June 30, 2015. (Bold values exceed USEPA 2010 criteria)	16
Table 5. Potential sources of pathogen indicators in San Mateo Creek watershed.	18
Table 6. Park use and fecal matter observations at Gateway and De Anza Parks.	20

FIGURES

Figure 1. San Mateo Creek watershed, San Mateo County, CA.	6
Figure 2. Bacteria sampling stations in San Mateo Creek watershed.	8
Figure 3. Downstream end of De Anza Park showing a large debris trapping structure..	11
Figure 4. Footpath along right bank of San Mateo Creek at De Anza Park. The channel is within the riparian vegetation on the right side of the photo.	11
Figure 5. Upstream end of Gateway Park looking downstream.	12
Figure 6. Downstream end of Gateway Park looking upstream.	13
Figure 7. Bacteria sampling events and mean daily flow, San Mateo Creek, CA.	16
Figure 8. Land uses in lower San Mateo Creek watershed.	19

APPENDICES

Appendix A	Results of Indicator of Fecal Pollution Study: <i>E. coli</i> , Enterococci and Bacteroidales analysis of San Mateo Creek, San Mateo, CA (BioVir Laboratories 2015)
Appendix B.	San Mateo Creek flow below Lower Crystal Springs Reservoir (USGS 11162753), and tidal height at Coyote Point Marina (NOAA 9414449)

1.0 INTRODUCTION

This report presents the results of the San Mateo Creek Pathogen Indicator Stressor/Source Identification (SSID) Project which was initiated in 2013 to address requirements listed under Provision C.8.d.i of the San Francisco Bay Region National Pollutant Discharge Elimination System (NPDES) stormwater Municipal Regional Permit (MRP) (Order R2-2009-0074). Per MRP Provision C.8.d.i, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) has conducted two SSID Projects during the permit term. SMCWPPP conducted two projects in San Mateo Creek based on creek status monitoring results that exceed trigger thresholds (per Table 8.1 of the MRP). SSID projects are designed to identify and isolate potential sources and/or stressors associated with observed potential water quality impacts. Additional actions required by Provision C.8.d.i are to identify and evaluate the effectiveness of potential actions for controlling the cause(s) of the trigger stressor/source, and to confirm the problem was addressed.

SMCWPPP initiated the Pathogen Indicator SSID Project in San Mateo Creek in response to monitoring data collected by SMCWPPP during water year¹ 2012 (WY2012) that exceeded fecal coliform and *Escherichia coli* (*E. coli*) trigger thresholds. Historical pathogen indicator bacteria data from San Mateo Creek collected by others also indicated potential water quality issues. This introduction (Section 1.0) provides background on pathogen indicators and water quality objectives (WQOs) developed to protect recreational beneficial uses. Section 2.0 of this report describes the watershed and past pathogen indicator monitoring results. Section 3.0 presents results of the SSID project monitoring. Section 4.0 reviews potential sources of bacteria to San Mateo Creek and current management actions. Section 5.0 recommends consideration of additional management actions and monitoring. References are listed in Section 6.0.

1.1 Pathogen Indicators and Water Quality Objectives

The State Water Resources Control Board (State Water Board) is part of the California Environmental Protection Agency and administers water rights, water pollution control, and water quality functions for the state. The State Water Board and its nine Regional Water Quality Control Boards implement the federal Clean Water Act (CWA) and the state Porter-Cologne Act. Surface water and groundwater quality are regulated through development and enforcement of WQOs and implementation of plans that will protect the Beneficial Uses of the State's waters. Regional Water Quality Control Plans (referred to as Basin Plans) designate Beneficial Uses, WQOs that ensure the protection of those uses, and programs of implementation to achieve WQOs.

Several Beneficial Uses have been designated for San Mateo Creek, including water contact recreation (REC-1) and noncontact water recreation (REC-2), which are defined in the San Francisco Bay Basin Plan as:

¹ Most hydrologic monitoring occurs for a period defined as a water year, which begins on October 1 and ends on September 30 of the named year. For example, water year 2012 (WY2012) began on October 1, 2011 and concluded on September 30, 2012.

- **REC-1:** *“Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs.”*
- **REC-2:** *“Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where water ingestion is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.”*

REC-1 activities involve body contact with water where immersion and ingestion of water is reasonably possible. In San Mateo Creek, REC-1 uses are limited due to the lack of public access to the creek and typically shallow water habitat where access is available. The most likely places where humans could come in contact with San Mateo Creek waters are at creek-side parks such as De Anza Historical Park (also known as Arroyo Court Park) and Gateway Park. However, these parks do not include swimming or bathing beaches and the water is relatively shallow. Therefore, water contact is likely very limited. REC-2 is a more appropriate designation for San Mateo Creek. REC-2 uses that may occur at San Mateo Creek parks include hiking, picnicking, sightseeing, and nature studies.

REC-1 use of water bodies with fecal contamination can cause gastrointestinal (GI) and other types of illnesses if pathogens (i.e., certain viruses, bacteria, or protozoa) are present and if water is ingested. Testing water samples for specific pathogens is generally not practical for a number of reasons (e.g., concentrations of pathogens from fecal contamination may be small but still of concern, laboratory analysis is often difficult and expensive, and the number of possible pathogens is large). Therefore, the presence of pathogens is usually *inferred* by testing for “pathogen indicator” organisms, including fecal indicator bacteria (FIB). Since the 1950’s, numerous epidemiological investigations have been conducted to evaluate the relationship between illness rates and suitable pathogen or fecal indicators. The United States Environmental Protection Agency (USEPA) recommends using *E. coli* and enterococci as indicators of fecal contamination based on historical and recent epidemiological studies (USEPA 2012).

The San Francisco Bay Basin Plan (2013) Table 3-1 establishes REC-1 WQOs for fecal coliform, total coliform, and enterococci, and REC-2 WQOs for fecal coliform. Table 3-2 of this Basin Plan refers to the now superseded 1986 USEPA criteria for *E. coli* and enterococci in ambient water. Criteria listed by both agencies are based on sampling protocols where five equally-spaced samples are collected over a 30-day period and the geometric mean (GM) is calculated. A statistical threshold value (STV) sometimes referred to as a “single sample maximum” (SSM) is also listed. The STV is intended to be a value that should not be exceeded by more than a designated percentage of the samples used to calculate the GM, but is typically used as a SSM by regulators. San Francisco Bay Basin Plan (2013) WQOs for pathogen indicators in freshwater/estuarine water are listed in Table 1. Comparisons are often made to the 90th percentile WQOs when evaluating the results of FIB analysis of single grab samples.

The USEPA (1986) ambient water quality criteria for *E. coli* and enterococci were derived from epidemiological studies of bathers recreating at surface water beaches that received

bacteriological contamination via treated human wastewater². The criteria distinguish between different levels of beach usage and establish STVs corresponding to the 75th, 82nd, 90th, and 95th percentiles of the expected water quality sampling distribution. In 2012, USEPA published new recreational water quality criteria that supersede the 1986 recommendations. The USEPA (2012) GM criteria remain similar to 1986 criteria; however, the SSM (or STV) no longer distinguishes between different levels of beach usage and is set at the updated 90th percentile. USEPA (2012) considers the 90th percentile protective of all primary contact recreation. Furthermore, USEPA no longer recommends use of fecal coliform as a FIB.

The San Francisco Bay Basin Plan (2013) has not been updated to reference or reflect the new USEPA (2012) criteria. However, the State Water Board is proposing amendments to the Basin Plans to include updated WQOs for bacteria to protect REC-1 beneficial uses. The proposed amendments may include a revised indicator organism (*E. coli* or enterococci) based on the ambient recreational criteria developed by USEPA (2012), designation of a new limited water contact recreation (LREC-1) use, and other elements necessary for bacteria control implementation (e.g., natural source exclusion approaches, high flow suspension, seasonal suspensions). A draft staff report for public comment is anticipated in fall of 2015 with adoption in spring 2016.

Table 8.1 of the MRP lists “trigger” thresholds that must be considered during evaluation of MPR Provision C.8.c Creek Status monitoring data. For pathogen indicators, the trigger thresholds are USEPA fecal coliform and *E. coli* criteria.

² Similar health studies conducted at sites affected by non-human sources of fecal contamination have not provided a clear linkage between water quality measured by FIB and health effects (USEPA 2014).

Table 1. Bacteriological objectives and criteria for water recreation in freshwater.

	Total Coliform	Fecal Coliform	<i>E. coli</i>	Enterococci
	(MPN/100ml)	(MPN/100ml)	(CFU/100ml)	(CFU/100ml)
REC-1				
GM	--	200 ^a	125 ^b , 126 ^c	33 ^b , 35 ^c
Median	240 ^a			
SSM	10,000 ^a	--	--	--
75 th Percentile (designated beach)	--	--	235 ^b	61 ^b
82 nd Percentile (moderate bathing use)	--	--	298 ^b	89 ^b
90 th Percentile (light bathing use)	--	400 ^a	406 ^b	108 ^b
95 th Percentile (infrequent bathing use)	--	--	576 ^b	151 ^b
STV	--	--	410 ^c	130 ^c
REC-2				
Mean	--	2,000 ^a	--	--
90 th Percentile	--	4,000 ^a	--	--

GM = geometric mean, REC-1 = water contact recreation, REC-2 = noncontact water recreation, SSM = single sample maximum, STV = statistical threshold value

^a San Francisco Bay Basin Plan (Regional Water Board 2013)

^b USEPA (1986)

^c USEPA (2012). Criteria correspond to an illness rate of 36 incidents of GI per 1,000 primary contact recreators.

2.0 Study Area

San Mateo Creek drains a 33-square mile watershed including parts of unincorporated San Mateo County, the City of San Mateo, and the Town of Hillsborough (Figure 1). The upper watershed is characterized by the northwest/southeast trending ridges and valleys of the San Andreas Rift Zone and the Santa Cruz Mountains. Runoff from this undeveloped 29-square mile area drains to a system of reservoirs which are owned and operated by the San Francisco Public Utilities Commission (SFPUC). These include the San Andreas Reservoir, Upper Crystal Springs Reservoir, and Lower Crystal Springs Reservoir.

Below the Lower Crystal Springs reservoir dam, the watershed encompasses approximately five square miles and is mostly urbanized, with imperviousness of approximately 38 percent (STOPPP 2002). Low and medium density residential uses characterize the area upstream of El Camino Real. High density residential and commercial uses characterize the watershed downstream of El Camino Real. Runoff from these areas is conveyed to the creek via a network of underground storm drain pipes (i.e., the municipal separate storm sewer system (MS4)). Nearly 50 percent of the creek channel below the dam has been modified (STOPPP 2002). In the modified reaches, flows are conveyed within engineered channels and underground pipes, including a 2,000 foot culvert that begins downstream of El Camino Real. San Mateo Creek flows to San Francisco Bay at Ryder Park, just south of Coyote Point.

Prior to WY2014, dry weather flows from the Crystal Springs Reservoir System to San Mateo Creek were limited to about 0.7 cubic feet per second (cfs) as the result of water leaks from aging pipes at the pump stations. This dry season flow condition changed with construction on the Lower Crystal Springs Dam and Pump Station which was conducted between January and October 2014 as part of SFPUC's Water System Improvement Program (WISP). During the construction period, leaks were sealed and water was pumped from the reservoir directly into the creek, resulting in dry season flows that averaged about 1.0 cfs. With completion of the project in November 2014, SFPUC began implementation of a defined water release schedule intended to enhance habitat for steelhead and other native fish in lower San Mateo Creek (i.e., below the dam). Release schedule baseflows, measured at the U.S. Geological Survey (USGS) gage located approximately 0.2 mile downstream of the dam (USGS Gage #11162753), must range from 3 to 17 cfs, depending on the water year type (e.g., dry, normal, wet) and the time of year (NMFS 2010). The release schedule was approved by the U.S. Army Corps of Engineers as part of the formal consultation process with the National Marine Fisheries service (NMFS) and the California Department of Fish and Game (CDFG) for Endangered Species Act compliance for the WISP projects (San Francisco Planning Department 2010).



Figure 1. San Mateo Creek watershed, San Mateo County, CA.

2.1 Prior Pathogen Indicator Monitoring

2.1.1 2003 Monitoring

In 2003, the Regional Water Board monitored several stations within the San Mateo Creek watershed to assess water quality and establish regional reference sites as part of the Surface Water Ambient Monitoring Program (SWAMP). In addition to several other general water quality parameters³, grab samples were collected and analyzed for total and fecal coliform and *E. coli* (Regional Water Board 2007). The pathogen indicator sampling was conducted at three stations on San Mateo Creek (Sierra Drive, De Anza Park, and Gateway Park) on five consecutive dry season weeks (July 21, July 28, August 4, August 11, and August 18, 2003). All of the geometric means exceeded corresponding WQOs and most of the individual samples exceeded the 90th percentile WQOs. Pathogen indicator bacteria results, downloaded from the California Environmental Data Exchange Network (CEDEN), are listed in Table 2. Sample locations are mapped in Figure 2.

³ Sondes programmed to continuously monitor pH, dissolved oxygen, temperature, and specific conductivity were deployed for one or two week “episodes” during three parts of the annual hydrograph: wet season, decreasing hydrograph/spring, and dry season.

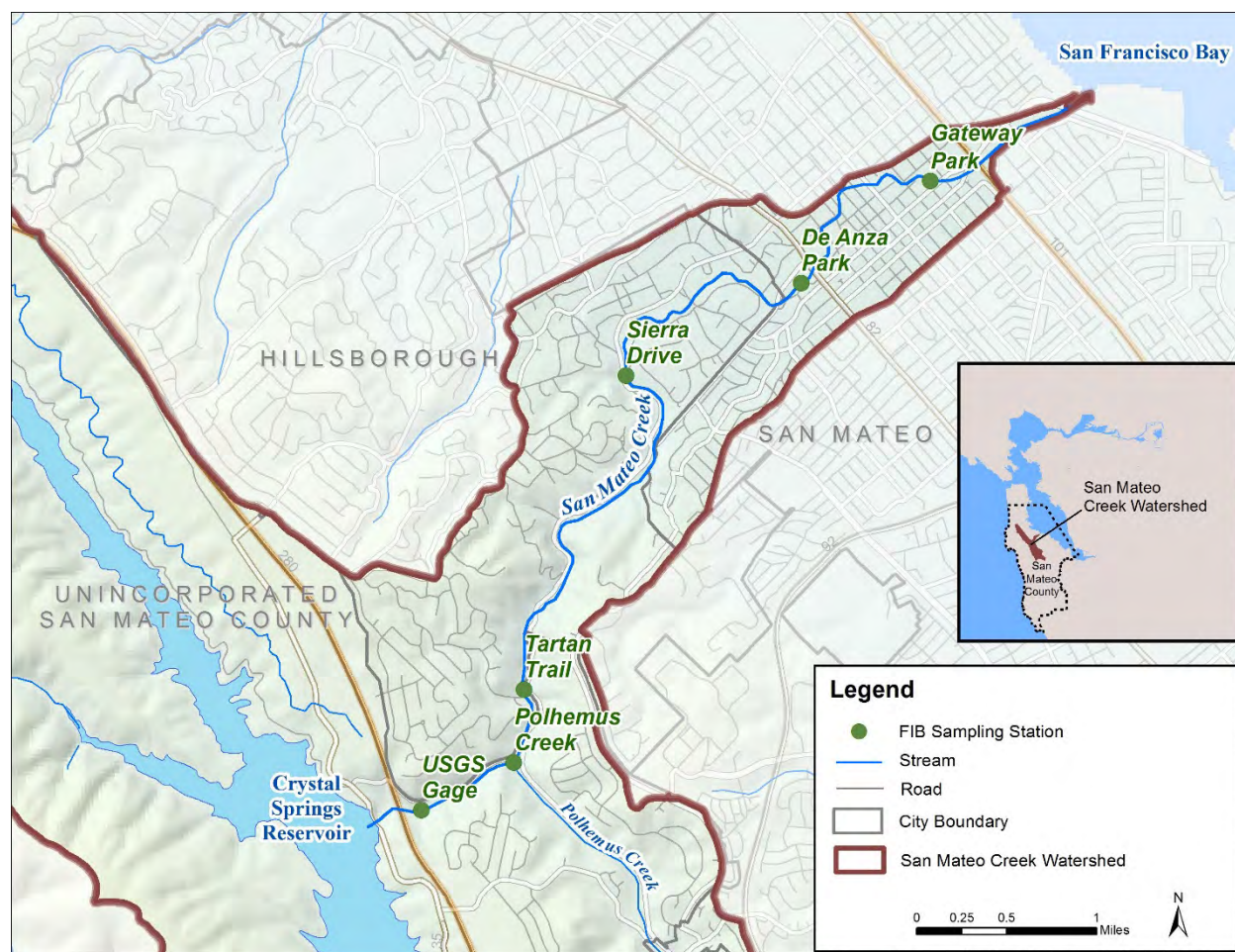


Figure 2. Bacteria sampling stations in San Mateo Creek watershed.

2.1.2 2012 Monitoring

In WY2012, SMCWPPP conducted MRP Provision C.8.c pathogen indicator sampling (fecal coliform and *E. coli*) at locations in five city parks or trails throughout San Mateo County where it appeared possible that the public could engage in water contact recreation, including one of the Regional Water Board (2007) stations – San Mateo Creek at De Anza Historical Park. The monitoring design was to collect single water grab samples (rather than five consecutive samples collected equally spaced over a 30-day period). Therefore, the 90th percentile WQOs are the more appropriate criteria to use when evaluating the data. Both the fecal coliform and *E. coli* WQOs for REC-1 were exceeded. REC-2 WQOs (for fecal coliform) were not exceeded. Results at the De Anza park station are within the same range measured by the Regional Water Board in 2003 (Table 2) (SMCWPPP 2014a).

Table 2. Pathogen indicator levels measured in San Mateo Creek.

Station	Sample Date	Total Coliform (MPN/100ml)	Fecal Coliform (MPN/100ml)	<i>E. Coli</i> (MPN/100ml)
<i>REC-1 WQO (GM/90th PCTL)</i>		240/10,000 ¹	200/400	126/410
<i>REC-2 WQO (mean/90th PCTL)</i>		NA	2,000/4,000	NA
Gateway Park				
	7/21/2003	16,000	240	340
	7/28/2003	20,000	170	110
	8/4/2003	24,000	1,600	460
	8/11/2003	24,000	1,600	2,800
	8/18/2003	24,000	130	220
<i>Gateway Park Geometric Mean</i>		21,338	423	403
De Anza Park				
	7/21/2003	17,000	350	910
	7/28/2003	12,000	1,600	1,200
	8/4/2003	16,000	1,600	2,100
	8/11/2003	17,000	1,600	1,600
	8/18/2003	17,000	1,600	780
<i>De Anza Park Geometric Mean</i>		15,665	1,181	1,234
	7/17/2012	ns	1,300	1,300
Sierra Drive				
	7/21/2003	16,000	1,600	2,300
	7/28/2003	6,100	920	260
	8/4/2003	8,700	540	300
	8/11/2003	16,000	1,600	3,000
	8/18/2003	24,000	1,600	24,000
<i>Sierra Drive Geometric Mean</i>		12,667	1,153	1,668

GM = geometric mean, NA = not applicable, ns = not sampled, WQO = water quality objective.

¹ Total coliform WQOs are shown as median/single sample maximum (SSM).

3.0 SSID Investigation and Results

The San Mateo Creek Pathogen Indicator SSID Project investigated the magnitude, seasonal variability, and predominant sources of pathogen indicators in the watershed. The investigation used both field and desktop approaches based on guidance provided in The California Microbial Source Identification Manual: A Tiered Approach to Identifying Fecal Pollution Sources to Beaches (SCCWRP 2013). The field approach used for the study is discussed in this section. Desktop approaches to identifying potential bacterial sources are discussed in Section 4.0.

Field monitoring approaches to investigate potential sources of bacteria included:

1. **FIB Monitoring:** Grab samples were collected approximately monthly from February 26 through November 4, 2014 at Gateway Park and De Anza Park. Samples were analyzed for FIB (*E. coli* and enterococcus). As part of SMCWPPP's creek status monitoring program (MRP Provision C.8.c), additional FIB (fecal coliform and *E. coli*) grab samples were collected from five stations (including De Anza Park) within the watershed during a single dry season sampling event in WY2014 (July 8, 2014) and a separate event in WY2015 (June 30, 2015) to capture a snapshot of bacterial source areas.
2. **Bacteroidales Monitoring / Microbial Source Tracking:** The February 26 through November 4, 2014 monthly grab samples from Gateway Park and De Anza Park were analyzed for the bacterial group of the Bacteroidales for source species identification. During each site visit, observations of fecal material and potential fecal sources were noted.

Details and results are discussed in the sections below. See also Appendix A for additional details on the Gateway Park and De Anza Park FIB and Bacteroidales study.

3.1 FIB Monitoring

Two stations previously sampled for FIB by the Regional Water Board as part of the SWAMP and by SMCWPPP in compliance with MRP Provision C.8.c requirements were targeted by the San Mateo Creek Pathogen Indicator SSID Project: Gateway Park and De Anza Park (Figure 2). Both stations are located in creekside parks, locations that had the highest potential for water contact recreation (REC-1) in San Mateo Creek; however, low baseflows at both parks result in relatively shallow water depths, bathing beaches do not exist, and swimming holes are absent, suggesting that REC-2 uses are more likely. Samples were analyzed for FIB (*E. coli* and enterococcus) and the bacterial group of Bacteroidales.

3.1.1 Stations and Study Design

De Anza Park is a small creekside park located within a residential neighborhood just upstream of the El Camino Real crossing. A narrow, unpaved footpath runs through dense ivy under the riparian canopy along an approximately 800-foot reach. A few benches offer opportunities for relaxation. Runoff from nearby streets (e.g., Arroyo Court) is conveyed directly to the creek via storm drains. Samples were collected near the downstream end of the park. Photos in Figures 3 and 4 illustrate the park environment and channel.



Figure 3. Downstream end of De Anza Park showing a large debris trapping structure.



Figure 4. Footpath along right bank of San Mateo Creek at De Anza Park. The channel is within the riparian vegetation on the right side of the photo.

Gateway Park is located approximately one mile downstream of De Anza Park near downtown San Mateo. Nearly half of the creek channel between the two stations is contained within an underground culvert. Below Gateway Park, the creek enters another large culvert and is then conveyed within an engineered channel to San Francisco Bay. Gateway Park is considered the upstream extent of the tidally-influenced reach of San Mateo Creek. Gateway Park features manicured lawns, a playground, paved trails, and picnic tables. Samples were collected near the downstream end of the park. Figures 5 and 6 illustrate the Gateway Park environment and channel.



Figure 5. Upstream end of Gateway Park looking downstream.



Figure 6. Downstream end of Gateway Park looking upstream.

Grab samples were collected approximately monthly from February 26 to November 4, 2014 from the De Anza and Gateway Park stations. During the wet season, sampling was scheduled opportunistically to occur during or immediately after storm events. Dry weather sampling at the Gateway Park station, which is within the tidally-influenced reach of San Mateo Creek, was timed to occur as close as possible to low tide in order to avoid capturing Bay water that is pushed up the creek during high tide. Sampling methods were consistent with the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) Creek Status Monitoring Program Standard Operating Procedures (SOPs) (BASMAA 2014a). Quality control samples were collected consistent with the BASMAA RMC Quality Assurance Project Plan (QAPP) (BASMAA 2014b).

Additional pathogen indicator samples were collected on July 8, 2014 and June 30, 2015, to fulfill monitoring requirements listed in MRP Provision C.8.c (Creek Status Monitoring). Grab water samples for *E. coli* and fecal coliform were collected from the De Anza Park station and four additional stations farther up in the watershed, including the Sierra Drive station which was sampled by the Regional Water Board in 2003. Creek Status Monitoring stations were located immediately downstream of storm drain outfalls with relatively large catchments. All five stations are mapped in Figure 2.

3.1.2 FIB Results

FIB results from Gateway Park and De Anza Park are listed in Table 3 and described in Appendix A. Table 3 also lists precipitation conditions noted during sampling. Three samples

were collected during or shortly after precipitation events: February 26, February, 28, and April 1, 2014. The September 23 and November 4, 2014 samples were collected during dry periods but after the first few storm events of WY2015 had occurred (Figure 7). Flow and tidal hydrographs for each sampling event are included as Appendix B.

Typical of FIB monitoring results (USEPA 2010), there was a high degree of variability in measured densities with standard deviations exceeding the median results. Dry season *E. coli* densities were generally within the same range as those reported for these stations in 2003 (Regional Water Board 2007) and 2012 (SMCWPPP 2014a) (see Table 2). With one exception (i.e., De Anza Park on May 20), *E. coli* densities were consistently above the USEPA 2010 criteria of 410 CFU/100ml (Table 1). There was a slight seasonal signal, with *E. coli* densities generally higher during the wet periods. The highest *E. coli* densities (24,000 MPN/100ml at Gateway Park and 8,000 MPN/100ml at De Anza Park) were measured during the February 26 storm event. The lowest *E. coli* densities were measured on May 20 (500 MPN/100ml at Gateway Park and 300 MPN/100ml at De Anza Park). Enterococci results followed the same general pattern.

Table 3 lists specific conductance (SC) and temperature measurements collected during sampling visits. Specific conductance is a measure of the ability of water to conduct an electrical current. It is highly dependent on the amount of dissolved solids (such as salt) in the water and often used as a proxy for salinity. Specific conductance in freshwater streams generally ranges from 100 μ mhos/cm to 500 μ mhos/cm; whereas, specific conductance in San Francisco Bay ranges from approximately 10,000 to 30,000 μ mhos/cm depending on the amount of freshwater entering the system. Specific conductance measured at Gateway Park ranged from 136 to 404 μ mhos/cm and was similar to measurements at De Anza Park suggesting that Gateway Park samples characterized watershed runoff and stream flow rather than tidal inflows. The series of charts in Appendix B depict sample times with tidal and flow data, confirming this finding.

Table 4 lists *E. coli* and fecal coliform densities from the creek status monitoring events on July 8, 2014 and June 30, 2015. FIB densities measured just below Lower Crystal Springs Reservoir at the USGS gage are very low (4 MPN/100ml *E. coli* in 2014 and 2015). Polhemus Creek, a small tributary that discharges to San Mateo Creek between the USGS gage and the Tartan Trail station, also had low FIB densities (30 MPN/100ml in 2014 and 13 MPN/100ml in 2015). FIB densities increase significantly in the downstream direction and do not exceed USEPA 2012 criteria until the Sierra Drive station (500 MPN/100ml in 2015). The highest densities (1,700 MPN/100ml in 2014) were measured at De Anza Park. REC-2 WQOs for fecal coliform (4,000 MPN/100ml) were not exceeded.

Table 3. *E. coli*, enterococci, and Bacteroidales monitoring results, Gateway Park and De Anza Park, WY2014.

Date	Time	<i>E. coli</i> (MPN/100ml)	Enterococci (MPN/100ml)	Bacteroidales (P/A)	HUM183 (P/A)	Dog (P/A)	Temp. (°C)	SC (µmhos/cm)	Precipitation Notes
Gateway Park									
2/26/2014	13:20	24,000	>2,419	P	P	P	ns	ns	recent rain
2/28/2014	12:30	4,700	4,900	P	P	P	13.4	190	raining
4/1/2014	10:47	2,200	1,300	P	P	A	11.2	296	intermittent showers
4/22/2014	12:30	5,000	980	P	P	P	14.3	404	none
5/20/2014	11:25	500	727	P	P	A	16.0	309	none
6/18/2014	11:00	1,100	1,414	P	P	A	16.5	221	none
7/16/2014	8:30	1,400	1,414	P	P	A	18.1	357	none
9/23/2014	8:30	5,000	816	P	P	A	17.4	259	none
11/4/2014	16:00	800	1,986	P	P	P	ns	136	none
	Mean	4,967	1,773						
	Median	2,200	1,414						
	SD	7,374	1,292						
De Anza Park									
2/26/2014	12:50	8,000	2,419	P	P	P	ns	ns	recent rain
2/26/2014	12:50	8,000	1,733	P	P	P	--	--	field duplicate
2/28/2014	12:10	5,300	1,700	P	P	P	13.5	220	raining
4/1/2014	10:10	800	1,300	P	P	A	10.4	334	intermittent showers
4/22/2014	12:00	1,700	816	P	P	A	12.5	388	none
5/20/2014	11:10	300	249	P	P	A	15.5	295	none
6/18/2014	10:30	1,100	1,120	P	P	A	15.5	227	none
7/8/2014	9:10	1,700	ns	ns	ns	ns	ns	ns	none
7/16/2014	8:45	1,400	1,120	P	P	A	17.4	291	none
9/23/2014	9:10	9,000	1,733	P	P	A	16.8	256	none
11/4/2014	15:30	1,100	1,120	P	P	P	ns	135	none
	Mean	3,040	1,210						
	Median	1,550	1,120						
	SD	3,190	487						

ns = not sampled, P/A = present/absent

Table 4. Fecal coliform and *E. coli* densities measured in San Mateo Creek watershed on July 8, 2014 and June 30, 2015. (Bold values exceed USEPA 2012 REC-1 criteria)

Site ID	Creek Name	Site Name	<i>Fecal Coliform</i> (MPN/100ml)	<i>E. Coli</i> (MPN/100ml)	<i>Fecal Coliform</i> (MPN/100ml)	<i>E. Coli</i> (MPN/100ml)
<i>MRP Trigger Threshold (REC-1 WQO)</i>			400	410	400	410
<i>REC-2 WQO</i>			4,000	--	4,000	--
<i>Sample Date</i>			<i>7/8/2014</i>		<i>6/30/2015</i>	
204SMA060	San Mateo Creek	DeAnza Park	1700	1700	500	500
204SMA080		Sierra Drive	300	300	500	500
204SMA100		Tartan Trail	50	50	50	50
204SMA119		USGS Gage	8	4	4	4
204SMA110	Polhemus Creek	At Mouth	30	30	13	13

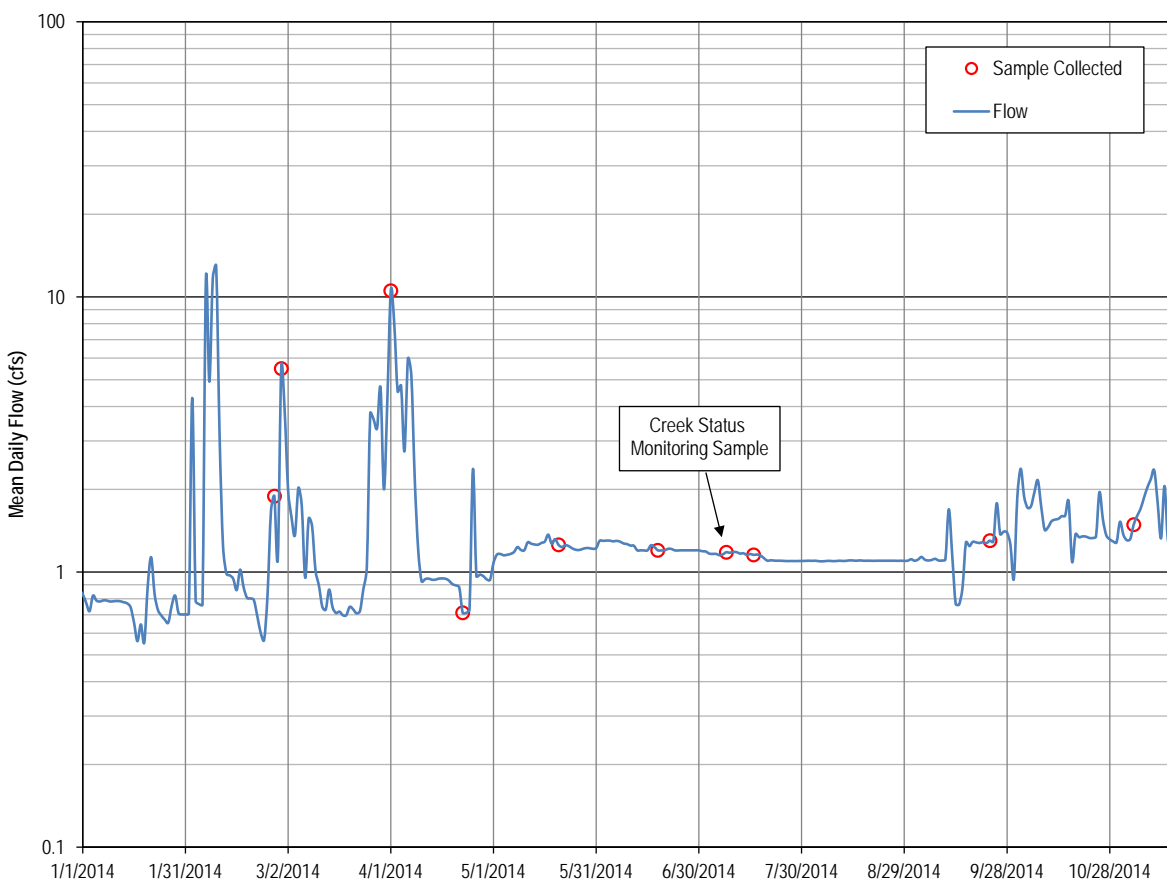


Figure 7. Bacteria sampling events and mean daily flow, San Mateo Creek, CA.

3.3 Bacteroidales Monitoring/Microbial Source Tracking

The presence of *E. coli* in San Mateo Creek may indicate fecal contamination; however, *E. coli* results alone do not indicate whether or not the fecal contamination is associated with a potentially controllable source such as human or pet waste. Therefore, microbial source tracking (MST) techniques were applied to begin characterizing which individual animal species are contributing to fecal contamination in the creek. The Gateway Park and De Anza Park investigation included sampling for the bacterial group of Bacteroidales as an MST approach. Bacteroidales are an abundant bacteria found in human and animal feces that have been found to survive for up to six days in the environment similar to other pathogens but have little potential for growth. They have a high degree of host specificity and therefore can be used to distinguish between human and other sources of fecal contamination by analyzing gene markers using real-time polymerase chain reaction (rt-PCR). An iterative process was followed in which each sample was first analyzed for the presence of the general genetic marker (GEN-BAC) for the Bacteroidales group. Samples with a positive GEN-BAC result were subsequently analyzed for the presence or absence of the human genetic marker (HUM183) and the dog marker. Results of the Bacteroidales analyses are listed in Table 3. See Appendix A for a more detailed discussion of the analytical techniques and quality assurance methods used in the Bacteroidales analyses.

Bacteroidales (GEN-BAC) and the human marker were present in all samples at both parks. Based on the relative abundance of the human marker to the GEN-BAC marker, it appears that the human marker made up less of the Bacteroidales group in the samples during or following rainfall events (February 26 and 28, 2014) (Table 3). This suggests that human sources of fecal contamination are less significant during periods when San Mateo Creek is receiving flow volumes from storm runoff and more significant during baseflow. In contrast, the dog marker was generally only present during the rain-affected samples (e.g., February 26 and 28, 2015) (Table 3). This suggests that canine feces deposited in the parks or in areas that wash into the MS4 are reaching the creek during storm events.

4.0 Potential Bacteria Sources and Ongoing Management Actions

Table 5 lists potential sources of pathogens that may be present in the San Mateo Creek watershed. Potential sources are grouped into two categories: controllable and uncontrollable. Controllable sources are those that could be reduced through management actions implemented by municipalities or others; however, the magnitude of reduction may be constrained. Uncontrollable sources occur naturally and would be difficult or impossible to reduce. The SSID study was designed to begin assessing which sources are present in the watershed and which are most important. Desktop approaches included map and aerial photo review and interviews with municipal staff regarding animal control, homeless encampments, and other potential bacterial sources. The sections below describe potential bacterial sources and current management actions that may reduce those sources.

Table 5. Potential sources of pathogen indicators in San Mateo Creek watershed.

Controllable Sources
Pet Waste (cats and dogs).
Wildlife (birds, rodents, deer) in some urban areas may be partially controllable. Human activities, such as littering, can attract wildlife by creating scavenging areas.
Trash Receptacle Leachate. Rodents and birds scavenge in trash bins. They may also contain discarded pet waste or diapers.
Human Waste Discharges (homeless encampments, leaking sewer lines and septic systems).
Uncontrollable Sources
Birds and other wildlife (deer, raccoons, ground squirrels, rabbit, skunk, opossum, wild turkey) in less urban areas (e.g., open space, riparian corridors, and forested areas).
Bacteria naturally present in the environment (e.g., soils and sediments in the watershed, creek, and conveyance system).

4.1 Land Use

Approximately 88 percent of the San Mateo Creek watershed lies within the undeveloped areas upstream of Lower Crystal Springs Reservoir. Section 3.2 (below) describes how FIB densities immediately below the reservoir are very low, suggesting that the upper watershed is not a major source of FIB to lower reaches. Figure 8 maps land uses in the lower watershed (i.e., drainage area below Lower Crystal Springs Reservoir) which is located in three municipalities: unincorporated San Mateo County, Hillsborough, and the City of San Mateo. Immediately below the reservoir, land uses consist primarily of low density residential. Development density transitions to industrial and commercial uses in the City of San Mateo near the mouth of the creek. Residential, commercial, and industrial land uses may be associated with all of the potential sources listed in Table 5 except wildlife in less urban areas.

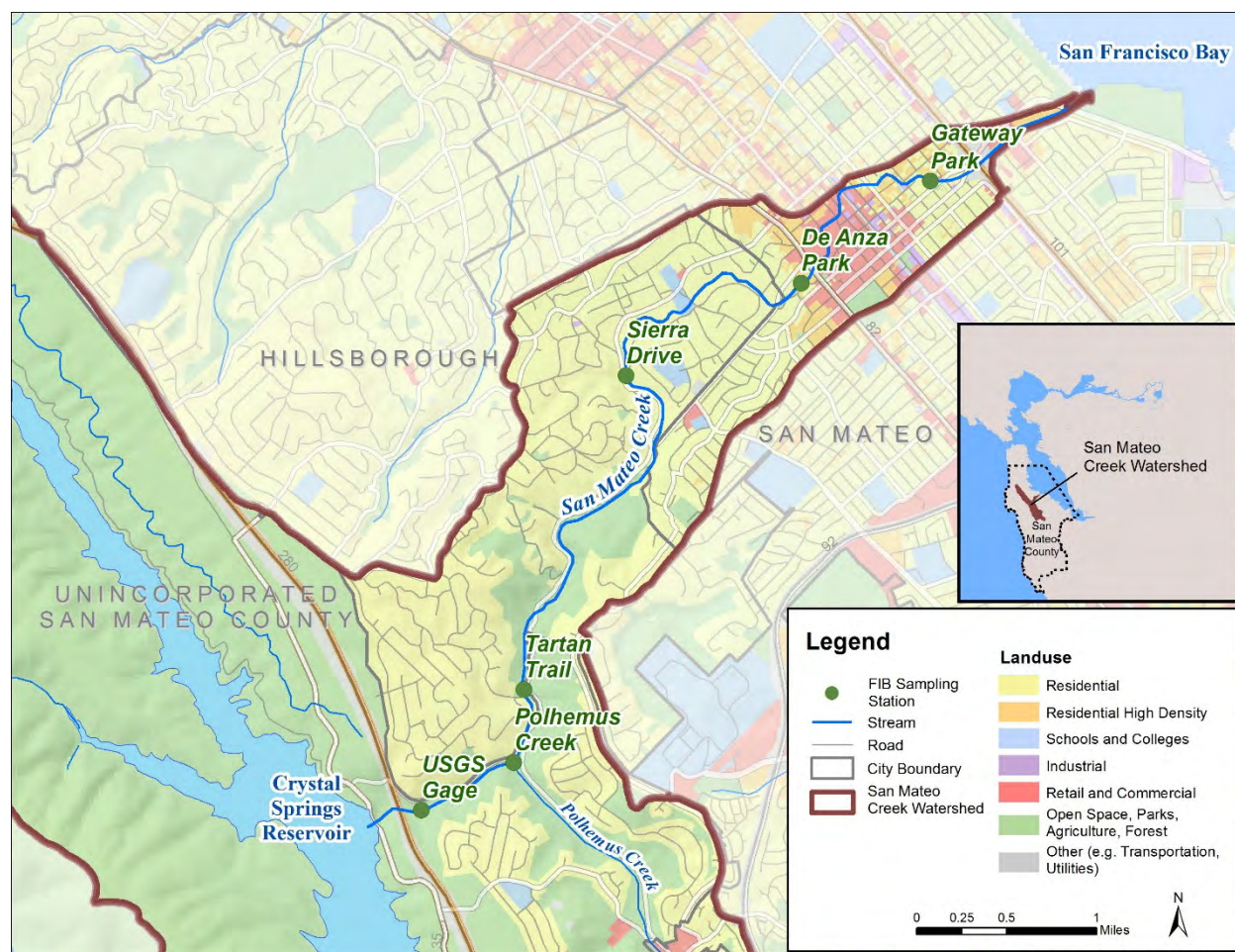


Figure 8. Land uses in lower San Mateo Creek watershed.

4.2 Pet Waste

Pet waste left on sidewalks, streets, yards, trails, and open space areas can enter the creek during runoff events (e.g., storms, sidewalk washing, irrigation). Even in the absence of other fecal sources, pet waste from dogs, cats, and other domestic animals contains fecal indicator bacteria (e.g., *E. coli*, fecal coliform) in quantities that can cause exceedances of WQOs in nearby creeks. Many pet owners may not be aware of how pet waste contributes to water contamination. Municipal codes limit the number of pets (including chickens) that can be kept on residential properties. Dog and cat licensing is required throughout the lower San Mateo Creek watershed (i.e., City of San Mateo, Hillsborough, unincorporated County) through the County Health System. There are approximately 7,000 dogs and 2,000 cats licensed in the City of San Mateo and Hillsborough. Because not all pet owners obtain licenses, a more likely count of the number of pets residing in these cities is 15,000 dogs and 13,000 cats⁴. This represents a large potential source of bacteria to San Mateo Creek.

⁴ Estimates based on extrapolation guidelines from the American Veterinary Medical Association.

The De Anza and Gateway Park study included observations of fecal material and sources in the parks during site visits. Although confirmatory laboratory analysis of the fecal material was not conducted, feces ascribed to dogs were observed at Gateway Park during three of the nine site visits and at De Anza Park during six of nine visits (Table 6). Furthermore, City of San Mateo Park staff noted frequent dog play in the creek and problems with owners not picking up after their dogs.

The City enforces municipal code requirements primarily through the complaint system. Complaints about excessive animal feces on residential properties are received frequently (i.e., weekly) and cleanup requests are usually very successful. The City Parks Department controls pet waste at all parks by posting signs about picking up after dogs and providing tens of thousands of dog bags per year in dog bag dispensers. Through participation in SMCWPPP, all municipalities in the watershed are working to educate the public about the consequences of pet waste on receiving waters and the need to pick it up. The “Get the Scoop on Pet Poop” flyer is posted on the SMCWPPP Team Effort website (<http://www.flowstobay.org/teameffort>) and distributed at outreach events.

Table 6. Park use and fecal matter observations at Gateway and De Anza Parks.

Table 6: Park use and fecal matter observations at Gateway and De Anza Parks.							
		Park Use (Y/N) (count)				Fecal Matter	
Date	Time	Ducks	Dogs	Humans	Deer	(Y/N)	Note
Gateway Park							
2/26/2014	13:20	Y (23)	N	Y (4)	N	N	--
2/28/2014	12:30	Y (18)	Y (1)	Y (6)	N	Y	duck feces
4/1/2014	10:47	Y (9)	N	Y (1)	N	Y	duck and dog feces on walkway
4/22/2014	12:30	Y (10)	N	Y (8)	N	N	--
5/20/2014	11:25	Y (6)	N	Y (8)	N	Y	duck and dog feces creekside
6/18/2014	11:00	Y (6)	N	N	N	Y	dog feces on bank
7/16/2014	8:30	N	N	N	N	Y	on foot bridge
9/23/2014	8:30	Y (22)	Y (2)	Y (2)	N	Y	human feces under foot bridge
11/4/2014	16:00	Y (16)	N	Y (6)	N	N	--
De Anza Park							
2/26/2014	12:50	Y (1)	N	Y (1)	N	Y	dog feces on curb above storm drain
2/28/2014	12:10	Y (7)	N	N	N	N	--
4/1/2014	10:10	Y (8)	N	N	N	Y	deer feces on creek bank
4/22/2014	12:00	Y (6)	N	Y (6)	N	Y	dog feces in gutter, deer
5/20/2014	11:10	Y (7)	Y (1)	Y (1)	Y (3)	Y	deer and dog feces
6/18/2014	10:30	Y (2)	Y (2)	Y (2)	Y (3)	Y	dog feces
7/16/2014	8:45	Y (4)	Y (1)	Y (1)	Y (1)	Y	dog feces on road, deer feces on bank
9/23/2014	9:10	N	N	Y (2)	Y (2)	Y	dog feces in plastic bag near outfall
11/4/2014	15:30	Y (3)	N	N	Y (4)	Y	deer feces

4.3 Trash

Unmanaged trash can be a source of bacteria to creeks, both directly and by attracting birds, rodents, and other wildlife. In compliance with Provision C.10.c of the MRP, municipalities in the lower San Mateo Creek watershed each developed a Long-Term Trash Load Reduction Plan and Assessment Strategy (Long-Term Plan) using a regionally consistent outline and guidance developed by BASMAA (City of San Mateo 2014, County of San Mateo 2014, Town of Hillsborough 2014). The Long-Term Plans identify and map trash generating areas and trash sources, delineate and prioritize Trash Management Areas (TMAs), and describe current and future control measures. Although the Long-Term Plans are focused on reducing the impacts of discharges from the MS4s, they also address direct dumping and wind dispersion of trash where possible.

Areas of high and very high trash generation were mapped in the lower San Mateo Creek watershed, including four creek hotspots (three in San Mateo and one in Hillsborough). Management actions being implemented in the watershed include installation and maintenance of full trash capture devices, enhanced street sweeping, creek cleanup events, outreach to businesses and residents, improved bins/container management, and bag and polystyrene bans. The goal is reduce trash in MS4 discharges by 70% in 2017 and 100% in 2022.

4.4 Wildlife

Wildlife sources of bacteria are generally considered uncontrollable. The riparian corridor along the perennial lower San Mateo Creek, and to a lesser extent parks and large residential lots in the watershed, provide desirable habitat for attracting and sustaining many wildlife and avian populations. These include raccoons, skunks, squirrels, deer, ducks, rodents, pigeons, snakes, woodrats, bobcats, mountain lions and coyotes. Multiple ducks and a family of deer were observed in the creek at De Anza Park during nearly every site visit (Table 6). In addition, raccoons and skunks are reported to enter the storm drain system throughout the lower San Mateo Creek watershed. Furthermore, rodents and pigeons are common nuisance wildlife in commercial and industrial areas of the City of San Mateo.

Former pigeon problems in downtown areas have been curtailed by hiring a bird control specialist who educates business owners on how to not attract birds and eliminate potential nesting sites. Other wildlife are controlled infrequently on an as-needed basis. In addition, the trash reduction efforts described in Section 4.3 are expected to reduce nuisance wildlife.

4.5 Wastewater

4.5.1 Municipal Wastewater Treatment

Most properties in the lower San Mateo Creek watershed are served by the San Mateo Wastewater Treatment Plant (WWTP) which discharges to San Francisco Bay under NPDES Order No. R2-2013-0006 and NPDES Order No. R2-2012-0096 (which establishes region-wide mercury and PCBs requirements) (Carollo 2014). Each municipality served by the WWTP

individually owns and operates their own respective collection systems and must comply with the Statewide General Waste Discharge Requirements for Sanitary Sewer Systems, and the Revised Monitoring and Reporting Program Order No. 2013-0058-EXEC.

Cease and Desist Order

A sanitary sewer overflow (SSO) is defined as any overflow, release, discharge, or diversion of untreated or partially treated wastewater from a sanitary sewer system. SSOs can contain FIB, pathogenic organisms, and other pollutants. They have the potential to pollute surface and ground water.

In 2009, the Regional Water Board issued Cease and Desist Order (CDO) No. R2-2009-0020 to the City of San Mateo and the satellite collection systems owned by Hillsborough and the County due to SSO discharges. The CDO requires the implementation of several prescribed actions to eliminate the conditions in the collection system that cause or contribute to SSOs or unauthorized discharges from the WWTP. Many of these actions are still under development.

- **Crystal Springs/El Cerrito Trunk Sewer Project.** The City of San Mateo, Hillsborough, and County must upsize piping in Hillsborough's collection system and install a new wet weather relief line in the City's collection system. The Crystal Springs/El Cerrito Trunk line parallels San Mateo Creek for approximately 15,800 linear feet between El Camino Real (near De Anza Park) and Polhemus Road. It was targeted by the CDO due to significant undersizing and several SSOs in January 2008 totaling 643,900 gallons. The project is under construction as of September 2015.
- **Crystal Springs County Sanitary District's (CSCSD) Remaining Capital Improvement Plan (CIP) Projects.** The County must complete, by September 2014, the eight remaining CIP project identified in its 1999 Sewer Master Plan.
- **SSO Spill Response.** By June 2009, each agency submitted an SSO Response Plan, which describes emergency response and contingency procedures in the event of an SSO.
- **Collection System Maintenance and Management.** Four Regional Water Board submittals were completed by May 2010, including development and implementation of a plan to ensure that the entire collection system is cleaned within a three-year timeframe; a report describing the computerized sewer maintenance management system; certification that all pump stations are capable of pumping peak wet weather flow and can operate continuously; and a Fats, Oils and Grease Blockage Control report.
- **Collection System Condition and Capacity Assessments.** Two Regional Water Board submittals were completed by November 2009, including a plan for inspection of gravity sewers and manholes and installation of flow meters to assess peak dry weather and wet weather flow rates.
- **Capacity Assurance.** Implementation of short-term capacity improvements is required by November 2016.

4.5.2 Individual Sewage Disposal Systems

One property in unincorporated San Mateo County is on a private septic system (e.g., individual sewage disposal system) with one or two leach fields. It is located just downstream of the San Mateo Creek and Polhemus Creek confluence. Per San Mateo County Ordinance chapter 4.84, it is subject to a triennial inspection by the County Health Officer to ensure its continued proper functioning.

4.5.3 Direct Sources of Wastes

Homeless encampments sometimes occur along the creek at bridge crossings in the denser residential and commercial areas of the City of San Mateo (i.e., Highway 101, 3rd Avenue, Darcy's Tunnel) at Gateway Park, and occasionally as far upstream as De Anza Park. These uses can be a significant source of human fecal material and other pollutants (e.g., trash) directly to the creek. When encampments are reported to the City of San Mateo Police Department, the homeless are notified with postings that they need to permanently vacate the encampment along with their belongings within a certain period of time. If they remain beyond the specified time period, then the Police Department can forcibly remove them and have the Public Works Department remove their belongings and any debris left behind.

The City and County of San Mateo are also actively involved in efforts to prevent encampments by helping to move homeless people into housing. In 2005, the County initiated the Housing Our People Effectively (HOPE) 10-year strategic plan to end homelessness in the County. One outcome of HOPE was the pilot Housing Outreach Team (HOT) program, implemented in 2006 in downtown San Mateo. The HOT program provides permanent housing and outreach to homeless people. In addition, in 2013, the City of San Mateo installed fencing in two problem areas to prohibit access to the Creek.

4.6 Bacteria Fate and Transport

An understanding of the fate and transport of bacteria in the system is critical to developing effective and cost-efficient control measures. Numerous variables can affect the concentration of FIB measured at any one location.

Removal mechanisms include inactivation (i.e., loss in viability of the microorganism) and physical transport (either downstream or into bed sediments). Inactivation or die-off is dependent on several factors, including temperature, pH, salinity, nutrient concentrations, predation, and ultraviolet (UV) irradiance. Bacteria can attach to sediment particles even under flowing or turbulent conditions resulting in removal from the water column and the formation of biofilms. However, bacteria colonies can grow in the sediment and later become resuspended in the water column. Bed sediments thereby can transition from a sink to a source. Modeling of these mechanisms is difficult because the conditions (physical and chemical variables) under which bacteria attach or detach from particles are not fully understood (Walters et al. 2013).

5.0 Discussion and Recommendations

During WY2014 and WY2015, the San Mateo Creek Pathogen Indicator SSID Project investigated elevated FIB densities observed in San Mateo Creek during WY2012 Creek Status Monitoring and historically. The San Mateo Creek watershed is characterized by a large (i.e., 27-square mile) open space upper watershed with controlled releases to a smaller (5-square mile) lower watershed which drains to San Francisco Bay. The lower watershed encompasses a gradient of increasingly dense urban land uses in the downstream direction.

5.1 Bacterial Extent and Sources

Field and desktop approaches were implemented to assess the seasonal and geographic extent and potential sources of elevated FIB densities.

- **Geographic Extent.** *E. coli* was measured at densities consistently exceeding REC-1 WQOs in lower San Mateo Creek along creekside parks (Gateway and De Anza Parks) where water contact recreation, although unlikely, could occur. Elevated FIB densities were not observed during dry season sampling at stations higher up in the watershed (i.e., above Sierra Drive). REC-2 WQOs for fecal coliform were not exceeded.
- **Seasonal Extent.** With one exception, *E. coli* was measured at densities exceeding REC-1 WQOs at Gateway and De Anza Parks densities throughout the monitoring period (i.e., February through November 2014 and June 2015). Although there was a high degree of variability in FIB densities (typical of bacteriological studies), there was a slight (but inconsistent) wet weather signal, with the highest *E. coli* densities observed during or shortly after storm events. A more intensive sampling program would be required to provide more statistical certainty regarding seasonal differences.
- **Potential Sources.** The presence of residential, commercial, and industrial land uses in the watershed suggests a number of potential bacteriological sources. Controllable sources include pet waste, human waste discharges from homeless encampments and leaking sewer lines, wildlife waste exacerbated by litter, and trash receptacle leachate; however, the extent to which municipalities can control these sources may be constrained. Uncontrollable sources include wildlife waste in less urban areas and bacterial growth in the environment. Application of MST techniques (i.e., human and dog genetic markers in the Bacteroidales group) suggest year-round human sources impact lower San Mateo Creek while dog sources primarily impact the creek during wet-weather.

5.2 Current and Planned Management Actions

A number of management actions designed specifically or opportunistically to control bacterial sources are currently planned or are being implemented by municipalities in the lower San Mateo Creek watershed. These include:

- **Pet Waste.** Control measures for pet waste currently include municipal code enforcement and complaint response, pet waste cleanup signage and dog bag dispensers, and public outreach and education.
- **Wildlife Waste.** Control measures for wildlife waste include a successful public education program targeting pigeons in commercial areas of San Mateo. Trash reduction efforts may also reduce nuisance wildlife.
- **Trash.** All municipalities in the lower San Mateo Creek watershed have developed and are implementing Long-Term Trash Load Reduction Plans with the goal of reducing trash in MS4 discharges by 70% in 2017 and 100% in 2022.
- **Wastewater.** All municipalities in the lower San Mateo Creek watershed are currently implementing or planning prescribed actions to eliminate conditions in the sanitary sewer collection system that cause or contribute to SSOs. Actions include improved maintenance and management to system assessments and tracking systems. In addition, replacement of the significantly undersized Crystal Springs/El Cerrito Trunk line, which runs along San Mateo Creek between El Camino Real and Polhemus Creek, is under construction as of September 2015. Homeless encampments along the creek are being targeted by the HOT program which provides permanent housing and outreach to homeless peoples. The City of San Mateo has also installed fencing in two problem areas.

5.3 Recommendations

Although municipalities are implementing many recent management actions, FIB densities measured in WY2014 and WY2015 in San Mateo Creek at Gateway and De Anza Parks remain within the same range as FIB densities measured in 2003 and WY2012. Furthermore, in spite of signage and public outreach, dog waste was frequently observed at Gateway and De Anza Parks and dog genetic markers were measured in many wet-weather samples. It is possible that management actions already planned for the near future will result in future reductions in FIB densities. For example, CDO actions may address the year-round presence of human genetic markers in water samples at De Anza Park where homeless encampments and other human sources are unlikely.

The City of San Mateo, Town of Hillsborough, San Mateo County, and SMCWPPP may wish to consider working together to increase public education and outreach targeting pet waste in the San Mateo Creek watershed. Potential examples include installation of additional cleanup signs, dog bag dispensers, and trash receptacles at creekside parks. Local municipalities should also continue the homeless elimination efforts begun through the HOPE strategy and HOT program. In addition, to help evaluate the effectiveness of current and planned control actions, SMCWPPP

may wish to consider continuing to monitor FIB in San Mateo Creek via its MRP Creek Status monitoring program. However, even if human and dog sources are better controlled, FIB monitoring results could still exceed WQOs due to uncontrollable sources such as wildlife and natural bacterial growth.

It is important to acknowledge that a) the REC-1 WQOs for FIB in the San Francisco Basin Plan do not distinguish among sources of FIB and that b) FIB do not directly represent actual pathogen concentrations. Animal fecal waste is much less likely to contain pathogens of concern to human health than human sources. In most cases, it is the human sources that are associated with REC-1 health risks rather than wildlife or domestic animal sources (USEPA 2012).

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DATE: April 9, 2015

TO: Bonnie DeBerry
EOA, Inc

FROM: Richard Danielson, Ph.D.
Laboratory Director

SUBJECT: Results of Indicator of Fecal Pollution Study: *E. coli*, *Enterococci* and
Bacteroidales analysis of San Mateo Creek, San Mateo, CA. **Amended Report**

From February, 2014 to November, 2014, samples were collected in San Mateo Creek, San Mateo, CA for a variety of indicator organisms, including the fecal coliforms, Enterococci and the bacterial group of the Bacteroidales. The target areas were within two public parks, DeAnza and Gateway (please see Figure 7).

In summary, at no point during this study did the microbiological water quality in San Mateo Creek at DeAnza Park or Gateway Park meet recreational (body contact) standards. In all instances, indicators of microbiological water quality significantly exceeded the standards. Further, there was evidence that the sources of the fecal pollution included wild animals, domestic animals and humans.

There were nine sample events, three collections following rainfall, the other six during dry conditions. Sample collection was timed with low-tide events in order to reduce the influence that high-tide water from San Francisco Bay may have had on the site at Gateway Park. 500 mL samples were collected in sterile plastic bottles from the shore using an extension pole to out into the flow of the creek. Samples were transported same-day to the laboratory with ice packs to keep them cool. All samples were processed within 5 hours of final collection.

Environmental information was collected at each site including temperature; conductivity; type of wild and domestic animal activity observed; and, general observations of the condition of the creek (odors, debris, weather conditions, etc.).

A summary of all the microbiological data is presented in Attachment A. Chain of custody forms with the raw data collected on site is presented in Attachment B. A collage of photographs taken throughout the year are presented in Attachment C.

Physical State of the Parks

DeAnza. The sample site in DeAnza Park was located in the eastern part of an urban green-way with many trees forming a canopy and thick ivy undergrowth. There is public access down to the creek at several locations with both constructed and foot-worn paths throughout. For the majority of the sample visits there was only occasional debris of waste (plastic bags, paper, etc.). Storm drains from the street lead into the creek. In regards to animal activity, there was a family of at least four deer that resided in the immediate area and deer scat was prominent

throughout along the banks of the creek. Ducks were numerous and almost always present. There was direct evidence of domestic canine activity on the street above and on several occasions people were walking their dogs in the park area during a sampling event.

Gateway. The sample site in Gateway Park was located at the eastern end of the park before an overpass. Gateway is a constructed urban park to the west of the creek with un-maintained banks on the east. Public access is an easy walk to the creek from the banks throughout the length of the creek through the park. Debris is common and spread along the length of the creek in the area comprised of plastic bags, paper, bottles, cans, etc. In regards to animal activity, ducks were numerous and always present. Turtles also inhabit the creek at this site. There was direct evidence of domestic canine activity on the walkways above and on several occasions people were walking their dogs in the park area during a sampling event.

Indicator Data – *E. coli* Bacteria

For the analysis of *E. coli* bacteria, Standard Methods for the Examination of Water and Wastewater, 9221F (2006) was used. This is a method where portions of the sample in increasing dilution are dispensed into a series of selective and differential media. In addition, to further select of *E. coli* bacteria, there is a high-temperature incubation step. The results of this test are expressed as a most probable number (MPN) per 100 mL volume. A summary of the data is presented in Figures 1 and 2 and Tables 1, below.

Figure 1.

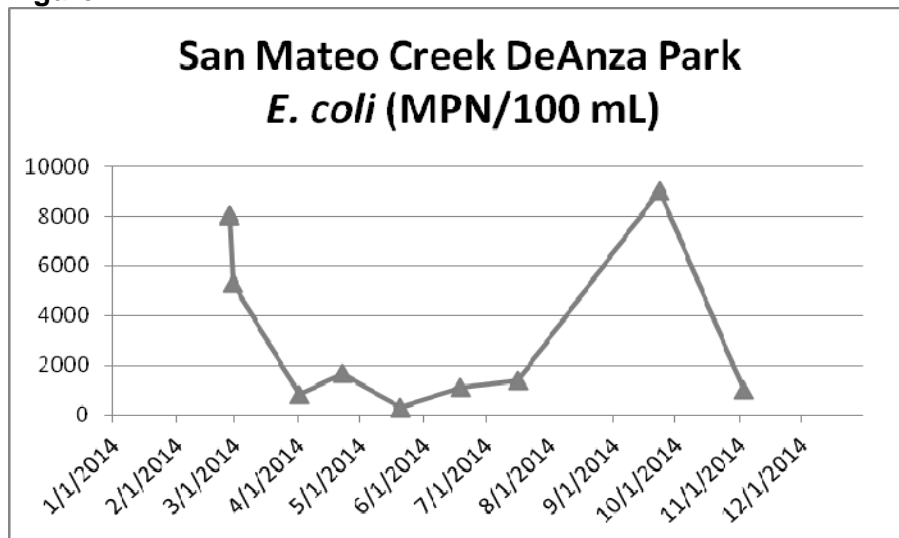


Figure 2

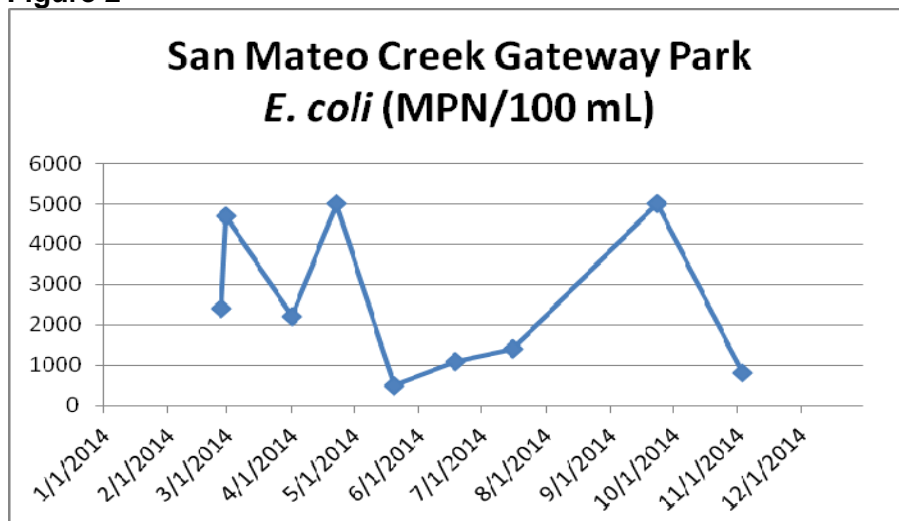


Table 1.

<i>E. coli</i> DeAnza			<i>E. coli</i> Gateway	
	MPN/100 mL			MPN/100 mL
Mean	3660		Mean	2400
Median	1550		Median	2200
Minimum	300		Minimum	500
Maximum	9000		Maximum	5000

Indicator Data – *Enterococcus* Bacteria

For the analysis of *Enterococcus* bacteria, the Enterolert (Idexx) Quantitray Method was used. This is a method where portions of the sample are dispensed into a series of smaller volumes into a segmented tray. The media is a minimal media supplemented with a compound that is broken down and fluoresces under a black light by the enterococci. In addition, to further select for *Enterococcus* bacteria, there is a high-temperature incubation step. The results of this test are expressed as a most probable number (MPN) per 100 mL volume. A summary of the data is presented in Figure 3 and 4, and in Table 2, below.

Figure 3

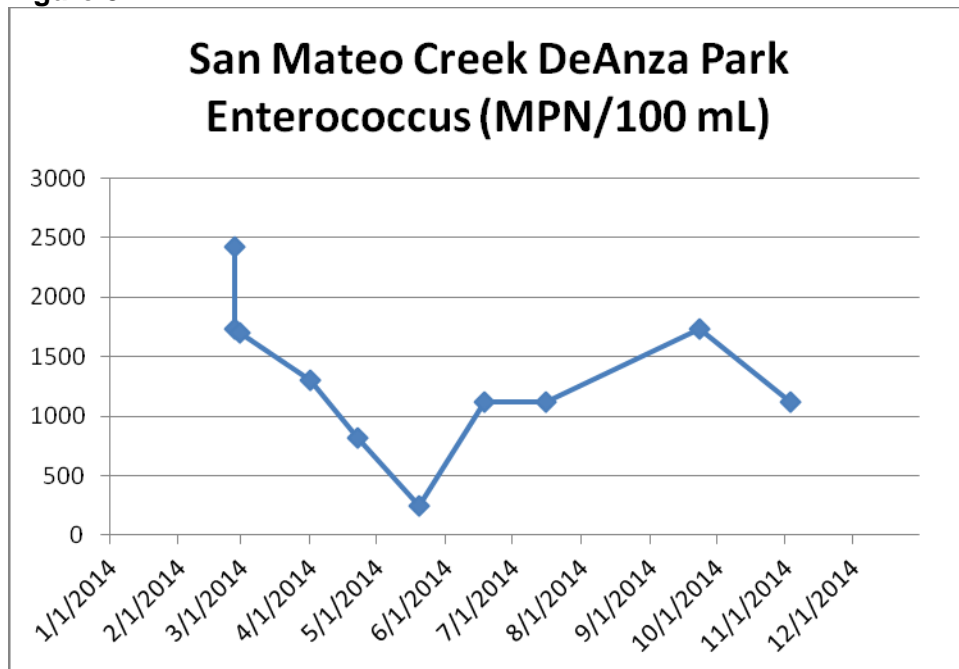


Figure 4

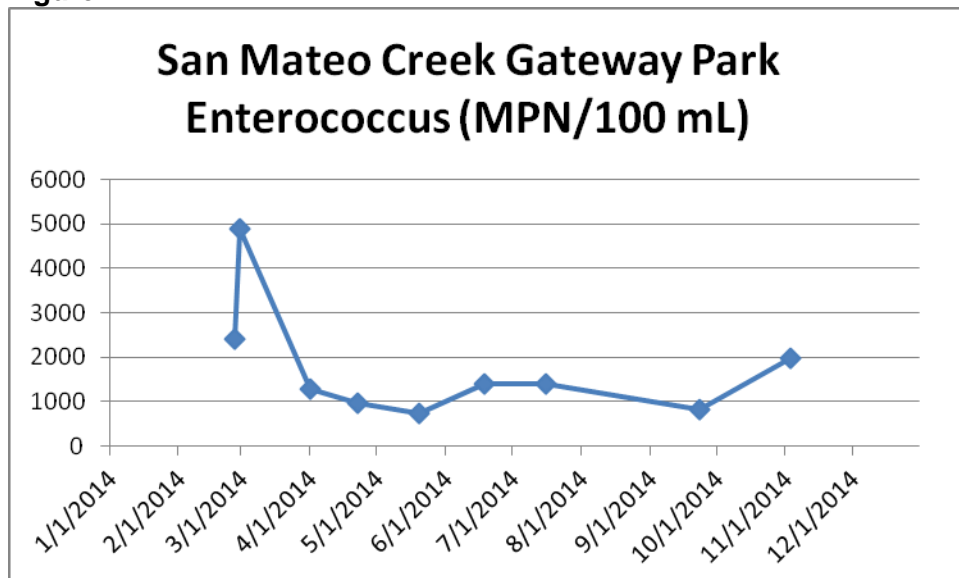


Table 2

Enterococcus DeAnza		Enterococcus Gateway	
	MPN/100 mL		MPN/100 mL
Mean	1331	Mean	1773
Median	1210	Median	1414
Minimum	249	Minimum	727
Maximum	2419	Maximum	4900

Indicator Data – The Bacteroidales

The bacteroidales were originally selected as they represent a significant part of the mammalian gut microbial population. Further, there are analytical techniques available that can detect and differentiate these organisms by the animal source from environmental samples. The technique used was real-time polymerase chain reaction (rt-PCR). Initially the analysis was for the detection of the general genetic marker (GEN-BAC) for the bacteroidales group (US EPA Method B, 2010; SCCWRP, 2013). Subsequent to identifying those areas that were positive for the presence of the GEN-BAC, analysis was requested for the human genetic marker (HF) also (SCCWRP, 2013; Lamendella et al, 2006) and for dog marker (Bernhard and Field, 2000). A standard from a human source was run with each set and arbitrarily set at a declining concentration scheme of 100,000, 10,000, 1,000, 100 and 10. All values were then compared against this standard to provide a relative association of HF to GEN-BAC.

In summary, the GEN-BAC and HF markers were detected at all sample sites during all sample periods throughout the study. The relative abundance of HF marker to GEN-BAC marker was used to provide a general assessment of distribution of these organisms within the bacteroidales group.

A summary of the data is presented in Figures 5 and 6.

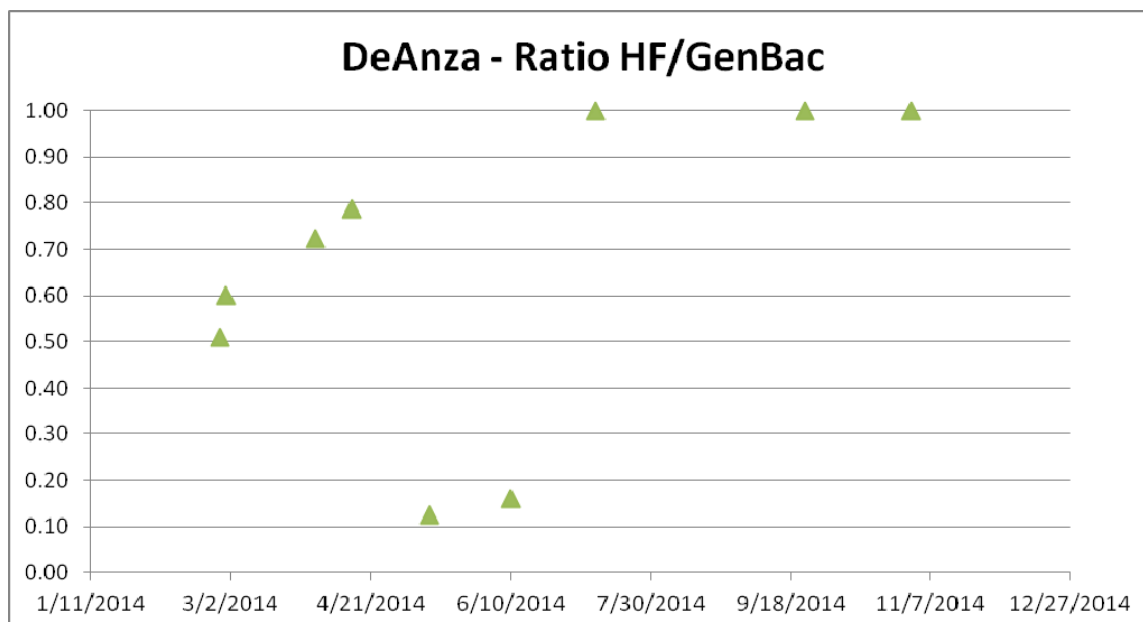
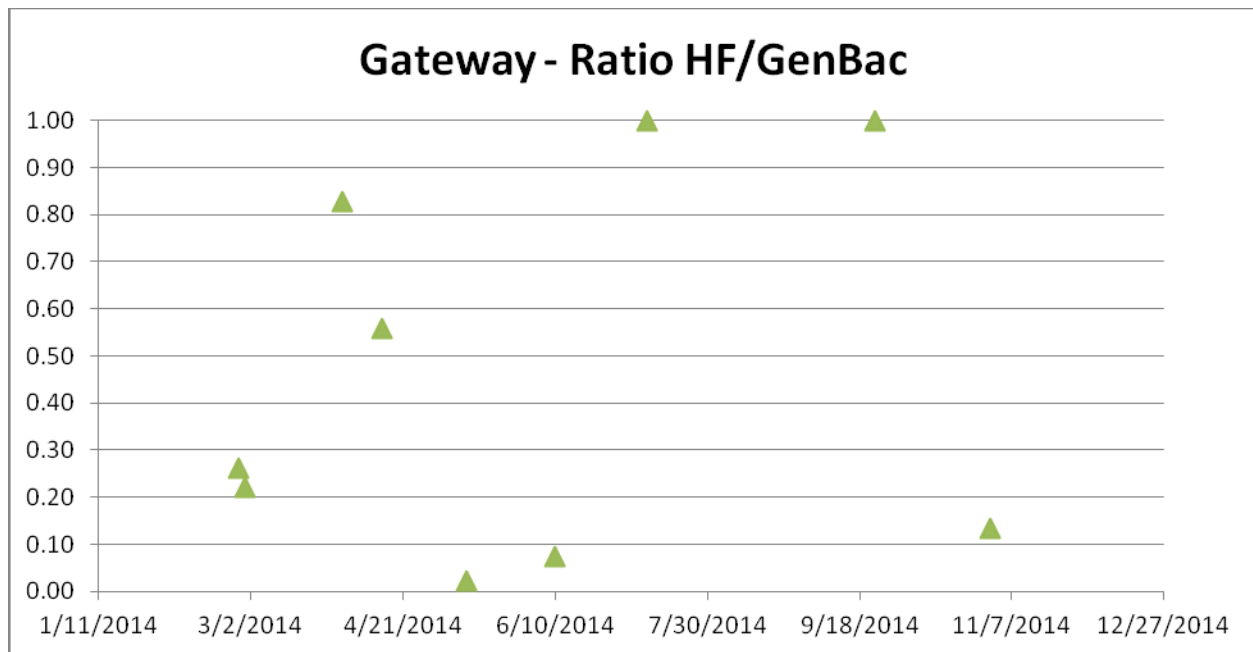
Figure 5.

Figure 6



For DeAnza, the HF marker made up less of the Bacteroidales group detected in the samples during or following a rainfall (2/26/2014 and 2/28/2014) with the exception of 10/31/2014. During the dry season sampling the HF and the GEN-BAC were of equal value. For Gateway, a similar distribution was observed, with the exception that on 10/31/2014, the HF marker was similar to previous rain-affected samples. For the two observations at 5/12/2014 and 6/10/2014, the low ratios are more due to the relatively low concentration of the bacteroidales relative to the other occasions.

Since there is much domestic canine activity at both parks, it was desired to determine what, if any, impact canine feces may have on the creek. There was evidence of canine feces being deposited at both parks. However, the canine marker was detected only following storm events with the exception of one additional observation at Gateway Park (Table 3). This indicates that during the study period canine feces was a contributor to fecal pollution from the runoff from the streets and parks.

Finding higher ratio of HF marker during the dry season indicates that the wild and domestic animal fecal material that is on the periphery of creek is not being transported into the creek at those times. During dry season the Bacteroidales that are being detected appears to be associated with human-related sources.

The Bacteroidales bacteria do not readily replicate outside of the animal host, and in fact, their survival outside the host is quit short. Therefore, detecting these bacteria is an indication of recent introduction into the environment.

Table 3. Dog Marker

	Sample Number	Date Collected	Result
DeAnza	140291-001	2/26/2014	+
	140286-001	2/28/2014	+
	140472-001	4/1/2014	ND
	140539-001	4/22/2014	ND
	140697-002	5/20/2014	ND
	140874-001	6/18/2014	ND
	141012-001	7/16/2014	ND
	141380-001	9/23/2014	ND
	141575-001	11/4/2014	+
Gateway	140291-003	2/26/2014	+
	140286-002	2/28/2014	+
	140472-002	4/1/2014	ND
	140539-002	4/22/2014	+
	140697-001	5/20/2014	ND
	140874-002	6/18/2014	ND
	141012-002	7/16/2014	ND
	141380-002	9/23/2014	ND
	141575-002	11/4/2014	+

There are a series of controls that are performed with RT-PCR analysis that are crucial to demonstrate that the reaction was successful. Positive and negative controls are performed to monitor the performance of the PCR machine (Qiagen, Rotorgene Q) and to check on false positive outcomes as a result of sample handling, respectively. A source of bacteroidales was added to samples as a nucleic acid extract control in order to determine if matrix inhibitors had been carried over into the reaction, or, for matrix inhibition in recovery.

References

Standard Methods for the Examination of Water and Wastewater, APHA-AWWA-WEF (on-line)

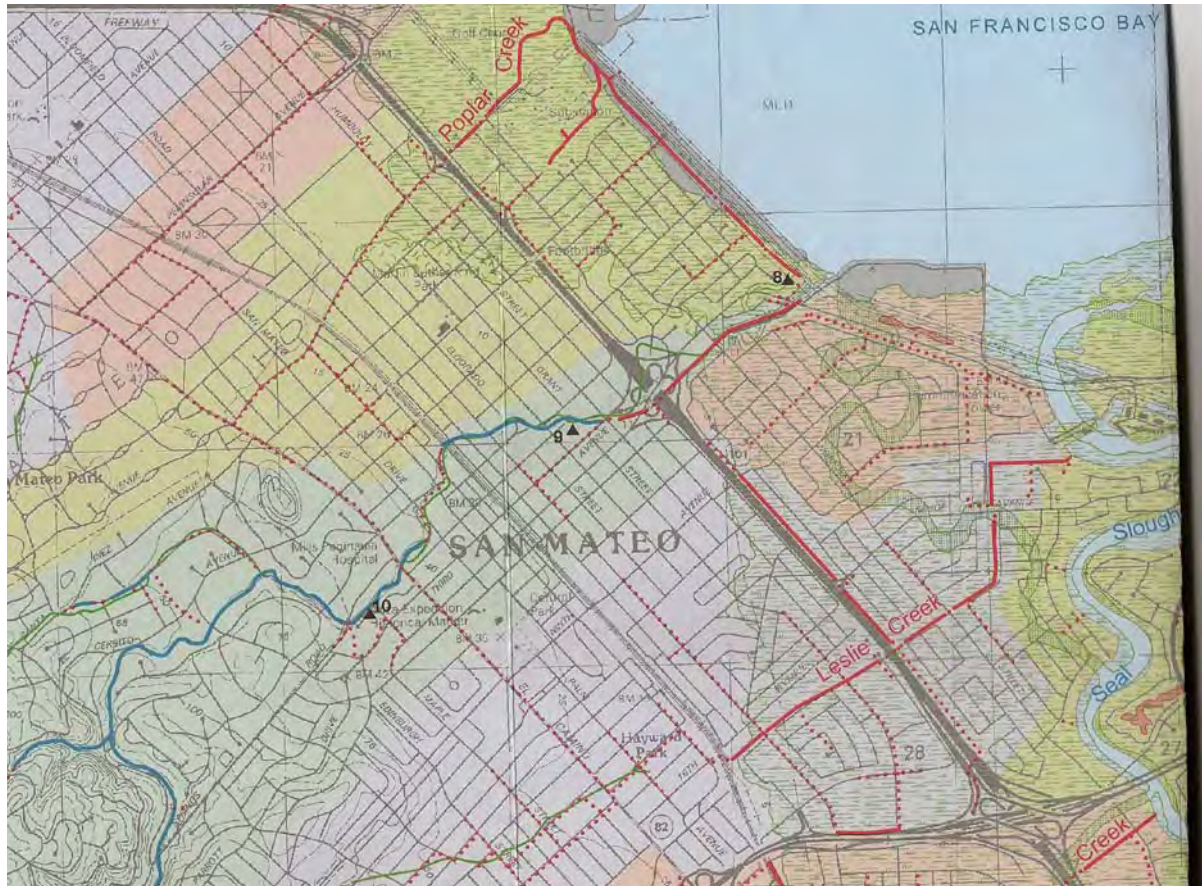
US EPA. Method B: Bacteroidales in Water by TaqMan® Quantitative Polymerase Chain Reaction (qPCR) Assay. June 2010.EPA-822-R-10-003.

Lamendella, R., J.W. Santo Domingo; A.C. Yannarell; S. Ghosh; G. DiGiovanni; R.I. Mackie; and D.B. Oerther. 2009. Evaluation of swine specific PCR assays used for fecal source tracking and analysis of molecular diversity of swine-specific “Bacteroidales” populations. Appl. Environ. Microbiol. 75. 5787-5796.

The California Microbial Source Identification Manual: A Tiered Approach to Identifying Fecal Pollution Sources to Beaches. Griffith, J.F., B.A. Layton, A.B. Boehm, P.A. Holden, J.A. Jay, C Hagedorn, C.D. McGee, and S.B. Weisberg. SCCWRP Tech Report 804. December 2013.

Bernhard, A.E. and K.G. Field. 2000. A PCR Assay to Discriminate human and Ruminant feces on the basis of host differences in *Bacteroides-Prevotella* Genes Encoding 16SRNA. Appl. Environ. Microbiol. 66:4571-4574.

Figure 7. Map of study area. DeAnza Park (Station 10) and Gateway Park (Station 9)



ATTACHMENT A – Microbiological Data

Sample	Date	Test	Method	Location	NumericResult	Units	Bacteroidales	HUM183	Dog
140291-001	2/26/2014	Coliform, E.coli,	SM9221	De Anza 1	8000	MPN/100ml	P	P	P
140291-001	2/26/2014	Enterococci	Quantitray / Enterolert	De Anza 1	2419.2	MPN/100ml			
140291-002	2/26/2014	Coliform, E.coli,	SM9221	De Anza 2	8000	MPN/100ml	P	P	P
140291-002	2/26/2014	Enterococci	Quantitray / Enterolert	De Anza 2	1732.9	MPN/100ml			
140291-003	2/26/2014	Coliform, E.coli,	SM9221	Gateway 1	24000	MPN/100ml	P	P	P
140291-003	2/26/2014	Enterococci	Quantitray / Enterolert	Gateway 1	>2419.2 ¹	MPN/100ml			
140286-001	2/28/2014	E. coli	SM9221	DeAnza 1	5300	MPN/100ml	P	P	P
140286-001	2/28/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1700	MPN/100ml			
140286-002	2/28/2014	E. coli	SM9221	Gateway 1	4700	MPN/100ml	P	P	P
140286-002	2/28/2014	Enterococci	Quantitray / Enterolert	Gateway 1	4900	MPN/100ml			
140472-001	4/1/2014	E. coli	SM9221	DeAnza	800	MPN/100ml	P	P	ND
140472-001	4/1/2014	Enterococci	Quantitray / Enterolert	DeAnza	1300	MPN/100ml			
140472-002	4/1/2014	E. coli	SM9221	Gateway	2200	MPN/100ml	P	P	ND
140472-002	4/1/2014	Enterococci	Quantitray / Enterolert	Gateway	1300	MPN/100ml			
140539-001	4/22/2014	E. coli	SM9221	DeAnza 1	1700	MPN/100ml	P	P	ND
140539-001	4/22/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	816.4	MPN/100ml			
140539-002	4/22/2014	E. coli	SM9221	Gateway	5000	MPN/100ml	P	P	P
140539-002	4/22/2014	Enterococci	Quantitray / Enterolert	Gateway	980.4	MPN/100ml			
140697-001	5/20/2014	E. coli	SM9221	Gateway near bridge	500	MPN/100ml	P	P	ND
140697-001	5/20/2014	Enterococci	Quantitray / Enterolert	Gateway near bridge	727	MPN/100ml			
140697-002	5/20/2014	E. coli	SM9221	DeAnza Creek	300	MPN/100ml	P	P	ND
140697-002	5/20/2014	Enterococci	Quantitray / Enterolert	DeAnza Creek	248.9	MPN/100ml			
140874-001	6/18/2014	E. coli	SM9221	DeAnza 1	1100	MPN/100ml	P	P	ND
140874-001	6/18/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1119.9	MPN/100ml			
140874-002	6/18/2014	E. coli	SM9221	Gateway	1100	MPN/100ml	P	P	ND
140874-002	6/18/2014	Enterococci	Quantitray / Enterolert	Gateway	1413.6	MPN/100ml			
141012-001	7/16/2014	E. coli	SM9221	DeAnza 1	1400	MPN/100ml	P	P	ND
141012-001	7/16/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1119.9	MPN/100ml			

141012-002	7/16/2014	E. coli	SM9221	Gateway	1400	MPN/100ml	P	P	ND
141012-002	7/16/2014	Enterococci	Quantitray / Enterolert	Gateway	1413.6	MPN/100ml			
141380-001	9/23/2014	E. coli	SM9221	DeAnza 1	9000	MPN/100ml	P	P	ND
141380-001	9/23/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1733	MPN/100ml			
141380-002	9/23/2014	E. coli	SM9221	Gateway	5000	MPN/100ml	P	P	ND
141380-002	9/23/2014	Enterococci	Quantitray / Enterolert	Gateway	816	MPN/100ml			
141575-001	11/4/2014	E. coli	SM9221	DeAnza 1	1100	MPN/100ml	P	P	P
141575-001	11/4/2014	Enterococci	Quantitray / Enterolert	DeAnza 1	1119.9	MPN/100ml			
141575-002	11/4/2014	E. coli	SM9221	Gateway	800	MPN/100ml	P	P	P
141575-002	11/4/2014	Enterococci	Quantitray / Enterolert	Gateway	1986.3	MPN/100ml			

ND = Not Detected

1. Amended #140291-3, Enterococcus, 04/09/2015

**ATTACHMENT B – CHAIN OF CUSTODY FORMS AND
FIELD DATA**



SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751

® Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001

11.1°C

291-1-3

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856				DATE OF SAMPLING: 2.26.14	
NAME OF SAMPLER: (Please print and sign - REQUIRED) <i>RZ Dal Danielson</i>				PURCHASE ORDER #:	
Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER: Weather Conditions:					
SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① De Anza 1	1250	0.5L	—	De Anza Park	E. coli, Enterococci + MST
② De Anza 2	1250	0.5L	—	De Anza Park	<i>[Signature]</i>
③ Gateway 1	1320	0.5L	—	Gateway Park	<i>[Signature]</i>

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C):	SC (µmhos/cm):	Gateway	TEMP (°C):	SC (µmhos/cm):
DUCKS: <u>Y</u> /N COUNT: 1 LOCATION: <u>③ HISTORIC MARKER</u>			DUCKS: <u>Y</u> /N COUNT: 23 LOCATION: <u>w/in 50 yds upstream sample pt</u>		
DOGS: <u>Y</u> /N COUNT: LOCATION:			DOGS: <u>Y</u> /N COUNT: LOCATION:		
HUMANS: <u>Y</u> /N COUNT: 1 LOCATION: <u>BENCH BY CREEK</u>			HUMANS: <u>Y</u> /N COUNT: 4 LOCATION: <u>playground</u>		
OTHER: COUNT: LOCATION:			OTHER: COUNT: LOCATION:		
FECAL MATTER: <u>Y</u> /N COUNT: 1 LOCATION: <u>CURB ABOVE STORM DRAIN</u>			FECAL MATTER: <u>Y</u> /N COUNT: LOCATION:		
OTHER OBSERVATIONS (e.g., odors, <u>debris</u> , active runoff, flowing storm drains, encampments): <i>flowing</i>			OTHER OBSERVATIONS (e.g., odors, <u>debris</u> , active runoff, flowing storm drains, encampments): <i>[Signature]</i>		

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
<i>RZ Dal</i>	2.26.14 1430	<i>[Signature]</i>	2/26/14 1430



SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
286-1-2
9.9°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612. Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856	DATE OF SAMPLING: 2.28.14 PURCHASE ORDER #:
NAME OF SAMPLER: (Please print and sign - REQUIRED) RS Danielson	Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER: Weather Conditions: <u>raining</u>

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① DeAnza 1	1210	0.5 L		DeAnza Park	E. coli/Enterococci/MS
② Gateway 1	1230	0.5 L		DeAnza Gateway Park	" " "

Observations - (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C): 13.5°	SC (µmhos/cm): 220	Gateway	TEMP (°C): 13.4	SC (µmhos/cm): 190
DUCKS: <u>Y</u> /N COUNT: 7 LOCATION: <u>throughout</u>	DUCKS: <u>Y</u> /N COUNT: 18 LOCATION: <u>throughout from bridge</u>				
DOGS: <u>Y</u> /N COUNT: LOCATION:	DOGS: <u>Y</u> /N COUNT: 1 LOCATION: <u>throughout</u>				
HUMANS: <u>Y</u> /N COUNT: LOCATION:	HUMANS: <u>Y</u> /N COUNT: 6 LOCATION: <u>throughout</u>				
OTHER: COUNT: LOCATION:	OTHER: COUNT: LOCATION:				
FECAL MATTER: <u>Y</u> /N COUNT: LOCATION:	FECAL MATTER: <u>Y</u> /N COUNT: LOCATION: <u>Duck</u>				
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):	OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):				

COPY

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
<u>RS</u>	2.28.14 1350	<u>Inc</u>	2/28/14 13:50



SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

140472 1,2
EOA 001

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856				DATE OF SAMPLING: 4/1/14	
NAME OF SAMPLER: (Please print and sign - REQUIRED) CRAIG JOHANSON				PURCHASE ORDER #:	
Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER:				Weather Conditions: Intermittent Showers.	
SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① DE ANZA	10:10	500mL		Creek	Microbial. Microbial source tracking
② Gateway	10:47	500mL		Creek	↓
					E. coli
					Enterococci

Observations - (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)					
De Anza 10:10	TEMP (°C): 10.4c	SC (µmhos/cm): 334	Gateway 10:47	TEMP (°C): 11.2	SC (µmhos/cm): 296
DUCKS: <u>Y</u> /N COUNT: 8 LOCATION:			DUCKS: <u>Y</u> /N COUNT: 9 LOCATION: Creek		
DOGS: <u>Y</u> /N COUNT: LOCATION:			DOGS: <u>Y</u> /N COUNT: LOCATION:		
HUMANS: <u>Y</u> /N COUNT: LOCATION:			HUMANS: <u>Y</u> /N COUNT: 1 LOCATION: playstructure.		
OTHER: COUNT: LOCATION:			OTHER: COUNT: LOCATION:		
FECAL MATTER: <u>Y</u> /N COUNT: LOCATION: By Historical marker.			FECAL MATTER: <u>Y</u> /N COUNT: LOCATION: Walkway Duck, Dog		
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): Deer? see photo			OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):		

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
	12:00 4/1/14	Maryam Boudary	4/1/14 1200

11:6°C



SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510 **EOA001**
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

539-1-3

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856	DATE OF SAMPLING: 4/22/14 PURCHASE ORDER #:
NAME OF SAMPLER: (Please print and sign - REQUIRED) RE DANIELSON <i>REDAL</i>	Matrix: <u>Creek Water</u> Drinking Water Wastewater Biscolid OTHER: Weather Conditions:

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① De Anza 1	1200	500 ml		De Anza	Endi Enders camp MST 11.5°
② Gateway	1230	500 ml		Gateway	" " " " 11.5°
③ received from Peter Dillabaker	1300	100 ml		Pano Infant	MST 17.6°

Observations - (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C): 12.5	SC (µmhos/cm): 396	Gateway	TEMP (°C): 14.3	SC (µmhos/cm): 404
DUCKS: <input checked="" type="radio"/> Y / <input type="radio"/> N COUNT: 6 LOCATION: 50 yds upstream	DUCKS: <input checked="" type="radio"/> Y / <input type="radio"/> N COUNT: 10 LOCATION: Immediate area + throughout				
DOGS: Y / <input checked="" type="radio"/> N COUNT: LOCATION:	DOGS: Y / <input checked="" type="radio"/> N COUNT: LOCATION:				
HUMANS: Y / <input type="radio"/> N COUNT: 6 LOCATION: throughout	HUMANS: <input checked="" type="radio"/> Y / <input type="radio"/> N COUNT: 8 LOCATION: Playground				
OTHER: COUNT: LOCATION:	OTHER: COUNT: LOCATION:				
FECAL MATTER: <input checked="" type="radio"/> Y / <input type="radio"/> N COUNT: 1 LOCATION: DEER ~ 80-90 yds upstream	FECAL MATTER: Y / <input type="radio"/> N COUNT: LOCATION:				
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): Two homeless persons + material Dog feces in gutter 25 yds up in street	OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): Recent weed abatement + lawn maintenance 30 debris items upstream - balls, bags, wrappers, etc.				

COPY

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
<i>REDAL</i>	4/22/14 14:10	<i>Jm</i>	4/22/14 14:10

③ - Raw wastewater - Jim



SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
697-1
15.7°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856	DATE OF SAMPLING: 5/20/14 PURCHASE ORDER #:
NAME OF SAMPLER: (Please print and sign - REQUIRED) Cray Johnson	Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER: Weather Conditions:

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① Gateway near Bridge	11:25	500ml			

Observations - (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C):	SC (µmhos/cm):	Gateway	TEMP (°C): 16.0	SC (µmhos/cm): 309
DUCKS: Y/N COUNT: LOCATION:			DUCKS: Y/N COUNT: 6 LOCATION: In Creek		
DOGS: Y/N COUNT: LOCATION:			DOGS: Y/N COUNT: LOCATION:		
HUMANS: Y/N COUNT: LOCATION:			HUMANS: Y/N COUNT: 8 LOCATION: picnic tables / playground		
OTHER: COUNT: LOCATION:			OTHER: COUNT: LOCATION: 1 Dog - creek side		
FECAL MATTER: Y/N COUNT: LOCATION:			FECAL MATTER: Y/N COUNT: LOCATION: Duck Creek side		
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):			OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):		

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
agrl	12:30 5/20/14	Jmc	5/20/14 12:35

1/2



SAMPLE DATA SHEET
SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
697-2-3
15.7°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856	DATE OF SAMPLING: 5/20/14 PURCHASE ORDER #: Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER: Weather Conditions:
NAME OF SAMPLER: (Please print and sign - REQUIRED) Chris Johnson	

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
2 DeAnza Creek	11:10	500mL			
3 Deer Pump (Scat)	11:00	SWAB			

Observations - (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C): 15.5	SC (µmhos/cm): 295	Gateway	TEMP (°C):	SC (µmhos/cm):
DUCKS: Y/N COUNT: 7 LOCATION: Creekside/In-creek	DUCKS: Y/N COUNT: LOCATION:				
DOGS: Y/N COUNT: 1 LOCATION: Roadside	DOGS: Y/N COUNT: LOCATION:				
HUMANS: Y/N COUNT: 1 LOCATION: Roadside	HUMANS: Y/N COUNT: LOCATION:				
OTHER: Deer COUNT: 3 LOCATION: Creekside/In-creek	OTHER: COUNT: LOCATION:				
FECAL MATTER: Y/N COUNT: LOCATION: Deer	FECAL MATTER: Y/N COUNT: LOCATION:				
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): Mama Deer: 2 Babies in creek			OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):		

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
[Signature]	11:30 5/20/14	[Signature]	5/20/14 12:35

2/12



SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
814-1-2
17.6°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856	DATE OF SAMPLING: 6.18.14 PURCHASE ORDER #:
NAME OF SAMPLER: (Please print and sign - REQUIRED) RE DANIELSON RE Daniel	Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER: Weather Conditions: Clear, Warm, Dry, Temp 20°C

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① DeAnza 1	1030	100 250ml	-	DeAnza Park	Enterococcus, E. coli MST
② Gateway 1	1100	500		Gateway Park	h 1

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C): 15.5	SC (µmhos/cm): 227	Gateway	TEMP (°C): 16.5	SC (µmhos/cm): 221
DUCKS: <input checked="" type="checkbox"/> Y/N COUNT: 2 LOCATION: ~60 YDS UPSTREAM			DUCKS: <input checked="" type="checkbox"/> Y/N COUNT: 6 LOCATION: @ Playground		
DOGS: <input checked="" type="checkbox"/> Y/N COUNT: 2 LOCATION: FECES ON STREET UP STREAM			DOGS: <input checked="" type="checkbox"/> Y/N COUNT: 0 LOCATION:		
HUMANS: <input checked="" type="checkbox"/> Y/N COUNT: 2 LOCATION: ~60 YDS UPSTREAM			HUMANS: <input checked="" type="checkbox"/> Y/N COUNT: 0 LOCATION:		
OTHER: DEER COUNT: 3 LOCATION: ~80 YDS UPSTREAM			OTHER: COUNT: 0 LOCATION:		
FECAL MATTER: <input checked="" type="checkbox"/> Y/N COUNT: 1 LOCATION: DOG FECES			FECAL MATTER: <input checked="" type="checkbox"/> Y/N COUNT: 1 LOCATION: DOG, on bank upstream		
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): Slow moving, strong sewer odor @ street			OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): Debris, slow moving		

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
RE Daniel	6/18/14 1300	JMC	6/18/14 13:00



SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
1012-1-2
12.8°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856	DATE OF SAMPLING: 7.16.14 PURCHASE ORDER #: Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER: Weather Conditions: overcast 17.3°C
NAME OF SAMPLER: (Please print and sign - REQUIRED) Danielson <i>[Signature]</i>	

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
DeAnza 1	0845	500 mL	—	DeAnza	E. coli, Enterococcus, MST
Gateway 2	0830	500 mL	—	Gateway	" " "

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza TEMP (°C): ^{7.16.14} 16.0 17.4 SC (µmhos/cm): 291	Gateway TEMP (°C): 18.1 SC (µmhos/cm): 357
DUCKS: Y/N COUNT: <u> </u> LOCATION: <u> </u>	DUCKS: Y <u>(N)</u> COUNT: <u> </u> LOCATION: <u> </u>
DOGS: <u>(Y)</u> /N COUNT: <u>1</u> LOCATION: STREET 40 yds W of sample point	DOGS: Y <u>(N)</u> COUNT: <u> </u> LOCATION: <u> </u>
HUMANS: <u>(Y)</u> /N COUNT: <u>1</u> LOCATION: bench	HUMANS: Y <u>(N)</u> COUNT: <u> </u> LOCATION: <u> </u>
OTHER: <u>DEER</u> COUNT: <u>1</u> LOCATION: <u>@ sample point</u>	OTHER: <u> </u> COUNT: <u> </u> LOCATION: <u> </u>
FECAL MATTER: <u>(Y)</u> /N COUNT: <u>DOG 1</u> LOCATION: <u>@ HIGHWAY CMT INTERSECTION STREET</u> <u>DEER - 1/4 MI</u> <u>Along creek bank - 150 yds W</u>	FECAL MATTER: <u>(Y)</u> /N COUNT: <u>2</u> LOCATION: <u>@ 30 yds W of bridge;</u> <u>@ bridge above creek</u>
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments):	OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): <u>debris</u>

COPY

RELINQUISHED BY (SIGNED) <i>[Signature]</i>	DATE/TIME 7.16.14 1000	RECEIVED BY (SIGNED) <i>[Signature]</i>	DATE/TIME 7/16/14 10:08
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SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
1380-1-2 8.3'

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856				DATE OF SAMPLING: 9.23.14	
NAME OF SAMPLER: (Please print and sign - REQUIRED) Paul Randall Paul Randall				PURCHASE ORDER #:	
Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER:				Weather Conditions: clear Overcast - fog, warm	
SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
① Gateway	8:30	500 ml	-	Gateway Park	Enterococcus, E. coli, MST
② De Anza	9:10	500 ml		De Anza Park	" "

Observations - (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)							
De Anza		TEMP (°C): 16.8	SC (µmhos/cm): 255.5	Gateway		TEMP (°C): 17.4	SC (µmhos/cm): 259
DUCKS: Y <input checked="" type="radio"/> N COUNT: LOCATION:				DUCKS: <input checked="" type="radio"/> Y / N COUNT: 22 LOCATION: Tules near bridge (3rd st)			
DOGS: Y <input checked="" type="radio"/> N COUNT: LOCATION:				DOGS: <input checked="" type="radio"/> Y / N COUNT: 2 LOCATION: end playground park, leashed w/ owner			
HUMANS: <input checked="" type="radio"/> Y / N COUNT: 2 LOCATION: park bench				HUMANS: <input checked="" type="radio"/> Y / N COUNT: 2 LOCATION: 3rd st bridge - getting cans			
OTHER: Deer COUNT: 2 LOCATION: east end of park				OTHER: COUNT: 0 LOCATION: in creek			
FECAL MATTER: <input checked="" type="radio"/> Y / N COUNT: 1 LOCATION: dog poop in plastic bag near outfall				FECAL MATTER: <input checked="" type="radio"/> Y / N COUNT: 1 LOCATION: human - under footbridge			
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): bag clear, flowing, min trash				OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): Trash at footbridge, tules above 3rd st bridge			

barely flowing - 1 hour after low tide

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
Paul Randall	9.23.14 10:15	Liz Barriga	9/23/14 10:50

rec'd in lab Jmc 9/23/14 @ 11:55



SAMPLE DATA SHEET

SHIPPING ADDRESS: BIOVIR LABORATORIES, INC., 685 STONE ROAD, UNIT 6, BENICIA CALIFORNIA 94510
1-800-GIARDIA (442-7342) FAX: 707-747-1751
Business Hours: Monday through Friday - 8:30 AM to 5:00 PM

EOA001
141575 21°C

COMPANY OR UTILITY: EOA, Inc., 1410 Jackson Street, Oakland, CA 94612 Attn: Bonnie de Berry TELEPHONE#: (510) 832-2852 EXT#: 123 MOBILE#: (415) 336-4458 FAX#: (510) 832-2856	DATE OF SAMPLING: 11/4/2014 PURCHASE ORDER #:
NAME OF SAMPLER: (Please print and sign - REQUIRED) <u>Richard Danielson</u>	Matrix: <u>Creek Water</u> Drinking Water Wastewater Biosolid OTHER: Weather Conditions: <u>Clear ≈ 73°F</u>

SAMPLE ID#	TIME	VOLUME	TREATMENT	SAMPLING LOCATION	ANALYSIS REQUESTED
14154 ⁵ -1 DeAnza 1	1530	500ml	None	DeAnza Park	E. coli; Enterococci, Source Tracking
14154 ⁵ -2 Gateway 1	1600	500mL	None	Gateway Park	E. coli; Enterococci, Source Tracking
157 11.4.14					

Observations – (Measure temp and specific conductance [SC]; walk the park looking for signs of fecal contamination or its sources)

De Anza	TEMP (°C):	SC (µmhos/cm): 135	Gateway	TEMP (°C):	SC (µmhos/cm): 136
DUCKS: <input checked="" type="checkbox"/> Y / <input type="checkbox"/> N COUNT: 3 LOCATION: 70 yds west of site			DUCKS: <input checked="" type="checkbox"/> Y / <input type="checkbox"/> N COUNT: 16 LOCATION: @ site		
DOGS: Y / <input checked="" type="checkbox"/> N COUNT: LOCATION:			DOGS: Y / <input type="checkbox"/> N COUNT: LOCATION:		
HUMANS: Y / <input checked="" type="checkbox"/> N COUNT: LOCATION:			HUMANS: <input checked="" type="checkbox"/> Y / <input type="checkbox"/> N COUNT: 6 LOCATION: throughout park		
OTHER: DEER COUNT: 3+1 LOCATION: @ sample site ≈ 60 yds west			OTHER: COUNT: LOCATION:		
FECAL MATTER: <input checked="" type="checkbox"/> Y / <input type="checkbox"/> N COUNT: many LOCATION: DEER, WEST OF SITE			FECAL MATTER: Y / <input type="checkbox"/> N COUNT: LOCATION:		
OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): chomping			OTHER OBSERVATIONS (e.g., odors, debris, active runoff, flowing storm drains, encampments): slow moving		

RELINQUISHED BY (SIGNED)	DATE/TIME	RECEIVED BY (SIGNED)	DATE/TIME
<u>[Signature]</u>	11/4/14 1820 - RB	<u>[Signature]</u>	11/5/14 08:30

ATTACHMENT C – PHOTOGRAPHS FROM THE FIELD SITES

DeAnza Park Sample Site Location



Rain Event February 2014





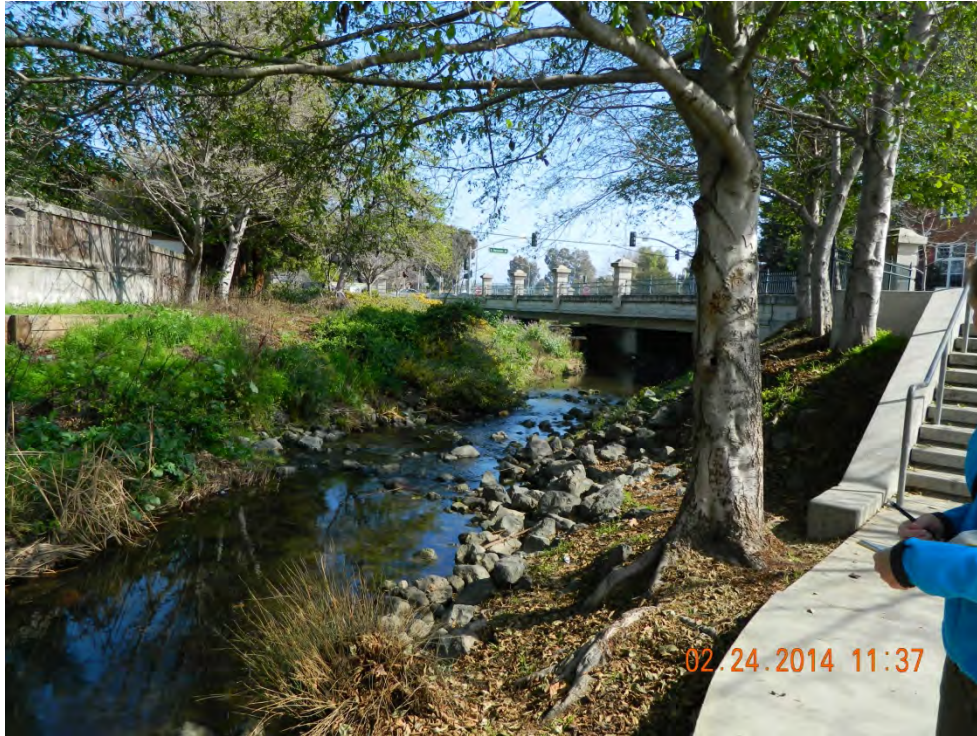
Dog and Bird Feces on street near storm drain above DeAnza sampling location



Deer Inhabitant at DeAnza Park



Gateway Sample Site Location



Gateway Sampling



Gateway Ducks just Upstream of Sample Site



Gateway Rain Event February 2014



San Mateo Creek Flow below Lower Crystal Springs Reservoir (USGS 11162753), and tidal height at Coyote Point Marina (NOAA 9414449)

