Total Maximum Daily Load for Bacteria and Nutrient Impairment Analysis In Petaluma River

Draft Project Report

California Regional Water Quality Control Board
San Francisco Bay Region

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https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/petalumabacterianutrienttmdl.html

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1. INTRODUCTION

This Draft Project Report summarizes the data and supporting information acquired to date, and provides technical analyses conducted to support development of a Total Maximum Daily Load (TMDL) to address and reduce bacteria impairment in the Petaluma River watershed. This report also includes an impairment assessment for nutrients in the Petaluma River. The results of this assessment indicate that a TMDL for nutrients cannot be established at this time, that implementation of the bacteria TMDL will support reductions in nutrient loading to the river, and that ongoing monitoring will identify whether additional actions are necessary to reduce nutrient loading in the watershed.

The report presents available data and information on the key conditions leading to the impairments, and an assessment of uncertainties identified while conducting the technical analyses. This Draft Project Report will be refined with any additional data or information that becomes available over the next few months and will become the Staff Report in support of a Basin Plan amendment that includes the TMDL for bacteria and its Implementation Plan. The first step in preparing the Basin Plan amendment is a CEQA scoping meeting. A discussion of the regulatory background and organization of this report are provided below.

1.1 Regulatory Background

The federal Clean Water Act (CWA) requires California to adopt and enforce water quality standards to protect all water bodies within the State. The Basin Plan delineates these standards for the Region. The standards include beneficial uses of waters in the Region, numeric and narrative water quality objectives to protect those uses, and provisions to enhance and protect existing water quality (antidegradation). Section 303(d) of the CWA requires states to compile a list of “impaired” water bodies, called the 303(d) list, that do not meet water quality standards and to establish TMDLs for the pollutants causing those impairments, such that applicable water quality standards are met.

Since 1975, the main stem of Petaluma River has been on the 303(d) list for impairment from elevated levels of fecal indicator bacteria (FIB). High FIB levels indicate presence of pathogenic organisms that are found in warm-blooded animal (e.g., human, cows, horses, dogs, etc.) waste and pose potential health risks to people who recreate in contaminated waters. Since 1986, the river has also been listed as impaired due to excessive algae growth, known as eutrophication, which is caused by high nutrient (nitrogen and phosphorus) levels. Eutrophic waters, which are symptomatic of excessive algae or aquatic plant growth, can significantly alter dissolved oxygen levels and pH, which are critical to aquatic wildlife and can also impact recreational beneficial uses. The proposed TMDLs and Implementation Plan are designed to resolve bacteria and nutrients impairment in Petaluma River.

A TMDL specifies the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and allocates the acceptable pollutant load to point and nonpoint sources. A TMDL is defined as the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background such that the capacity of the water body to assimilate pollutant loads (the loading capacity) is not exceeded. The Water Board is also required to develop a TMDL taking into account seasonal variations and including a margin of safety to protect against uncertainty in the analysis. In addition, the Water Board must develop a water quality management plan ("Implementation Plan") to implement the TMDL. Finally, TMDLs must be included in the State's water quality management plan (i.e., the Basin Plan).

U.S. EPA has oversight authority for the 303(d) program and is required to review and either approve or disapprove the state's 303(d) list and each TMDL developed by the state.

1.2 Document Organization

The process for establishing a TMDL includes compiling and considering available data and information, conducting appropriate analyses relevant to defining the impairment problem, identifying sources, and allocating responsibility for actions to resolve the impairment. This report is organized into chapters that reflect the key elements of a TMDL. Chapter 2 presents the background information about the physical setting of Petaluma River. Chapter 3 presents the problem definition that the project is based on and defines the project, why it is necessary, and its objectives. Chapter 4 includes the applicable water quality standards. Chapter 5 discusses the results of bacteria and nutrients water quality monitoring studies.

Chapter 6 presents the proposed bacteria numeric targets. Chapter 7 provides our understanding of the potential sources of bacteria loading to Petaluma River.

Chapter 8 presents the proposed pollutant load and wasteload allocations to identified pollutant sources. Chapter 9 presents the linkage analysis, which describes the relationship between pollutants sources, load allocations, and the proposed targets. Chapter 10 presents the Implementation Plan, which includes actions and requirements deemed necessary to resolve the water quality impairments. This Section also includes monitoring activities to better characterize sources of pollution, and demonstrate attainment of numeric targets and pollutant load and wasteload allocations

Chapter 11, References, lists all the information sources cited and relied upon in preparation of this report.

2. BACKGROUND

2.1 Watershed Location and Description

The Petaluma River is located in southern Sonoma County and a small portion of northeastern Marin County. The River drains into the northwestern part of San Pablo Bay (Figure 2.1), and is the eleventh largest small tributary to San Francisco Bay (Aquatic Science Center 2010). The Petaluma River watershed is approximately 19 miles long and 13 miles wide and encompasses approximately 146 square miles (378 km^2). Mountainous or hilly upland areas comprise 56% of the watershed, 33% percent of the watershed is valley, and the lower 11% is salt marsh (Sonoma Resource Conservation District 2015).

2.2 Hydrology and Water Resources

The River is comprised of a fluvial (flowing freshwater) section and a tidal slough section, and has several perennial and seasonally intermittent tributaries. Seasonal tributaries from the Sonoma Mountains in the northeast and the slopes of Mount Burdell and Weigand's Hill in the northwest feed Willow Brook, Liberty, and Weigand's Creeks, which merge to form the Petaluma River a little over 3 miles north of the City of Petaluma. The largest tributary, San Antonio Creek, defines the border between Marin and Sonoma Counties and drains the southwestern portion of the watershed (about 20% of the total watershed area). Other major tributaries include (from north to south along the eastern side of the main stem): Lichau, Willow Brook, Lynch, Adobe, Washington, and Ellis Creeks. The tidal slough section of the river begins approximately at the confluence with Lynch Creek, and continues through the saline Petaluma River Marsh complex, before discharging into San Pablo Bay. The tidal marshes along the Petaluma River cover approximately 5,000 acres, and form the largest remaining salt marsh complex in the San Pablo Bay (Aquatic Science Center 2010).

The Petaluma River system maintains a variety of marine, estuarine, and freshwater fish species. Salmonids in particular use the Petaluma River and its tributaries as habitat for spawning, rearing, and migration (Sonoma Resource Conservation District 2015). These systems are significant in providing habitat for both fisheries and riparian plant communities (Sonoma Resource Conservation District 2015).

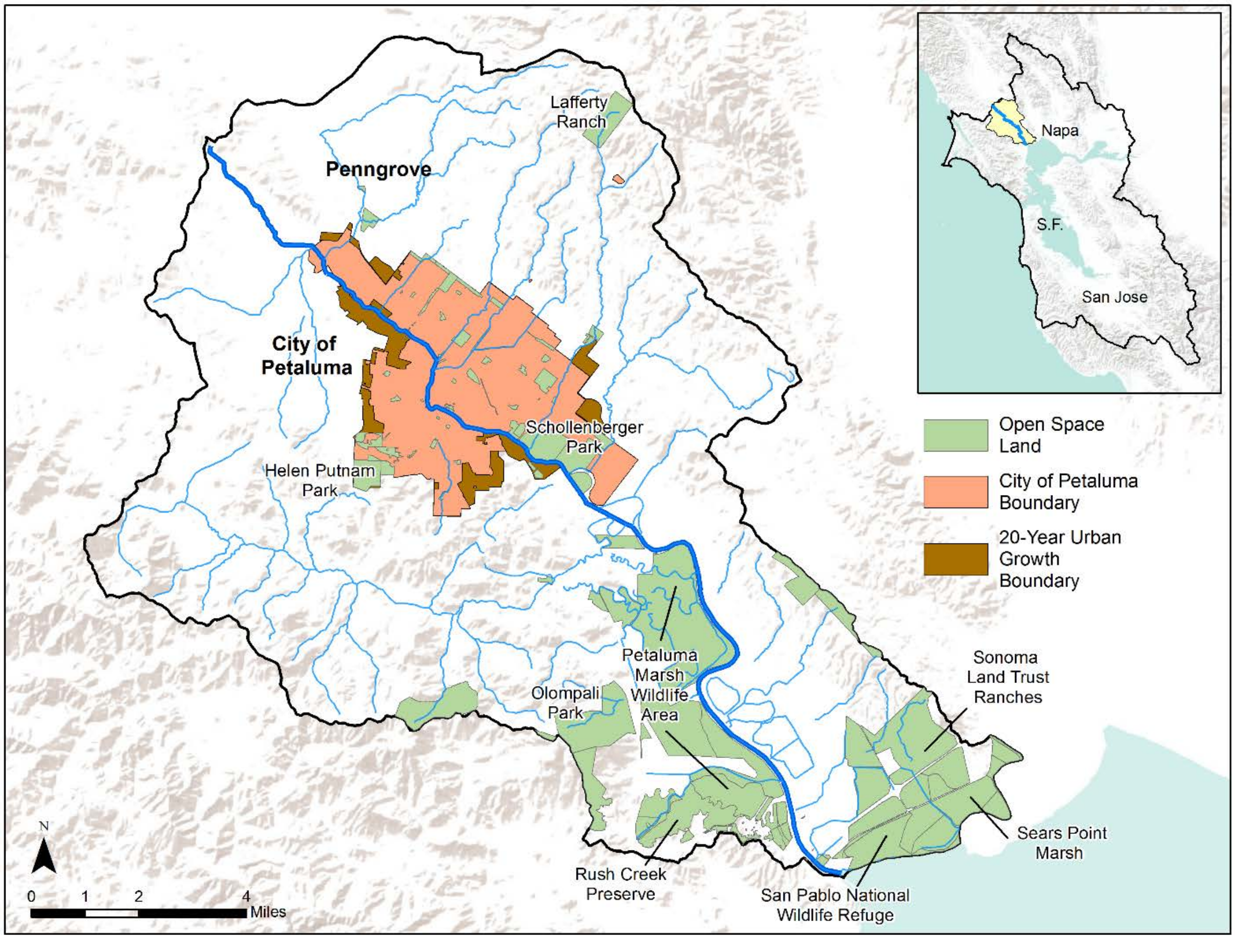

Figure 2.1. Petaluma River watershed.

2.3 Climate

Like the larger San Francisco Bay Area, the Petaluma River watershed has a Mediterranean climate, with cool, wet winters and warm, dry summers. Over 90% of the annual rainfall occurs during October to April. Average annual rainfall in the watershed ranges from about 20 inches at the mouth of the river to about 50 inches at the highest elevations in the watershed (Sonoma Resource Conservation District 2015). However, rainfall is highly variable from year to year (40-200% mean annual) (Aquatic Science Center 2010).

2.4 Land Use

2.4.1 Overview

The Petaluma River Watershed supports an array of land use activities (Figure 2.2). The predominant land uses within the Petaluma Watershed boundary are described below.

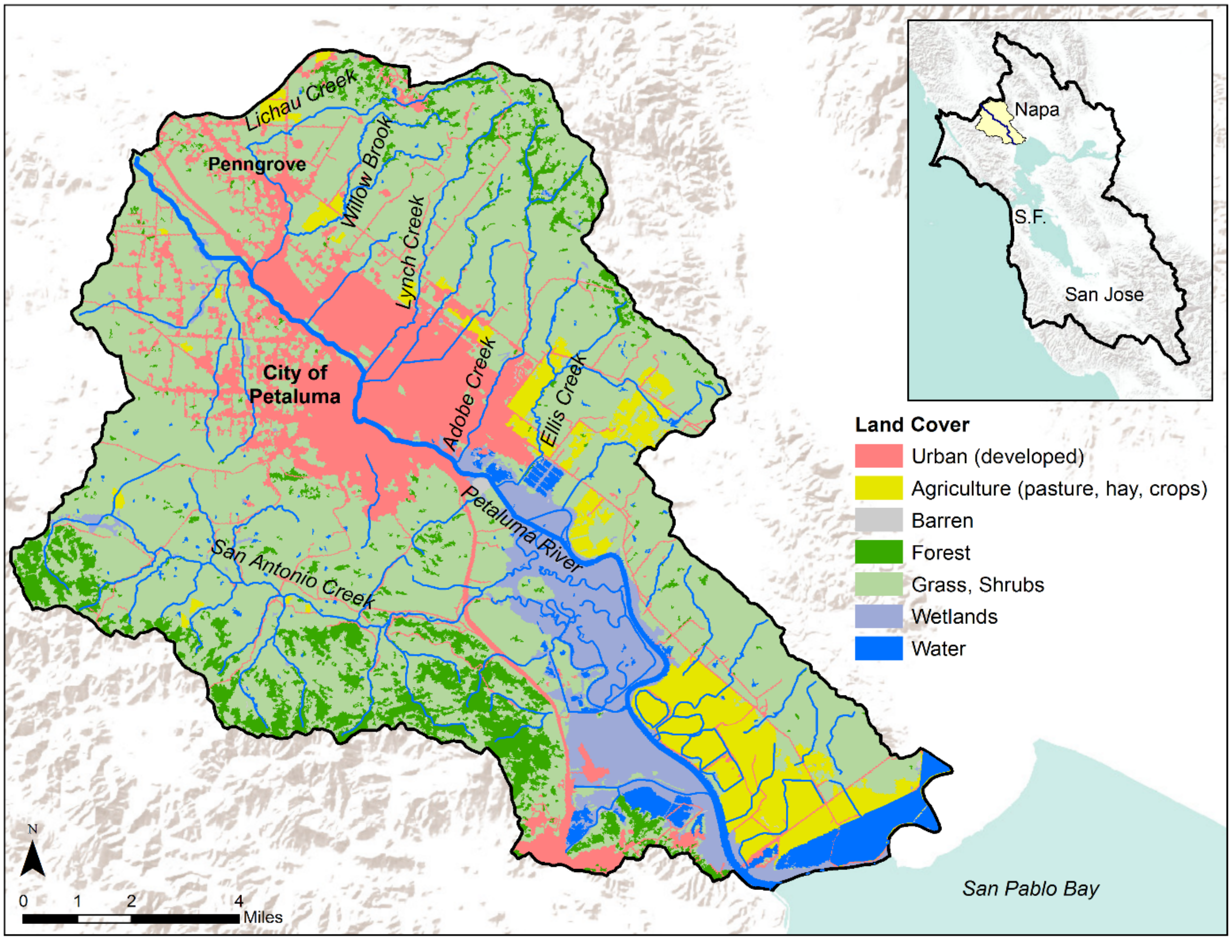

Figure 2.2. Land cover of the Petaluma River watershed.

2.4.2 Urban Development

Urban development is concentrated within the city limits of Petaluma, which with a population of 57,941 (in 2010) occupies the central portion of the watershed. The unincorporated community of Penngrove (population 2,522 in 2010) is located just to the north and supports limited commercial and rural residential developments (Figure 2.2; Sonoma Resource Conservation District 2015).

In 1998, the residents of Petaluma voted in Measure I which would create a 20-year urban growth boundary (UGB) (Figure 2.1). UGBs are considered a necessary proactive growth management measure to prevent urban growth into adjacent greenbelt lands such as: farms, ranches, open lands, and parks. The City chose to renew the measure in 2010 to extend the UGB timeline through the year 2025 (Sonoma Resource Conservation District 2015).

2.4.3 Open Space

The Petaluma River Watershed contains a vast and varied assortment of open spaces (Figure 2.1). The City of Petaluma owns and maintains a number of open space and recreational areas. Approximately 1,300 acres or 18 percent of acreage within the City's

UGB are comprised of parks and open spaces (Figure 2.2; Sonoma Resource Conservation District 2015). Helen Putnam Park encompassing 256 acres in the south western portion of Petaluma is a County Regional Park. Shollenberger Park is a 165 acres park designed around a dredge disposal site for the Petaluma River which also provides trails throughout the wetlands area. The largest community parks in Petaluma are Lucchesi (30 acres), Prince (22 acres), and Wiseman (21 acres) parks. (Sonoma Resource Conservation District 2015).

The Petaluma Marsh Wildlife Area (1,950 acre), located approximately six miles southeast of the City of Petaluma is managed by the California Department of Fish and Wildlife (CDFW). The Rush Creek Marsh (300 acre) is located south of Basalt Creek and north of Novato and is managed by Marin County Open Space District. The State Coastal Conservancy and U.S. Fish and Wildlife Service own and manage approximately 430 acres of marsh as part of the Baylands Project, located in the southwest corner of Lakeville Highway and Highway 37(Sonoma Resource Conservation District 2015).

The Sonoma Land Trust owns and manages over 1000 acres of land West of Lakeville and Reclamation road, of which 528 acres is in agricultural easement and the rest is used for growing oat hay and grazing. The Land Trust also manages 1800 acres of land, East of Lakeville and Reclamation road, of which around 1000 acres are grazed and a few hundred acres are farmed. Of the Land Trust's total acreage in the watershed 1000 acres will eventually be restored to tidal marsh. The Sonoma County Agricultural Preservation and Open Space District has numerous conservation easements on agricultural properties in the watershed that include hay, sheep, dairy, and grazing use (Sonoma Resource Conservation District 2015).

The City of Petaluma owns Lafferty Ranch on Sonoma Mountain, small parcels related to water supply on Manor Road, Petaluma River Marina, oxidation ponds and related facilities near Lakeville, Schollenberger Park, an international bird hotspot, Rocky Memorial Dog Park, the Alman Marsh near the marina, a portion of the McNear Peninsula near downtown, and 160 acres of marsh and oxidation ponds near Schollenberger Park (Sonoma Resource Conservation District 2015).

Other open space land in the watershed includes: Burdell Ranch managed by CDFW, and Petaluma Adobe State Historic Park and Olompali State Historic Park owned by California Department of Parks and Recreation. These parks offer a range of activities such as hiking, mountain biking, and horse-back-riding (Sonoma Resource Conservation District 2015).

2.4.4 Agricultural Lands

Agriculture is the dominant land use within the Petaluma River Watershed. In the past, the area has been a production center for poultry and dairy products. Over the years, the poultry industry has declined, but milk is still one of the watershed's leading agricultural commodities (Sonoma Resource Conservation District 2015). Dairy operations are mainly concentrated in the San Antonio, Adobe, Lynch, and Willow creeks watersheds; however, they are also found in other areas. Vineyards have recently increased in the watershed, particularly near Lakeville, along Highway 101, and in the San Antonio Creek watershed (Sonoma Resource Conservation District 2015). Other agricultural uses within the watershed include livestock farming (beef, sheep, emus, llamas), horse facilities (including boarding and training facilities), crop farming (oats, olives, truck crops, Christmas trees), poultry production (turkeys, chickens, ducks, and eggs), greenhouses, and floral nurseries (Sonoma Resource Conservation District 2015).

2.4.5 Recreation

The Petaluma River and extensive park and open space network within its watershed provide a wide range of water-based recreational opportunities such as swimming, fishing, and boating. The River is used by both human-powered and motor-powered boats and water crafts of various types. Currently, there are two vessel marinas on the river serving the boating community within the watershed. These marinas, combined, contain close to 200 permanent slips. Below is a listing of clubs or businesses providing or supporting various aquatic recreational activities on the Petaluma River:

- **Clavey Paddle Sports**: offering scheduled kayak and stand up paddleboard tours, socials, and classes on the Petaluma River;
- **Friends of the Petaluma River:** a non-profit organization dedicated to celebrating and conserving the Petaluma River, its wetlands and wildlife. The group offers tours of the Petaluma River and chartered cruises;
- **Gilardi's Lakeville Marina:** with approximately two dozen permanent slips, offers various services, including long-term mooring, to boats of various size;
- **He'e Nalu Outrigger Canoe Club:** providing an environment to practice the ancient sport of outrigger canoe;
- **North Bay Rowing Club:** a club with a diverse membership of men and women of all ages with interests in recreation and racing;
- **Petaluma Marina:** with 167 permanent slips, the Petaluma Marina offers many facilities and services to boaters and kayakers on the river;
- **Petaluma Small Craft Center:** a group of clubs and individuals whose mission is to improve access to the Petaluma River for human-powered watercraft;
- **Petaluma Stand Up Paddle:** providing rentals, lessons, tours, sales, and accessories related to stand up paddling; and,
- **Petaluma Yacht Club:** provides services to club members such as cruise-ins to the club house and the Petaluma River Turning Basin.

Aside from aquatic recreation, there are also three golf courses within the watershed, along the eastern edge of the City. These golf courses encompass a combined 2 square kilometers of land.

3. PROJECT DEFINITION

This chapter presents the problem statement upon which the proposed Basin Plan amendment project is based. It also presents the project definition and objectives by which the project is evaluated under the California Environmental Quality Act (CEQA).

3.1 Problem Statement

The entire 24.27 miles of the Petaluma River main stem, including the tidal portion at the mouth, is listed on the Clean Water Act 303(d) list of impaired water bodies due to elevated fecal indicator bacteria (FIB) levels and excessive algae growth from nutrients. High FIB levels (e.g., *E. coli, Enterococcus*) indicate presence of pathogenic organisms that are found in warm-blooded animal (e.g., human, cows, horses, dogs, etc.) waste and pose potential health risks to people who recreate in contaminated waters. The listing of the river as impaired was based on exceedances of bacterial water quality objectives for the water contact recreation beneficial use. The River is also listed as impaired due to excessive algae growth, known as eutrophication, which is caused by high nutrient (nitrogen and phosphorus) levels. Eutrophic waters can significantly alter dissolved oxygen and pH levels, which are critical to aquatic wildlife and can also impact recreational beneficial uses (see Chapter 5 for additional discussion).

3.2 Project Definition

The project is the adoption of a proposed Basin Plan amendment to establish a Total Maximum Daily Load (TMDL) and an Implementation Plan for controlling bacteria in the entire Petaluma River watershed, including the San Antonio Creek watershed. The Water Board is obligated under CWA section 303(d) to establish this TMDL for the river to address its bacterial impairment. This Draft Project Report includes an assessment of nutrients however, this project does not include a TMDL for nutrients. The following components form the basis of the proposed regulatory provision and define the project:

- Numeric targets for FIB in water column;
- Allocation of the allowable FIB concentrations to various source categories as load and wasteload allocations;
- A plan to implement a TMDL that includes actions to reduce bacteria loads to achieve load and wasteload allocations in Petaluma River; and
- A monitoring program to evaluate progress in meeting the bacteria numeric targets and load and wasteload allocations.

3.3 Project Objectives

The objectives of the proposed Basin plan amendment are consistent with the mission of the Water Board and the requirements of the CWA and Water Code (Porter-Cologne Water Quality Control Act). The objectives are to:

- Comply with the CWA requirement to adopt TMDLs for section 303(d)-listed water bodies;

- Protect existing beneficial uses in Petaluma River affected by high FIB levels (i.e., contact and non-contact water recreational uses);
- Set numeric targets to attain relevant water quality standards in Petaluma River;
- Avoid imposing regulatory requirements that are more stringent than necessary to meet numeric targets and attain water quality standards; and
- Attain relevant water quality standards in Petaluma River as quickly as feasible, by completing implementation of needed bacteria reduction measures in as short a time as is practicable.

4. WATER QUALITY STANDARDS

4.1 Overview

Under the authority of the CWA, the Water Board has established water quality standards for protecting beneficial uses of the water bodies within the Region. Water quality standards consist of: The beneficial uses of the water body in question, water quality objectives (numeric or narrative) to protect those beneficial uses, and the state of California's antidegradation policy, which requires continued maintenance of existing high-quality waters.

The Basin Plan contains specific water quality standards for bacteria, as well as for nutrients and related substances. The elements of the applicable bacteriological water quality standards for Petaluma River are described below in Section 4.2. The water quality standards and evaluation guidelines for nutrients or related substances are discussed in Section 4.3.

4.2 Bacteriological Water Quality Standards

4.2.1 Use of Fecal Indicator Bacteria (FIB) as Indicators of Fecal Pathogens

More than 100 types of pathogenic microorganisms can occur in water polluted by fecal matter and cause outbreaks of waterborne disease (Havelaar 1993). The detection and enumeration of all pathogens of human health concern is impractical. Many different pathogens can reside in a single water body, and organism-specific detection methods are costly and time consuming (U.S. EPA 2002). Therefore, FIB are commonly used to assess microbial water quality for recreational uses. Several types of FIB colonize the intestinal tracts of warm-blooded animals and are routinely shed in their feces. These organisms are not necessarily pathogenic but are abundant in waste from warm-blooded animals and are easily detected in the environment. The detection of FIB indicates that the environment is contaminated with fecal waste and that pathogenic organisms may be present.

Commonly used FIB include total coliform, fecal coliform, *Escherichia coli* (*E. coli*), and *Enterococcus*.

- Total coliform include several genera of bacteria commonly found in the intestines of warm-blooded animals. However, many types of coliform bacteria grow naturally in the environment—that is, outside the bodies of warm-blooded animals.
- Fecal coliform are a subset of total coliform and are more specific than total coliform to wastes from warm-blooded animals but are not unique to humans.
- *E. coli* are a subset of fecal coliform and are thought to be more closely related to the presence of human fecal pathogens than fecal coliform (U.S. EPA 2002).
- *Enterococcus* represents a different bacterial group from coliform and is also regarded to be a good indicator of fecal contamination from warm-blooded animal sources, especially in salt water (U.S. EPA 2002).

4.2.2 Microbial Source Tracking Techniques

Knowing the source(s) of bacteria in a water body is of great value in taking actions to reduce bacterial contamination. Microbial Source Tracking (MST) is a relatively new and developing methodology used to determine the source of fecal contamination in environmental samples. The main principal of the MST technique is to select a differentiable characteristic to identify various strains of bacteria associated with different sources.

MST methods are divided into three basic groups: chemical, phenotypic, and genotypic. Chemical methods detect compounds linked to human wastewater. It is assumed that if these chemicals (e.g., optical brighteners commonly present in laundry detergents) are detected, there must be a human wastewater source associated with the contamination of the water body. Phenotypic methods (e.g., antibiotic resistance analysis) detect the type and quantity of substances produced by fecal bacteria. Genotypic methods rely on the unique genetic characteristics of different strains of fecal bacteria. The distinctions between fecal bacteria from different animals (including humans) occur because of the differences between the diet and intestinal environments of their host animals. These bacteria have, therefore, developed differentiable characteristics that can be related to their sources.

There have been significant improvements in MST methods in recent years. However, at this point, no single MST method is capable of identifying specific bacterial sources and their contributions to the water quality impairment in all situations.

One of the newest and fast becoming popular MST methods is based on the genetic analysis of host-associated *Bacteroidales* bacteria. Bacteria of the *Bacteroidales* order are commonly found in the feces of humans and other warm-blooded animals. Therefore, the presence of *Bacteroidales* in water is an indication of fecal pollution and the possible presence of enteric pathogens. Since different host species (e.g., human, dog, horse, bovine) have different types of *Bacteroidales* associated with them, the detection of DNA from *Bacteroidales* bacteria in the environment can be used to determine the origin of the fecal pollution.

As later discussed in Section 7.2, the findings from a MST study conducted by the Water Board Staff in the Petaluma River have been used to help identify and assess potential contributing sources of bacteria in this project.

4.2.3 Beneficial Uses Impacted By Bacteria

The Basin Plan designates beneficial uses for each water body in the Region and the water quality objectives and implementation measures necessary to protect those uses. The designated beneficial uses of Petaluma River (and its tributaries) that could be negatively impacted (impaired) by high levels of fecal pathogens (as inferred from high concentrations of FIB) are water contact recreation (REC-1), and non-contact water recreation (REC-2) (Table 4.1).

Table 4.1. Beneficial Uses of Petaluma River Relevant to Bacteria TMDL	
Designated Beneficial Uses	**Description**
Water Contact Recreation (REC-1)	Uses of water for recreational activities involving body contact with water such that 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.
Non-contact Water Recreation (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, beach combing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

4.2.4 Bacteria Water Quality Objectives

The Basin Plan contains bacteria water quality objectives (objectives), shown in Table 4.2, to protect REC-1 and REC-2 uses. Objectives for REC-2 are less stringent than the water quality objectives for REC-1. Therefore, attainment of REC-1 objectives through the implementation of TMDL will also meet the objectives for REC-2. The goal of this TMDL is to restore and protect REC-1 and REC-2 beneficial uses by reducing the levels of fecal pathogens, as inferred from reduction in levels of FIB, in Petaluma River.

As shown in Table 4.2, the Basin Plan objectives currently include fecal coliform, total coliform, and *Enterococcus*. However, subsequent scientific studies have shown that *E. coli* and *Enterococcus* are more closely associated with human illness than are the other FIB. U.S. EPA has recommended States adopt objectives for bacteria based on *E. coli* and *Enterococcus*; and the State Water Resources Control Board (State Water Board) is in the process of adopting new objectives based on U.S. EPA's recommendations (https://www.waterboards.ca.gov/bacterialobjectives/), as further described below.

CWA section 304 requires U.S. EPA to develop criteria recommendations to aid states in developing water quality standards. In 2012, U.S. EPA issued new recommended Recreational Water Quality Criteria for bacteria indicators, reflecting the latest scientific knowledge and epidemiological investigations conducted at nine beaches from 2003 to 2009 (U.S. EPA 2012). Results of these investigations reaffirmed an association of *E. coli* and *Enterococcus* with gastrointestinal illness and found total and fecal coliform not highly associated with illness. U.S. EPA recommended criteria for fresh and marine waters are shown in Table 4.3.

Table 4.2. Basin Plan's Recreational Water Quality Objectives for Bacteria[a]			
Beneficial Use	**Fecal Coliform (MPN[b]/100 mL)**	**Total Coliform (MPN/100 mL)**	**Enterococcus (MPN/100mL)[c]**
Water Contact Recreation (REC-1)	Geometric Mean < 200 90^{th} percentile < 400	Median < 240 No sample > 10,000	Geometric Mean < 35 No sample > 104
Non-contact Water Recreation (REC-2)	Mean < 2000 90^{th} percentile < 4000	Not Available	Not Available

a. Based on a minimum of five consecutive samples equally spaced over a 30-day period.
b. Most Probable Number (MPN) is a statistical representation of the results of the standard coliform test.
c. Applicable to marine and estuarine waters only.

Table 4.3. U.S. EPA's Recreational Water Quality Criteria for Bacteria Being Considered for Adoption by State Water Board		
	Criteria Elements	
Indicator	**GM[a] (cfu[c]/100 mL)**	**STV[b] (cfu/100 mL)**
Enterococcus (marine & freshwater)	30	110
E. coli (freshwater only)	100	320

a. Geometric mean
b. Statistical threshold value
c. Colony forming unit per 100 milliliters of sample, which is equivalent to Most Probable Number (MPN) per 100 milliliters of sample.

Duration: The water body geometric mean value is calculated based on a minimum of five samples equally spaced over a six-week period. The water body Statistical Threshold Value is evaluated over a 30-day interval.

Frequency: The water body GM shall not be greater than the applicable GM magnitude in any six-week interval, calculated weekly. The applicable STV shall not be exceeded by more than 10 percent of the samples collected in a single month's time.

Attainment: To determine the attainment of the bacteria water quality standards, the GM values shall be applied based on a statistically sufficient number of samples, which is generally not less than five samples equally spaced over a six-week period. If a statistically sufficient number of samples are not available to calculate the GM, then attainment of the water quality standard shall be determined based on the STV.

4.2.5 Antidegradation

The federal antidegradation policy, found in the Code of Federal Regulations, title 40, section 131.12, requires that state water quality standards include an antidegradation policy consistent with the federal policy. The Basin Plan implements, and incorporates by reference, both the State and federal antidegradation policies, which are intended to protect beneficial uses and maintain the water quality necessary to sustain them. The State Water Board established California's antidegradation policy through State Water Board Resolution 68-16, "Statement of Policy with Respect to Maintaining High Quality Waters in

California," which is deemed to incorporate the federal antidegradation policy where the federal policy applies under federal law. Resolution 68-16 requires that existing water quality be maintained unless degradation is consistent with the maximum benefit to the citizens of California. The proposed TMDL for bacteria is not expected to degrade water quality, but instead to improve water quality by reducing the sources of fecal pathogens and thereby reducing incidences of FIB exceedances.

4.3 Nutrients Water Quality Standards

Sections below discuss relevant beneficial uses, narrative and numeric objectives, or evaluation guidelines for nutrients.

4.3.1. Beneficial Uses Impacted by Nutrients

As stated above, the Basin Plan specifies beneficial uses for water bodies in the San Francisco Bay Region. Table 4.4 lists the designated beneficial uses of the Petaluma River that can be impacted by nutrients.

Table 4.4. Beneficial Uses of Petaluma River Potentially Impacted by Nutrients

Designated Beneficial Uses	Description
Cold Water Habitat (COLD)	Uses of water that support cold water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. Cold freshwater habitats in the watershed support rainbow trout and diadromous steelhead fisheries.
Warm Water Habitat (WARM)	Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Fish Migration (MIGR)	Uses of water that support habitats necessary for migration, acclimatization between fresh water and saltwater, and protection of aquatic organisms that are temporary inhabitants of waters within the region.
Preservation of Rare and Endangered Species (RARE)	Uses of waters that support habitats necessary for the survival and successful maintenance of plant or animal species established under state and/or federal law as rare, threatened, or endangered.
Estuarine Habitat (EST)	Uses of water that support estuarine ecosystems, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds), and the propagation, sustenance, and migration of estuarine organisms. Estuarine habitat provides an essential and unique habitat that serves to

Table 4.4. Beneficial Uses of Petaluma River Potentially Impacted by Nutrients	
Designated Beneficial Uses	**Description**
	acclimate diadromous steelhead migrating into fresh or marine water conditions.
Fish Spawning (SPWN)	Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish are vital.
Wildlife Habitat (WILD)	Uses of waters that support wildlife habitats, including, but not limited to, the preservation and enhancement of vegetation and prey species used by wildlife, such as waterfowl. The two most important types of wildlife habitat are riparian and wetland habitats.
Navigation (NAV)	Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

4.3.2 Nutrients Water Quality Objectives and Evaluation Guidelines

Currently, there are very few numeric objectives for evaluating nutrient levels and eutrophication. Table 4.5 specifically lists the beneficial uses that could be affected by nutrients and associated objectives or evaluations guidelines. It is important to note that evaluation guidelines are not established objectives, but, rather, are peer-reviewed thresholds used as guidance to inform consideration as to whether the relevant narrative objectives are being achieved. All these evaluation guidelines are to be evaluated in an instantaneous manner. Sections below discuss these objectives and evaluation guidelines.

Table 4.5. Applicable Water Quality Objectives or Evaluation Guidelines for Nutrients and Associated Beneficial Uses			
Beneficial Use	**Analyte**	**Water Quality Objective [1]**	**Evaluation Guideline***
WARM, COLD, WILD, RARE	Total ammonia (Chronic)		0.38-3.30 mg/L [2]
COLD	Benthic biomass (Ash free dry weight)	Biostimulatory substances narrative	60 g/m^2 [3]
WARM	Benthic biomass (Ash free dry weight)	Biostimulatory substances narrative	80 g/m^2 [3]
REC-1, REC-2, WARM, COLD	Percent macroalgae cover	Biostimulatory substances narrative	30% filamentous cover [4]
COLD	Benthic chlorophyll *a*	Biostimulatory substances narrative	BURC II/III boundary < 150 mg/m^2 [3]
WARM	Benthic chlorophyll *a*	Biostimulatory substances narrative	BURC II/III boundary < 200 mg/m^2 [3]
WARM, COLD, WILD, RARE	Water column chlorophyll *a*	Biostimulatory substances narrative	15 µg/L [5]
WARM	Dissolved Oxygen [6]	5.0 mg/L	
COLD	Dissolved Oxygen	7.0 mg/L	
Generally applicable	pH	6.5 -8.5	

[1] *The San Francisco Bay Basin (Region 2) Water Quality Control Plan* (Water Board 2018)
[2] *2013 Aquatic Life Ambient Water Quality Criteria for Ammonia* – Freshwater EPA-822-R-13-001 (U.S. EPA 2013)
[3] *Technical Approach to Develop Nutrient Numeric Endpoints for California* (Tetra Tech 2006). BURC stands for beneficial use risk categories. These chlorophyll *a* values correspond to the BURC II/III boundary representing a threshold above which the risk of beneficial use impairment by nutrients is probable.
[4] *New Zealand periphyton guideline: Detecting, monitoring and managing enrichment of stream.* (Biggs 2000)
[5] *Interpreting Narrative Objectives for Biostimulatory Substances for California Central Coast Waters* (Central Coast Water Board 2010)
[6] Dissolved oxygen is used as a secondary indicator of beneficial uses impairment due to excessive nutrients and algal growth.
* Note: Evaluation Guidelines are used as numeric thresholds when numeric Water Quality Objectives are lacking.

U.S. EPA Office of Water has released recommended criteria for total ammonia to protect aquatic life beneficial uses to address toxicity due to un-ionized ammonia in freshwater (U.S. EPA 2013). U.S. EPA put forward both an acute and a chronic criterion which requires an assessment of total ammonia concentrations along with water pH and temperature because the toxic form of ammonia, the un-ionized fraction, depends on those parameters. The acute toxicity criterion is, by definition, higher than the chronic criterion, so if the chronic criterion is not exceeded; neither would be the acute criterion.

The Basin Plan's (Water Board 2018) narrative water quality objective for *biostimulatory substances* states that water bodies "shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses." This objective applies to nutrients, since eutrophication is synonymous with nutrient-induced biostimulation. Nutrient-induced biostimulation, or eutrophication, impairs aquatic habitat uses through broad impacts on the entire biological community. This objective also applies to impairment of recreational uses (primarily through the negative aesthetic effects of excessive algal growth), or aquatic life uses (though the impacts of algae on habitat quality).

The biostimulatory substances narrative water quality objective can be evaluated using four numeric thresholds related to algal biomass. Tetra Tech modeled the relationships between nutrients and benthic algae cover (Tetra Tech 2006). This effort resulted in statewide numeric guidance, called beneficial use risk category (BURC) thresholds. The first numeric threshold (150 mg/m^2) is based on benthic chlorophyll *a* levels for the Cold Freshwater Habitat beneficial use, which is more protective than the chlorophyll *a* threshold for Warm Freshwater Habitat beneficial use (200 mg/m^2). The same threshold was also used in the Ventura River Nutrients TMDL (Los Angeles Water Board 2012). However, a recent study by U.S. EPA (2014) showed that lower thresholds might be more appropriate for California streams. The development of appropriate freshwater nutrient numeric endpoints is a State Water Board-led effort to establish numeric criteria to evaluate nuisance algae conditions caused by eutrophication. Additionally, Tetra Tech also developed a corresponding benthic biomass threshold based on the benthic biomass ash-free dry weight. Levels of benthic biomass ash-free dry weight above 60 g/m^2 and 80 mg/m^2 are considered to be impairing for Cold and Warm Freshwater Habitats, respectively (Table 4.5).

The third numeric threshold related to the biostimulatory narrative objective was based on percent cover of filamentous algae (macroalgae). There is not a clearly established percent cover threshold described by Tetra Tech (2006), but the report references two papers that discussed such thresholds. Biggs (2000) recommended a 30 percent cover by filamentous green or brown algae, which was associated with benthic chlorophyll *a* values of approximately 120 mg/m^2, in order to protect recreation and fisheries. Additionally, Quinn (1991) used a 40 percent cover threshold to protect recreation and aesthetics. Tetra Tech used 20 percent filamentous cover to set the chlorophyll *a* threshold (Tetra Tech 2006). The Water Board set the evaluation guideline threshold to 30% filamentous algae cover when assessing nutrient impairment in the Napa River and Sonoma Creek (Water Board 2014). Therefore, the evaluation guideline for this assessment was set at 30 percent filamentous algae cover.

The fourth direct numeric threshold relates to the biostimulatory narrative objective for the water column chlorophyll *a* metric. Water column chlorophyll *a* measures the amount of algae growing in the water column, which are called phytoplankton. There are no formal criteria for evaluating this indicator, so we relied on an evaluation guideline published by the Central Coast Water Board (Central Coast Water Board 2013) of 15 μg/L, which is also the same threshold used by North Carolina to protect trout-supporting (cold water) water bodies and Oregon to determine nuisance levels. This concentration was derived by the Central Coast Water Board by investigating sites known to be impacted by nutrients and reference conditions which did not have excessive levels of nutrients.

In addition to the above water quality objectives and guidelines used for direct evaluation of nutrients impairments, Table 4.5 also lists objectives for dissolved oxygen and pH that are used to indirectly evaluate impairment of beneficial uses due to excessive nutrients and algal growth.

Additional evaluation guidelines related to dissolved oxygen and pH, listed in Table 5.6, have to do with the magnitude of daily swings in the levels of these analytes. Daily fluctuations of dissolved oxygen or pH magnitudes greater than 5 mg/L or 1 unit, respectively, is indicative of severely eutrophic waters and, therefore, can be used to evaluate impairments due to excessive nutrients (Water Board 2014). These guidelines are used to further evaluate impairment of the Petaluma River by nutrients.

A number of nutrient analytes (i.e., total phosphorus, total nitrogen, and orthophosphate) that were collected as part of the water quality monitoring of the river and its tributaries lack numeric guidance or the existing numeric guidance is unsuitable for this region. U.S. EPA provided guidance on eutrophication thresholds by setting benchmarks for total nitrogen and total phosphorus for the western U.S. using the 25th percentile method of available data (U.S. EPA 2000a). The numeric guidance for subregion 6, which covers the Petaluma River watershed, was 0.518 mg/L for total nitrogen (TN) and 0.03 mg/L for total phosphorus (TP). However, nutrient data collected from reference streams (streams with minimal anthropogenic stress in the watershed) within the San Francisco Bay Area showed frequent exceedances of these benchmarks, demonstrating that these are not suitable criteria for reference conditions in the Bay Area (Water Board 2012). Therefore, in the absence of vetted numeric guidance, TP and TN were not compared to specific thresholds in this impairment assessment. Further, neither the Basin Plan (Water Board 2018) nor the California Toxics Rule (U.S. EPA 2000b) provide any guidelines for phosphate (PO_4^{3-}), so this analyte was also not used in the evaluation of the nutrient impairment. Nonetheless, the nitrogen and phosphorous data are analyzed and summarized in section 4.7 for supplementary purposes.

5. IMPAIREMENT ASSESSMENT

5.1 Overview

This chapter summarizes and discusses the results from the studies used to evaluate bacteria and nutrient water quality impairments in the Petaluma River watershed. The bacteria water quality impairment and results are discussed first. The water quality monitoring results used to assess nutrients impairment are discussed second.

5.2 Bacteria Water Quality Impairment Assessment

The entire Petaluma River, including the tidal portion at the mouth, is listed as an impaired water body under CWA section 303(d) due to high FIB levels. The listing of the river as impaired is based on exceedances of bacterial water quality objectives for recreational beneficial uses. The sections below summarize the bacteriological data used to evaluate the current status of the bacteria impairment.

5.2.1 Fecal Indicator Bacteria (E. coli) Monitoring Study (2015-2016)

From winter 2015 through summer 2016, Water Board Staff conducted a FIB (*E. coli*) water quality monitoring study within the Petaluma River watershed to evaluate the current state of bacterial impairment of the river. The study collected *E. coli* samples at 16 stations along both the main stem and tributaries of Petaluma River (Figure 5.1, Table 5.1). It included five-consecutive-week sampling series in each of winter, spring, and summer seasons of 2015 and 2016, for a total of 30 sampling events. All raw data from this study will be stored in CEDEN (ceden.org).

Table 5.2 and Figures 5.2-5.4 summarize the *E. coli* monitoring data collected during this study. These data were analyzed using the following protocol. Geometric means of *E. coli* concentrations were calculated for each five-week series and values were compared to U.S. EPA's geometric mean criterion for *E. coli* of 100 MPN/100 mL (Table 4.3). All values exceeding the criterion were counted as exceedances and were divided by the total number of geometric means to determine percent exceedances.

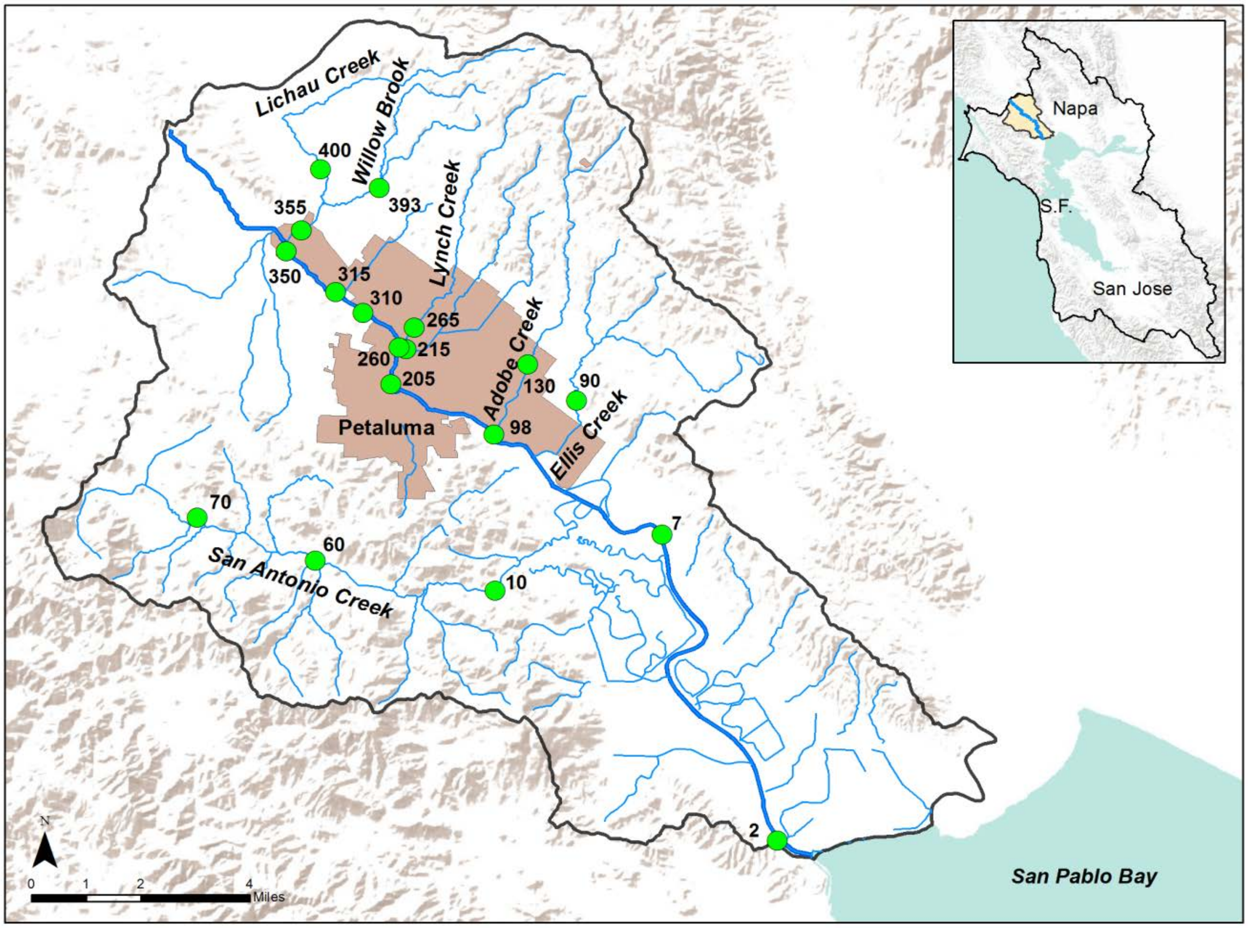

Figure 5.1. Water quality sampling stations in the Petaluma River Watershed.

Table 5.1. Water Quality Monitoring Stations in Petaluma River Watershed				
Station Code	**Station Name**	**Station Description**	**Latitude**	**Longitude**
206PET400	Lichau-400	Lichau Creek - at Penngrove Park	38.294312	-122.666254
206PET393	Willow-393	Willow Brook - 890m upstream of Lichau Creek confluence	38.285731	-122.65625
206PET355	Lichau-355	Lichau Creek - at N McDowell Blvd 650m upstream of Petaluma River confluence	38.277545	-122.672016
206PET350	Pet-350	Petaluma River - 715m upstream of Petaluma Blvd N bridge. Just downstream of Rainsville Rd bridge	38.271718	-122.676919
206PET315	Pet-315	Petaluma River - Just downstream of Corona Rd Bridge	38.26098	-122.65982
206PET310	Pet-310	Petaluma River - Petaluma Village Premium Outlet Mall, just downstream of bridge leading into mall	38.25539	-122.650371
206PET265	Lynch-265	Lynch Creek 591m upstream of Petaluma River confluence	38.25174	-122.633153
206PET260	Pet-260	Petaluma River - 100m upstream of Payran Street bridge	38.246232	-122.637995
206PET215	Trib-215	Unnamed Creek - 220m upstream of confluence with Pet River, 60m below Ellis St bridge	38.2458	-122.635577
206PET205	Pet-205	Petaluma River - Just upstream of E. Washington St bridge	38.236157	-122.640363
206PET130	Adobe-130	Adobe Creek - Ely Blvd crossing, near Fairway Meadows Golf Course	38.242536	-122.594417
206PET098	Pet-98	Petaluma River - 100m downstream of confluence with Adobe Creek	38.223164	-122.605189
206PET090	Ellis-90	Ellis Creek - 1.7mi upstream of Petaluma River confluence. At Ely Rd crossing.	38.233155	-122.577665
206PET070	San A.-70	San Antonio Creek - Just downstream of Chileno Valley Rd bridge crossing	38.19838	-122.704343
206PET060	San A.-60	San Antonio Creek - Just downstream of Point Reyes Petaluma Rd bridge crossing	38.187549	-122.664172
206PET010	San A.-10	San Antonio Creek- upstream of San Antonio Rd bridge crossing	38.180759	-122.60322
206PET007	Pet-7	Petaluma River - Lakeville Marina dock	38.197109	-122.547627
206PET002	Pet-2	Petaluma River - Black Point Boat Lunch dock	38.114621	-122.506072

The State's Water Quality Control Policy for developing California's Clean Water Act Section 303(d) List (Listing Policy) specifies that a water segment shall be placed on the section 303(d) list if bacteria water quality standards in the California Code of Regulations, Basin Plans, or statewide water quality control plans are exceeded more than 10 percent of the time, (assuming that water quality monitoring is conducted in both dry and wet seasons) (State Water Board 2015, Table 3.2). *E. coli* geometric mean data from each sampling station exceeded bacteria water quality standards more than the requisite 10 percent of the time.

Table 5.2. Summary of Exceedances of *E. coli* Geometric Mean Objective for Petaluma River (Winter 2015 - Summer 2016)			
Sampling Station	**Number of Values**	**Number of Exceedances**	**Percent Exceedance**
Lichau-400	6	4	67%
Willow-393	4	4	100%
Lichau-355	5	4	80%
Pet-350	5	4	80%
Pet-315	6	5	83%
Pet-310	6	4	67%
Lynch-265	6	5	83%
Pet-260	6	6	100%
Trib-215	6	4	67%
Pet-205	6	6	100%
Adobe-130	4	3	75%
Pet-98	6	6	100%
Ellis-90	5	5	100%
San A.-70	5	5	100%
San A.-60	5	5	100%
San A.-10	5	5	100%

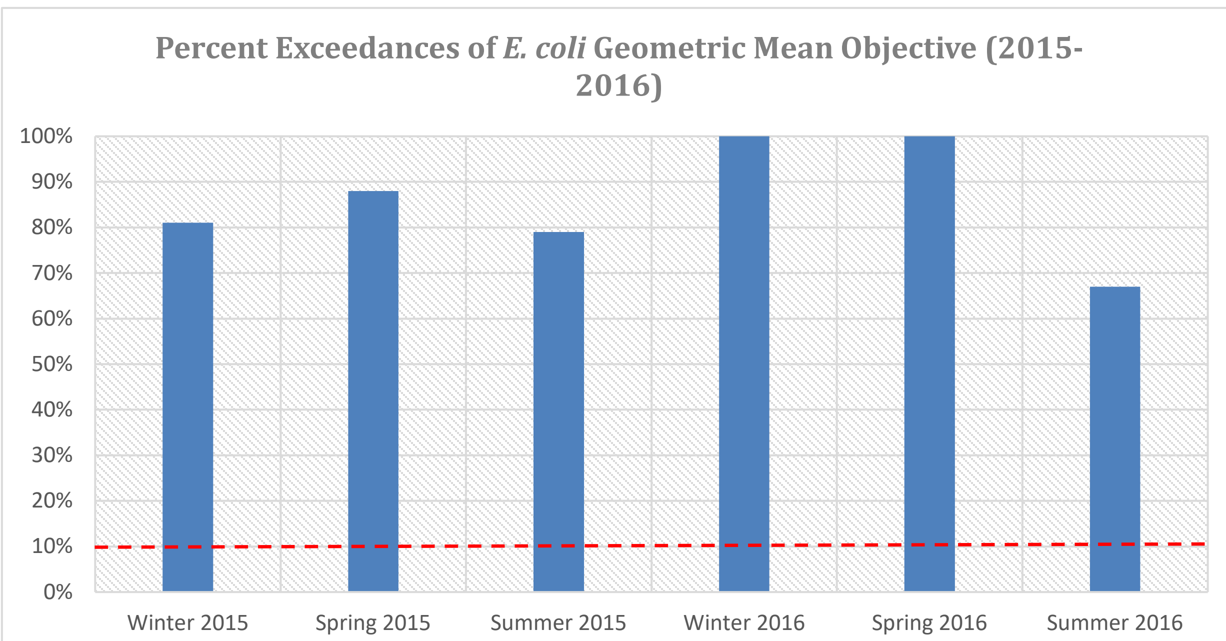

Figure 5.2. Seasonal exceedances of *E. coli g*eometric mean objective for all stations. The allowable exceedance frequency (10%) from the Listing Policy is represented by the red dashed line.

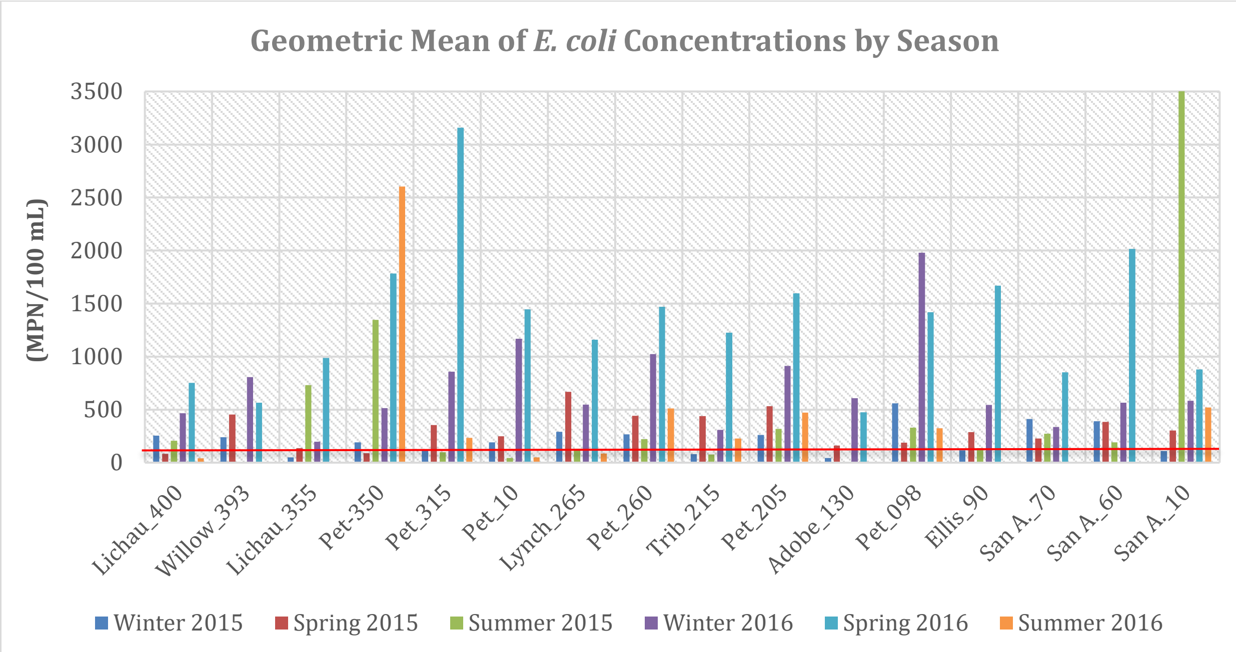

Figure 5.3. Geometric mean of *E. coli* concentrations. The red horizontal line represents the applicable water quality objective (100 MPN/100 mL).

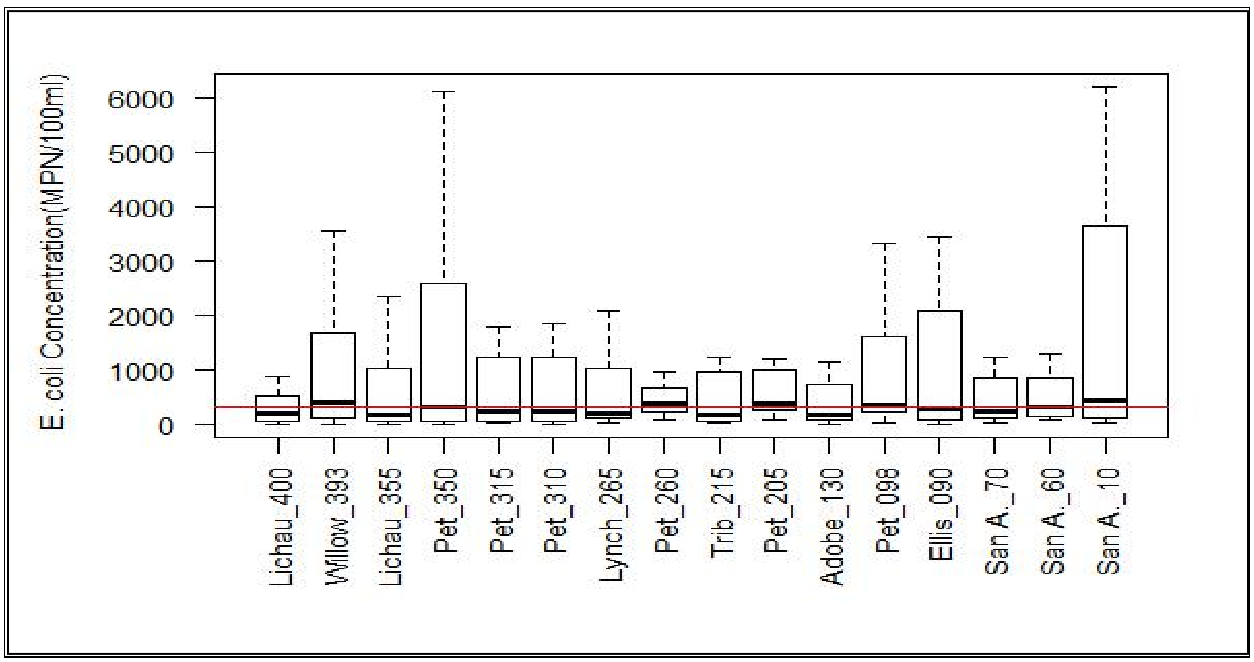

Figure 5.4. Box Plot of *E. coli* single sample concentrations by sampling station (2015-2016). Boxes represent 25^{th}-75^{th} percentiles (interquartile range-IQR). Bold line inside the box represents median or 50^{th} percentile. Upper whisker represents top of the box plus 1.5 times the IQR. Lower whisker represents bottom of the box minus 1.5 times the IQR.

5.2.2 Fecal Indicator Bacteria (Enterococcus) Monitoring Study (2017-2018)

As mentioned before, *Enterococcus* is a better FIB in the saline/estuarine waters. So, to better evaluate the bacterial water quality in the tidal (saline) portion of the Petaluma River, Water Board Staff also collected *Enterococcus* samples at six stations along this portion of the river (Figure 5.1). The sampling was conducted during three five-consecutive-week sampling series in winter and summer 2017 and winter 2018. All raw data from this study will be stored in CEDEN (ceden.org).

Table 5.3 and Figures 5.5 & 5.6 summarize the *Enterococcus* data. These data were analyzed using the same protocol used for the *E. coli* data discussed above.

Table 5.3. Summary of Exceedances of *Enterococcus* Geometric Mean Objective for Petaluma River (2017-2018)

Sampling Station	Number of Values	Number of Exceedances	Percent Exceedance
Pet-310	3	3	100%
Pet-260	3	3	100%
Pet-205	3	3	100%
Pet-98	3	3	100%
Pet-7	3	1	33%
Pet-2	3	2	66%

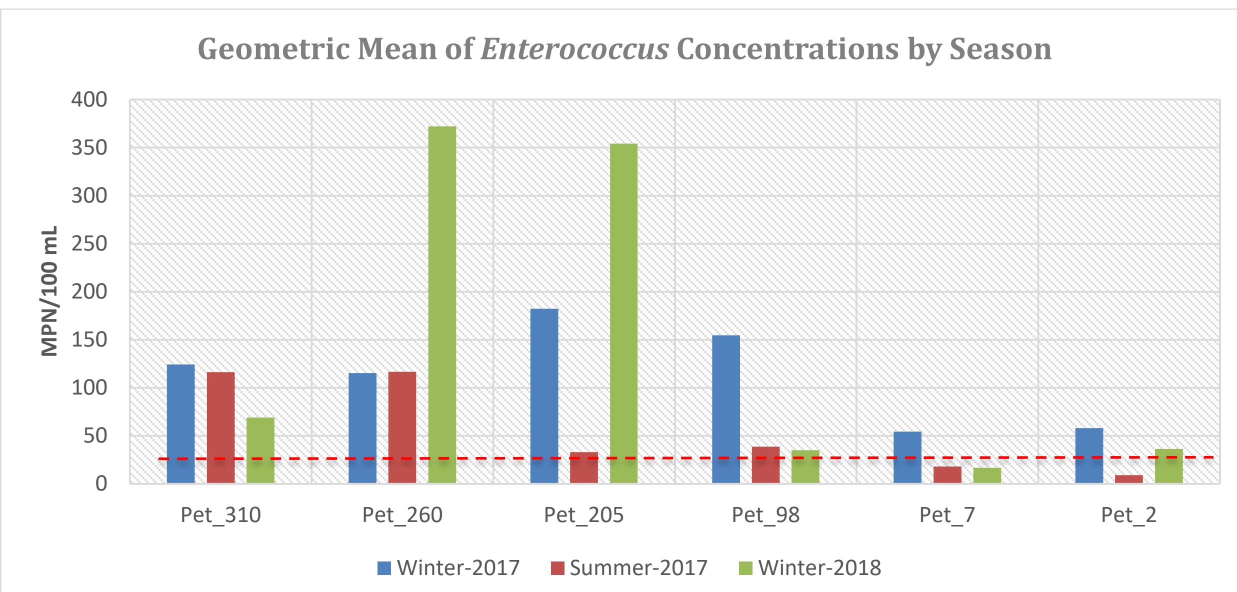

Figure 5.5. Geometric mean of *Enterococcus* concentrations. The red dashed line represents the applicable water quality objective (30 MPN/100 mL).

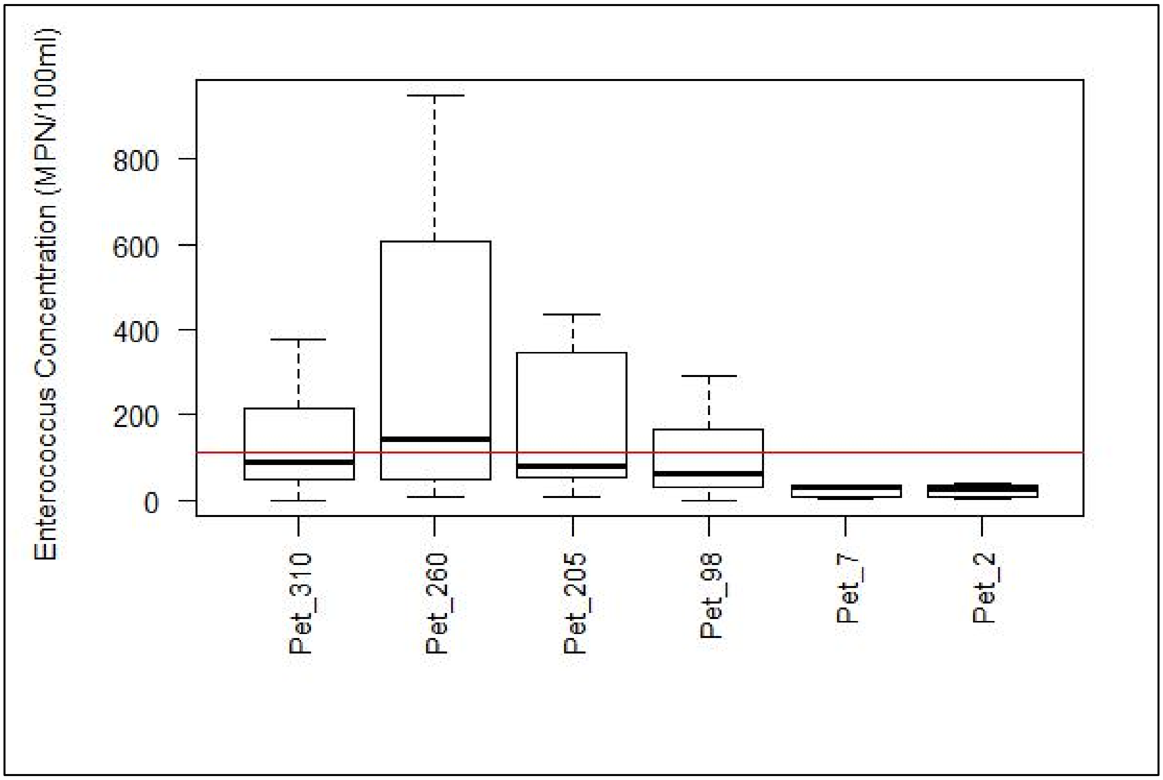

Figure 5.6. Box Plot of *Enterococcus* single sample concentrations by sampling station (2017-2018)

Enterococcus concentrations from each sampling station exceeded bacteria water quality objectives more than the requisite 10 percent of the time in both seasons. However, the *Enterococcus* concentrations showed a decrease in magnitude from up (more developed) to downstream (less developed) sites.

5.2.3 Bacteria Water Quality Impairment Assessment Conclusion

Based on the result of the recent bacterial water quality monitoring, Petaluma River and its tributaries are still impaired due to exceedances of bacterial water quality standards for water contact recreation uses. Further, as illustrated by Figures 5.2-5.6, the data show the impairment is both temporally and spatially widespread in main stem and all sampled tributaries.

Further, we will use the findings from this impairment assessment to add San Antonio Creek to the 303(d) list of impaired water bodies in a future listing effort.

5.3 Nutrient Water Quality Impairment Assessment

Petaluma River has been listed as an impaired water body under CWA section 303(d) due to nutrients, since 1980's. The listing of the river as impaired was based on signs of excess algal growth (eutrophication), which can be caused by excess nutrient levels. The sections below summarize the recent water quality data used to evaluate the current status of the nutrient impairment.

5.3.1 Background

Water quality impairment from nutrients is usually associated with excess concentrations of nitrogen and phosphorus, as these are usually growth-limiting factors in freshwaters. The primary consequence of excess nutrients is eutrophication, the stimulation of excessive algae or weedy plant growth. Algae blooms often occur in the form of large floating mats of filamentous algae, but excessive algae can also grow on the stream bottom (e.g., benthic algae). Algae blooms can cause severe changes in dissolved oxygen and pH, significantly affecting aquatic life beneficial uses. Furthermore, certain types of algae (e.g., cyanobacteria) can produce toxins that are harmful to wildlife, domestic animals, and humans. Additionally, nuisance algae levels can impair recreation-based beneficial uses by producing strong decaying odors or preventing suitable swimming conditions. Understanding the levels and behavior of nitrogen and phosphorus in water bodies is an important step in preventing eutrophic conditions.

While high nutrient loads often result in nuisance algae growth, a number of other variables, such as sunlight, water temperature, and stream velocity, also influence the levels of algae observed in water bodies. The complex causes and results of excessive algae growth are described in detail in *Conceptual Approach for Developing Nutrient TMDLs for San Francisco Bay Area Waterbodies* (Water Board 2003).

Eutrophication drivers vary to a great extent from location to location, which complicates efforts to predict algae growth and underscores the need to collect site-specific data. Also, the environmental factors that promote algal growth can occur downstream from the source of nutrients, and therefore, the presence of algae does not necessarily indicate a source of nutrients at the area the algae is observed.

Conditions that tend to support eutrophication, such as sufficient light, low flows, and higher temperatures occur during the dry spring and summer months, and act together with dry weather loads of nitrate and orthophosphate to effect algae growth. Loads of nitrate and orthophosphate during the wet winter months rapidly flow out of the watershed to the Bay and do not contribute, or contribute only minimally, to algal growth observed in the spring and summer.

Oxygen depletion is an important effect of excessive algal growth due to its direct negative impact on aquatic life. Most native aquatic organisms found in streams are adapted to high levels of dissolved oxygen, and when oxygen levels fall, these organisms must either leave the system or die. Factors that consume oxygen in aquatic systems include decomposition, biological oxidation of ammonia to nitrate (nitrification), and respiration. In pristine streams these processes are fairly slow relative to reoxygenation from the atmosphere, and dissolved oxygen levels remain near equilibrium with the atmosphere – that is, near 100 percent saturation. By contrast, excessive nutrient loading can drastically accelerate algal-related oxygen-consuming processes, respiration by living algal cells, and decomposition of dead algal material, causing severe oxygen depletion in the night time or very early morning.

Periphyton (benthic algae) growth in Bay Area streams occurs primarily from late spring though early autumn (Water Board 2012). This is the period when temperatures and light levels are optimal for algal growth, and when scouring high flow conditions are absent.

Even in the absence of statewide objectives, it is still possible to characterize impairment through qualitative or semi-quantitative observation of filamentous algae mats. It has been reported that the range of quantitative targets mentioned above correlates with approximately 30% stream cover by filamentous algae (Welch et al. 1988, Biggs, 2000, Tetra Tech 2006).

The causal relationship between nutrient concentrations and periphyton growth is complex and site-specific. For this reason, definitive nutrient concentration targets have not been developed. However, Tetra Tech has developed modeling tools, calibrated to California data, that can be used to provide provisional screening-level nutrient targets under conditions of slow flow, shallow water depth, adequate sunlight and warmer weather (Tetra Tech, 2006).

5.3.2 Nutrient Water Quality Results

Sections below summarize and discuss historical and recent nutrients and other associated data collected in the Petaluma River watershed.

5.3.2.1 Historical Data Summary

There are two sets of historical nutrient data available for the river. One is the long-term ammonia data collected from 2005 through present by the Ellis Creek Wastewater Treatment Plant upstream of their effluent discharge outfall in the river. The other is the nutrients data collected in 2003 by the Water Board’s Surface Water Ambient Monitoring Program (SWAMP) at seven sites located mainly on the Petaluma River tributaries.

The results of the long-term ammonia monitoring can be used to show ambient nutrient levels over time. These data show a steady decline in the concentrations of ammonia in the river from 2005 to present (Figure 5.7).

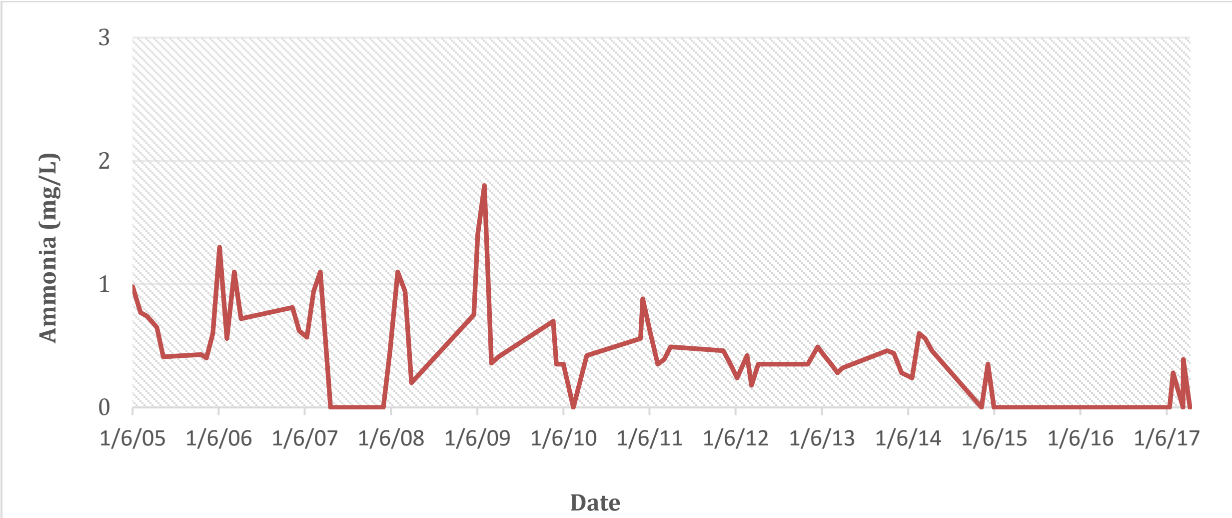

Figure 5.7. Ellis Creek Wastewater Treatment Plant long-term ambient ammonia monitoring data from a site 500 feet above their effluent discharge outfall in the Petaluma River.

A comparison of the 2003 SWAMP data to the recent data collected by the Water Board staff at 5 overlapping sites (Pet_400, Pet_310, Lynch_265, Adobe_130, and San A._10) from 2014-16 indicates no significant change in the level of other constituents (Figure 5.8).

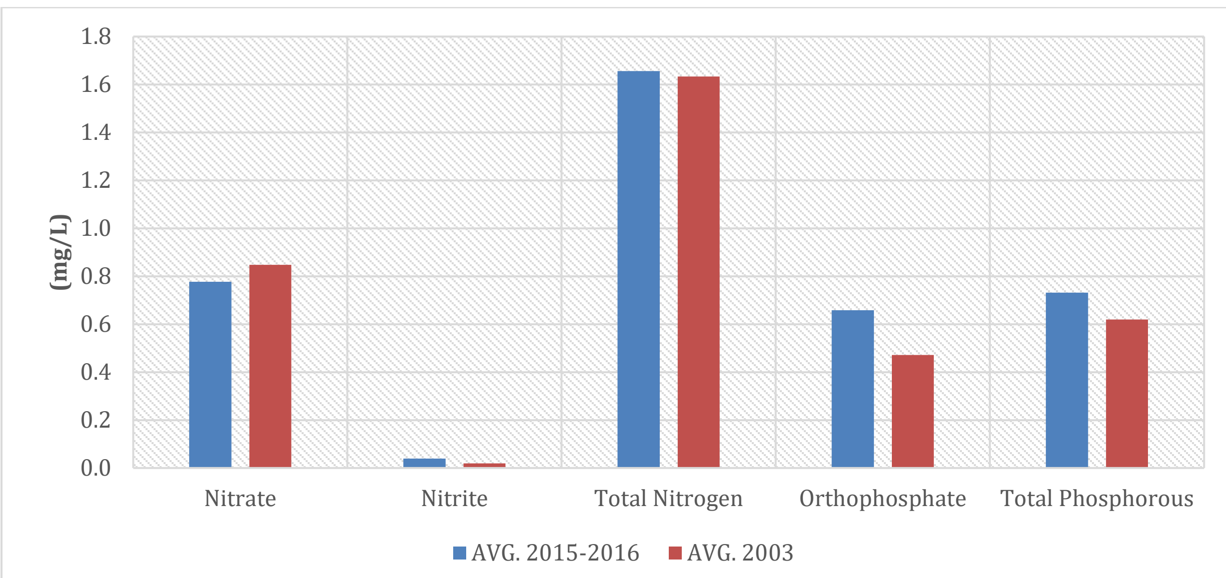

Figure 5.8. Comparison of 2003 nutrient data to 2014-2016 nutrient data.

5.3.2.2 Recent Data Summary

To evaluate current status of nutrients impairment in the Petaluma River and its tributaries, and evaluate potential changes in conditions, Water Board staff collected nutrients data (nitrogen, nitrate, nitrite, ammonia, phosphorous, orthophosphate), from the same 16 sampling stations used for the bacteria monitoring, during 7 separate events in winter 2014, and winter, spring, and summer of 2015 and 2016. In addition, staff collected algae data (benthic algal biomass, benthic chlorophyll *a*, water column chlorophyll *a*, and percent macroalgae cover), from nine of the 16 stations in April or May 2016. Lastly, pH and dissolved oxygen levels were continuously monitored at five stations from April to September 2016 (data collection at station 206PET010 continued beyond September; however, for consistency considerations, only the data collected up to September were used in the analyses). Table 5.4 lists the inventory of the data collected by the Water Board staff for evaluating the nutrients impairment of the river. Table 5.5 contains the algae/biomass data.

Table 5.6 lists the applicable water quality objectives or numeric evaluation guidelines and the number and percent of samples/data points exceeding them. The benthic algal biomass (ash free dry mass) threshold for COLD beneficial use was exceeded in three of nine or 33% of the samples. The percent macroalgae cover was exceeded in one of nine or 11% of the samples. Instantaneous dissolved oxygen levels thresholds for COLD and WARM beneficial uses were exceeded in 88% and 72% of the data points, respectively. The 7-day average of minimum values of dissolved oxygen thresholds for COLD and WARM beneficial uses were exceeded in 84% and 79% of the data points, respectively. Further, the threshold for daily dissolved oxygen change was exceeded in 12% of the collected values. Figure 5.9 shows the daily changes of dissolved oxygen levels for the two sites with the highest observed fluctuations, sites PET-60 and PET-90. These sites exceeded the daily dissolved oxygen swing threshold 32% and 57% of the times, respectively.

All other objectives or guidelines were met by all samples/data points.

Table 5.4. Inventory of Nutrients and Related Water Quality Data Collected in the Petaluma River Watershed				
Sampling Station	**Station Description**	**Sampling Dates**	**Number of Sampling Events**	**Constituent(s)**
Lichau_400	Lichau Creek-upstream	Nutrients: 4/29/14-7/19/16 Algae: 5/10/16 pH, DO: 4/25/16-7/20/16	6 1 Continuous	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW*), % Macroalgae Cover; -pH, Dissolved Oxygen
Willow_393	Willow Brook	Nutrients: 4/29/14-7/19/16	6	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate
Lychau_355	Lichau Creek-downstream	Nutrients: 4/29/14-7/19/16 Algae: 5/12/16	6 1	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW), % Macroalgae Cover
Pet_350	Mainstem #1, Non-tidal	Nutrients: 4/29/14-7/19/16	6	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate
Pet_315	Mainstem #2, Non-tidal	Nutrients: 4/29/14-7/19/16	6	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate
Pet_310	Mainstem #3, Tidal	Nutrients: 4/29/14-7/19/16 pH, DO: 4/25/16-9/1/16	6 Continuous	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -pH, Dissolved Oxygen
Lynch_265	Lynch Creek	Nutrients: 4/29/14-7/19/16 Algae: 5/9/16	6 1	-Nitrite, Nitrate, Total Nitrogen, Ammonia, -Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW), % Macroalgae Cover
Pet_260	Mainstem #4, Tidal	Nutrients: 4/29/14-7/19/16	6	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate
Trib_215	Unnamed Tributary	Nutrients: 4/29/14-7/19/16 Algae: 5/5/16 pH, DO: 5/5/16-9/1/16	6 1 Continuous	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW), % Macroalgae Cover; -pH, Dissolved Oxygen

Table 5.4. Inventory of Nutrients and Related Water Quality Data Collected in the Petaluma River Watershed				
Pet_205	Mainstem #5, Tidal	Nutrients: 4/29/14-7/19/16	6	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate
Adobe_130	Adobe Creek	Nutrients: 4/29/14-7/19/16 Algae: 4/26/16	6 1	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW), % Macroalgae Cover
Pet_098	Mainstem #6, Tidal	Nutrients: 4/29/14-7/19/16	6	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate
Ellis_90	Ellis Creek	Nutrients: 4/29/14-7/19/16 Algae: 4/28/16 pH, DO: 4/25/16-6/10/16	6 1 Continuous	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW), % Macroalgae Cover; -pH, Dissolved Oxygen
San Ant._70	San Antonio-Upstream	Nutrients: 4/29/14-7/19/16 Algae: 5/3/16	6 1	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW), % Macroalgae Cover
San Ant._60	San Antonio-Middlestream	Nutrients: 4/29/14-7/19/16 Algae: 5/4/16 pH, DO: 4/25/16-7/7/16	6 1 Continuous	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW), % Macroalgae Cover; -pH, Dissolved Oxygen
San Ant._10	San Antonio-Downstream	Nutrients: 4/29/14-7/19/16 Algae: 5/2/16	6 1	-Nitrite, Nitrate, Total Nitrogen, Ammonia, Phosphorous, Orthophosphate; -Water column Chl-a, Benthic Chl-a, Benthic biomass (AFDW), % Macroalgae Cover

*AFDW (ash free dry weight) is a method in which the collected biomass is dried and oxidized (ashed) in a furnace at high temperature and re-weighed. The loss upon oxidation is referred to as AFDW.

Table 5.5. Algae Data from Petaluma River Watershed					
Sampling Station	**Sampling Date**	**Water Column Chl-a (µg/L)**	**Benthic Chl-a (mg/m²)**	**Benthic Biomass (AFDW) (g/m²)**	**Percent Presence of Macroalgae (%)**
Lichau_400	10/May/2016	7.0	39.8	19.2	1
Lichau_355	12/May/2016	9.1	67.5	85.1	13
Lynch_265	09/May/2016	1.0	17.4	17.7	0
Trib_215	05/May/2016	14.0	40.2	105.0	27
Adobe_130	26/Apr/2016	ND*	4.9	5.2	0
Ellis_90	28/Apr/2016	4.0	26.1	120.0	61
San Ant._70	03/May/2016	2.0	45.6	20.2	0
San Ant._60	04/May/2016	3.0	79.3	45.2	21
San Ant._10	02/May/2016	ND*	12.2	28.8	0

*Detection limit was 0.2 µg/L for station 206PET010, and 0.4 µg/L for station 206PET130.

Table 5.6. Petaluma River Summary of Exceedances of Numeric Evaluation Guidelines			
Analyte	**Numeric Evaluation Guideline**	**Number & Percent of Exceedances**	**Metric Type**
Benthic biomass (Ash free dry weight) (COLD)	60 g/m^2	(3/9) = 33%	Evaluation Guideline
Percent macroalgae cover	30%	(1/9) = 11%	Evaluation Guideline
Benthic chlorophyll *a* (COLD)	150 mg/m^2	(0/9) = 0%	Evaluation Guideline
Water column chlorophyll *a*	15 µg/L	(0/9) = 0%	Evaluation Guideline
Total ammonia (Chronic)	0.38-3.30 mg/L	(0/108) = 0%	U.S. EPA Criterion
pH-Instantaneous	6.5-8.5 units	(1/41797) = 0.002%	Water Quality Objective
Dissolved oxygen-Instantaneous (WARM)	5.0 mg/L	(30254/41797) = 72%	Water Quality Objective
Dissolved oxygen-Instantaneous (COLD)	7.0 mg/L	(36762/41797) = 88%	Water Quality Objective
Daily dissolved oxygen change	< 5 mg/L	(55/444) = 12%	Evaluation Guideline
Daily pH change	< 1 unit	(0/444) = 0%	Evaluation Guideline

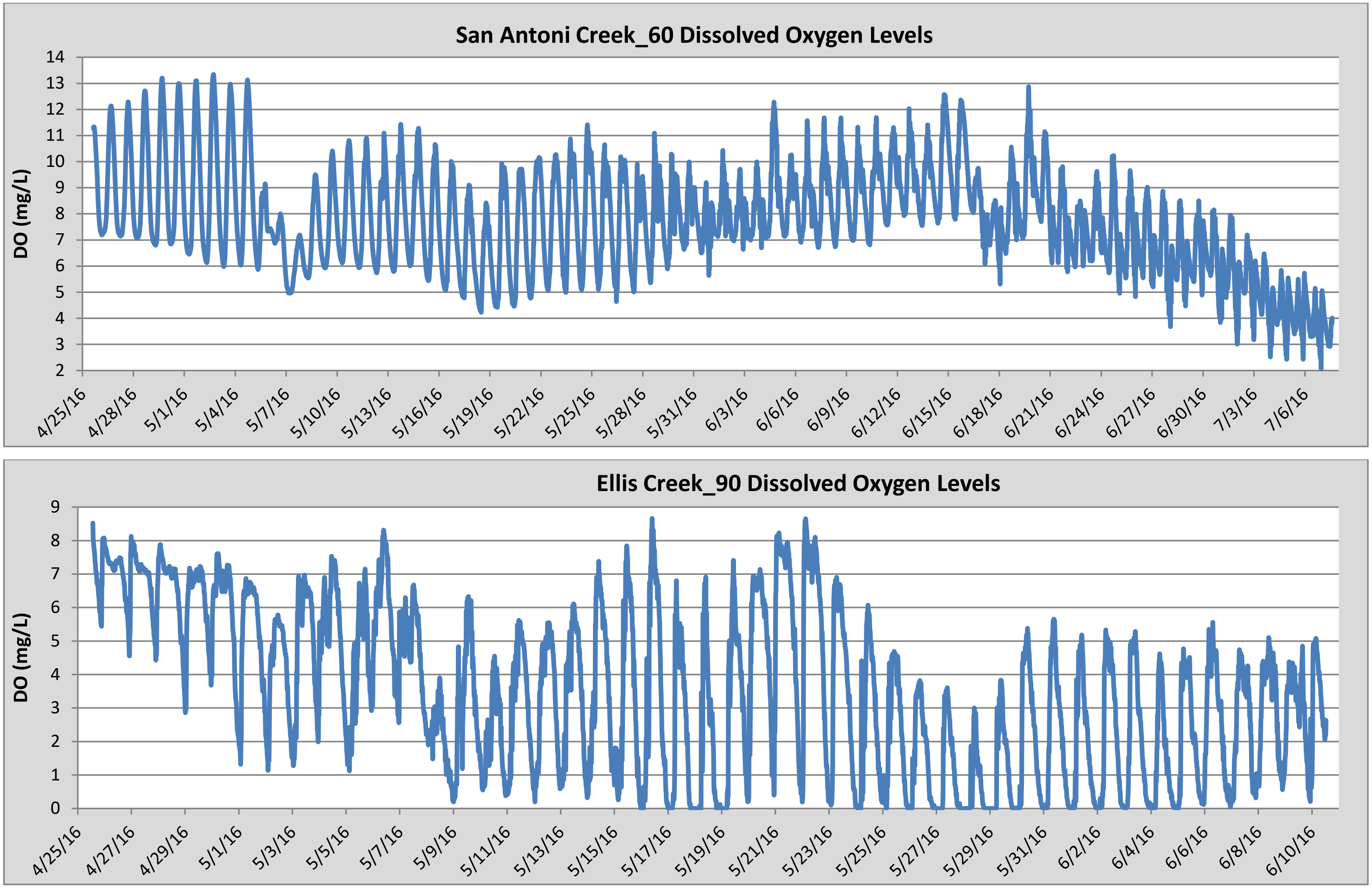

Figure 5.9. Instantaneous dissolved oxygen levels (mg/L) at the two stations with the highest daily fluctuations (2016).

5.3.2.3 Spatial Variation

The nutrient data to support this analysis were collected throughout the river's watershed (Figure 5.1). The sample locations were along the main stem and in tributaries of varying stream orders. Perennial streams compose the majority of the sample locations because they have water during the summer when algae growth peaks, but a handful of non-perennial streams were monitored as well. Collections of algae cover and benthic chlorophyll *a* from 2016 could be completed only from the wadeable sections of the main stem where the depth was 1m or less during the late spring. Figure 5.10 shows the concentrations of various nutrients at each sampling station within the watershed. The observed spatial variation could help identify where in the watershed nutrients inputs/levels are higher. As shown, stations San A._70 and Pet_310, 315, and 350 exhibit noticeably higher average levels of total phosphorous and orthophosphate than other stations. Also, Pet_98 and Pet_205, both located on the main stem of the river, show the highest average nitrate levels. Thus, the peak concentrations for nitrogen and phosphorous-based nutrients were not co-associated.

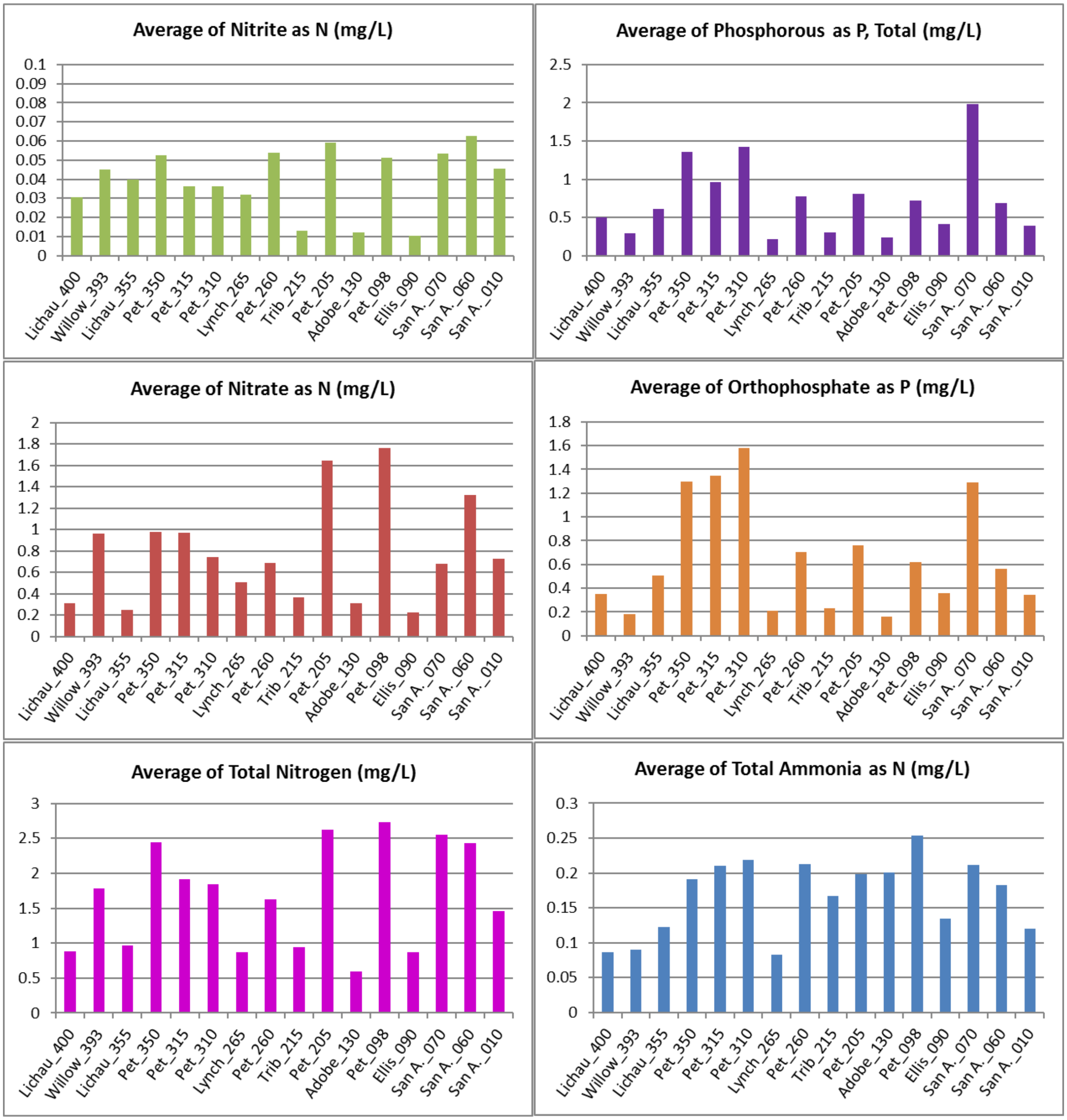

Figure 5.10. Average concentrations of nutrients in the Petaluma River watershed by site (2014-2016).

5.3.2.4 Comparison to the Regional Reference Streams Data

Figure 5.11 shows box plots of various nutrient data from the Petaluma River watershed compared against regional reference streams with no or little impacts from manmade sources or activities. The levels of nutrients measured in the Petaluma River watershed are significantly higher than those of the reference streams. Even though these levels are not toxic (do not exceed the established toxicity objectives for human or wildlife), levels are higher than reference streams, so anthropogenic activities are likely causing an increase in nutrient concentrations.

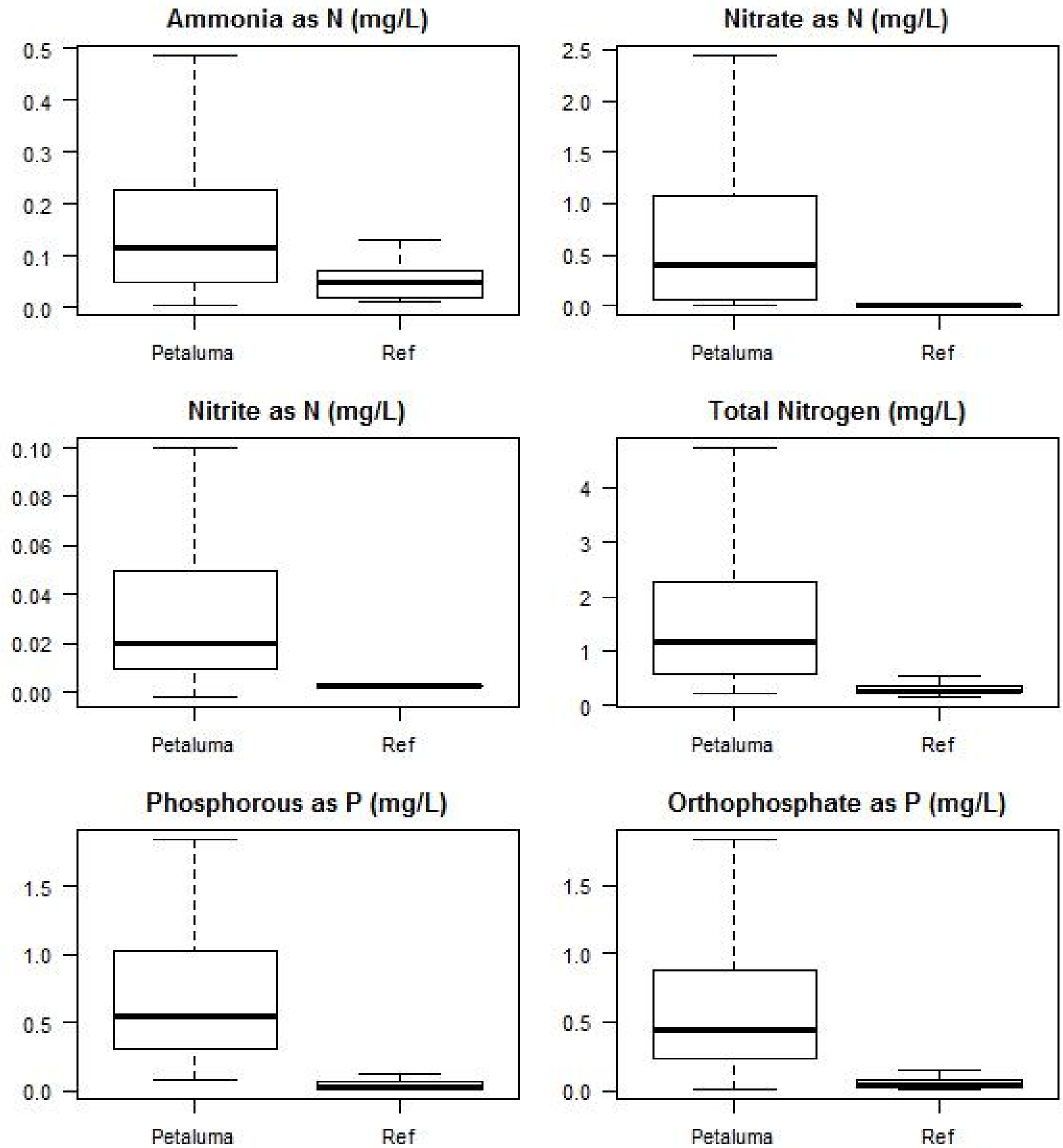

Figure 5.11. Box plots of nutrients data from the Petaluma River Watershed and the regional reference streams (2014-2016).

5.3.3 Nutrient Water Quality Impairment Assessment Conclusion

The comparison of the Petaluma River watershed data against the algal biomass thresholds (benthic algal ash free dry mass, benthic chlorophyll *a*, water column chlorophyll *a*, and percent macroalgae cover) show the narrative water quality objective in the Basin Plan for biostimulatory substances was exceeded infrequently, in four out of 36 samples. Daily changes in pH and dissolved oxygen were also infrequent, and the observed changes in dissolved oxygen were mostly from two sampling locations located on the tributaries (Pet-60 & Pet-90). At Ellis_90, we observed corresponding high AFDM and percent macroalgae cover. In contrast, San. A._60 did not show exceedances for any of the four algae indicators. In addition, out of over 100 samples for ammonia, none were above the recently published EPA aquatic life chronic toxicity criteria. In total, 88% of the measured dissolved oxygen levels failed to meet instantaneous cold water dissolved oxygen objectives (Table 5.6). The low levels of oxygen observed in the main stem appear to be more chronic conditions and not correlated to algae die offs, or nightly dips in oxygen, which are potential symptoms of eutrophic conditions. In addition, a majority of the Petaluma River main stem is tidally influenced, so it is likely that large portions of main stem dissolved oxygen concentrations will not meet cold water criteria (7 mg/L) developed for flowing freshwater systems. Lastly, the concentrations of various nutrients measured in the watershed were generally higher than those found in the regional reference streams with little or no man-made impacts (Figure 5.11), but were still below the established human and wildlife toxicity levels.

Based on the above findings, we conclude that the Petaluma River and its tributaries do not appear to be universally impaired due to exceedances of water quality objectives and evaluation guidelines related to nutrients. As such, a TMDL for nutrients is not warranted at this time and this TMDL does not explicitly address nutrient pollution. However, given the co-associated nature of FIB and nutrient sources, the control measures included in this TMDL to address FIB pollution sources will also address nutrient pollution sources. Nonetheless, Water Board staff will continue to periodically monitor nutrients and algae levels in the Watershed to evaluate conditions and address the 303(d) listing for nutrients. In particular, we are concerned about nutrients in main stem (Pet_350, Pet_315, Pet_310, Pet_205, and Pet_98) and San Antonio Creek (San A._70).

6. NUMERIC TARGETS

6.1 Overview

U.S. EPA defines numeric targets as appropriate measurable indicators, based on water quality standards that express the target, or desired, condition for designated beneficial uses of a water body. This TMDL will establish desired, or target, conditions for applicable beneficial uses (see Section 4) potentially affected by fecal pollution (fecal indicator bacteria). These targets are identified and discussed below.

6.2 Numeric Targets for Fecal Indicator Bacteria

The designated numeric targets for FIB in the Petaluma River watershed are presented in Table 6.1. These targets are the same as the current U.S. EPA's recommended water quality criteria (synonymous with water quality objective) for water contact recreation in fresh and/or marine (estuarine) waters (see Section 4.2.4). These criteria reflect the latest scientific knowledge and epidemiological investigations conducted and have also been proposed by the State Water Board as statewide water quality objectives for water contact recreation. They are as protective of what is currently in the Basin Plan, and will supersede Basin Plan's objectives when they are adopted by the State Water Board.

These targets are divided into two categories: the *Enterococcus* targets, which are applicable to the estuarine portion of the river up to site Pet_310 (Figure 5.1), and the *E. coli* targets, which are applicable to the fresh water portion of the main stem river (site Pet_310 and above) and its tributaries. These numeric targets are designed to protect the water contact recreation beneficial use in the watershed.

The targets are further divided into the geometric mean and statistical threshold values. The geometric mean targets take precedence over the statistical threshold value targets. The statistical threshold value targets are only meant to be used if it is not possible to calculate the geometric mean values due to lack of data.

6.3 Attainment of the Numeric Targets

The numeric targets are the desired condition for Petaluma River and its tributaries. Success in achieving these conditions will be evaluated in accordance with the Listing Policy (State Water Board 2015).

Table 6.1. Numeric Targets for Fecal Indicator Bacteria in the Petaluma River Watershed to protect recreation

Indicator/Applicable Waters	Numeric Target	
	GM[a] (cfu/100 mL)[c]	STV[b] (cfu/100 mL)
Enterococcus (for estuarine portions where the salinity is greater than 1 ppth[d] more than 5 percent of the time)	30	110
E. coli (for fresh water portions where the salinity is equal to or less than 1 ppth 95 percent or more of the time)	100	320

a. Geometric mean

b. Statistical threshold value

c. Colony forming unit per 100 milliliters of sample, which is equivalent to Most Probable Number (MPN) per 100 milliliters of sample.

d. parts per thousand

Duration: The water body geometric mean value is calculated based on a minimum of five samples equally spaced over a six-week period. The water body Statistical Threshold Value is evaluated over a 30-day interval.

Frequency: The water body GM shall not be greater than the applicable GM magnitude in any six-week interval, calculated weekly. The applicable STV shall not be exceeded by more than 10 percent of the samples collected in a single month's time.

Attainment: To determine the attainment of the bacteria water quality standards, the GM values shall be applied based on a statistically sufficient number of samples, which is generally not less than five samples equally spaced over a six-week period. If a statistically sufficient number of samples are not available to calculate the GM, then attainment of the water quality standard shall be determined only based on the STV.

7. POLLUTANT SOURCE ASSESSMENT

7.1 Overview

This section identifies the potential sources of FIB (fecal pollution) in the Petaluma River watershed and discusses our current understanding of them. Sources of fecal pollution are also sources of nutrients (Table 7.1).

These sources can be grouped into three categories: those originating from human waste, those originating from animal waste, and those discharged by the stormwater runoff. Implementation of corrective measures for these sources to abate discharges of FIB, would also result in the abatement of nutrients discharges.

Our identification of the potential sources of FIB in the watershed is based on the following information:

- Watershed water quality monitoring data revealing elevated bacteria levels at or downstream of potential sources;
- A microbial source tracking (MST) study conducted in 2016-2017 (Section 7.2);
- Reports of sanitary sewer overflows, provided by the local sewer agencies;
- Visual observations conducted by Water Board staff during site visits; and
- General knowledge that stormwater runoff typically contain high levels of pollutants such as FIB.

Due to the primarily diffused nonpoint source nature of discharges from these sources this report does not quantitatively estimate loads (i.e., the total number of bacteria discharged by each source per unit time) for the different identified sources in the Petaluma River watershed. However, findings from various water quality monitoring and studies in the watershed, as well as other available information, lead us to general conclusions about the likelihood, prevalence, and significance of different sources. The sections below discuss the MST study and the identified FIB sources in the watershed.

7.2 Microbial Source Tracking Study

As discussed in Chapter 4, MST is a methodology that can be used to identify specific sources of fecal contamination in environmental samples. In winter and spring of 2016, Water Board staff conducted one such study in the Petaluma River watershed. The study collected *Bacteroidales* samples in water from the same 16 stations (when flowing) used in the *E. coli* monitoring study. The samples were collected during two separate climatologic events, one in February (wet season) and one in June (dry season). All samples were analyzed for four host-specific *Bacteroides* species (human, horse, dog, and cow), plus the universal *Bacteroides* present in all warm-blooded species.

In winter and summer 2017 water Board staff collected some additional *Bacteroides* samples in the lower main stem. Table 7.2 contains the raw host-specific *Bacteroides* genetic marker data. Graphical representations of the data collected in 2016 are provided in Figures 7.1-7.4.

Table 7.1. Identified Potential Sources of FIB and Nutrients in the Petaluma River Watershed

Source Category	Potential Sources	Examples	Bacteria Source	Nutrient Source
Human Waste	Wastewater Treatment Plant	Ellis Creek Wastewater Treatment Plant and Water Recycling Facility	X	X
	Sanitary Sewer Collection Systems	Petaluma City collection system; Sonoma County Water Agency collection system-Penngrove	X	X
	Private Sewer Laterals	Sewer laterals serving individual private properties	X	X
	Onsite Wastewater Treatment Systems (OWTS)	Septic systems	X	X
	Vessel Marinas	Marina facilities, recreational boats, live-aboard boats, house boats	X	X
	Homeless Encampments	Various encampments on municipal properties and Caltrans right-of-way within the watershed	X	X
Animal Waste	Livestock- Confined Animal Facilities (CAF)	Cow dairies, horse facilities	X	X
	Livestock-Grazing Lands/Operations	Cattle ranches, sheep farms, goat farms	X	X
	Domestic Pets	Pet dogs, pet cats, etc.	X	X
	Wildlife	Deer, raccoons, birds, rodents, etc.	X	X
Municipal Stormwater Runoff	Runoff from residential, commercial, industrial, and recreational areas; stormwater infrastructures [a]	Discharges from human waste sources listed above; pet waste; wildlife waste; dumpsters and trash cans; landfills; recreational fields (golf courses, soccer fields); etc.	X	X

a. Illicit sanitary sewer connections to storm drains; biofilms and bacteria regrowth in storm drains; decaying plant matter, litter, and sediment in storm drains.

Table 7.2. Host-Associated Bacteroides Genetic Markers Concentrations in Petaluma River Watershed

Station Code	Sample Date	Human *Bacteroides* Marker (gene copies/mL)	Horse *Bacteroides* Marker (gene copies/mL)	Dog *Bacteroides* Marker (gene copies/mL)	Cow *Bacteroides* Marker (gene copies/mL)
Lichau-400	2/10/16	34.8	58.8	921.7	362.7
Willow-393	2/10/16	54.0	165.6	5.4	23.3
Lichau-355	2/10/16	*not detected*	40.7	0.6	*not detected*
Pet-350	2/10/16	*not detected*	17.6	3.6	926.2
Pet-315	2/10/16	8178.0	12.2	42.3	4.2
Pet-310	2/10/16	2157.6	5.9	*not detected*	166.2
Lynch-265	2/10/16	289.8	157.3	*not detected*	34.4
Pet-260	2/10/16	246.2	0.6	*not detected*	0.3
Trib-215	2/10/16	96.6	38.8	*not detected*	33.0
Pet-205	2/10/16	1668.3	11.2	10.2	453.2
Adobe-130	2/10/16	31.2	193.0	23.5	72.2
Pet-98	2/10/16	703.7	*not detected*	45.8	*not detected*
Ellis-90	2/10/16	166.8	64.5	*not detected*	29.6
San A.-70	2/10/16	171.4	1.1	398.2	*not detected*
San A.-60	2/10/16	56.4	67.4	62.6	551.2
San A.-10	2/10/16	32.4	210.3	2.0	149.9
Lichau-400	6/9/16	*not detected*	354.4	*not detected*	14.9
Pet-350	6/9/16	2.9	26.6	*not detected*	23.4
Pet-315	6/9/16	*not detected*	120.1	*not detected*	2.3
Pet-310	6/9/16	10.2	225.7	*not detected*	3.5
Lynch-265	6/9/16	*not detected*	144.5	*not detected*	51.7
Pet-260	6/9/16	*not detected*	212.0	*not detected*	11.0
Trib-215	6/9/16	*not detected*	53.8	*not detected*	233.2
Pet-205	6/9/16	6.2	127.8	*not detected*	20.2
Pet-98	6/9/16	*not detected*	12.9	*not detected*	*not detected*
Ellis-90	6/9/16	6.2	41.7	*not detected*	*not detected*
San A.-70	6/9/16	*not detected*	235.7	*not detected*	204.2
San A.-60	6/9/16	*not detected*	496.5	*not detected*	14.6
San A.-10	6/9/16	50.2	406.7	*not detected*	253.3
Pet-7	3/8/17	*not detected*	32.8	*not detected*	251.1
Pet-7	3/15/17	*not detected*	1.4	*not detected*	51.5
Pet-7	3/22/17	11.4	5.3	13.2	9.9
Pet-7	7/12/17	*not detected*	*not detected*	*not detected*	*not detected*
Pet-205	7/12/17	*not detected*	571	*not detected*	11.5
Pet-7	7/19/17	*not detected*	*not detected*	*not detected*	*not detected*
Pet-205	7/19/17	54	7	*not detected*	1.9
Pet-7	7/26/17	8	*not detected*	*not detected*	0.6
Pet-205	7/26/17	15	107	*not detected*	5.9

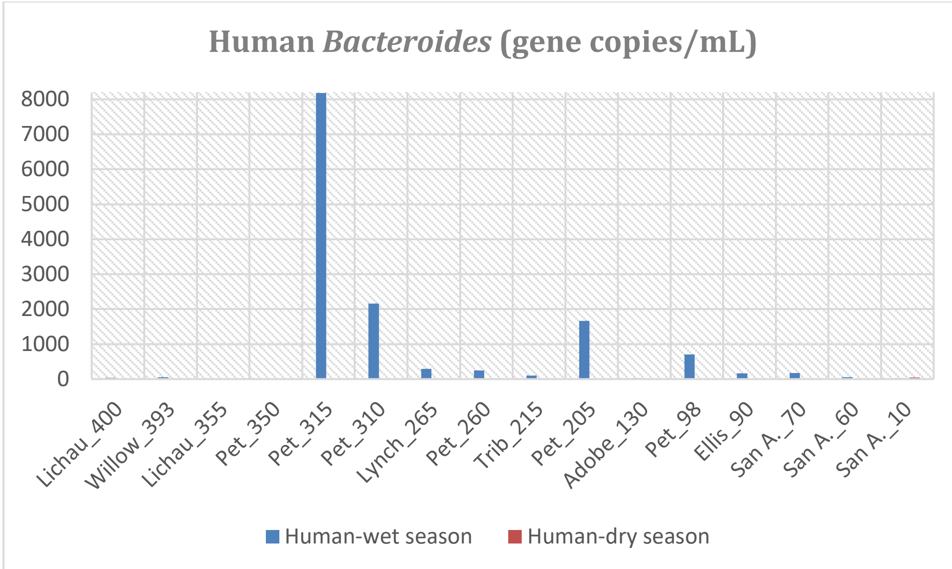

Figure 7.1. Human-associated *Bacteroides* genetic marker concentrations in the Petaluma River Watershed, February & June 2016. The dry season results showed much fewer detections.

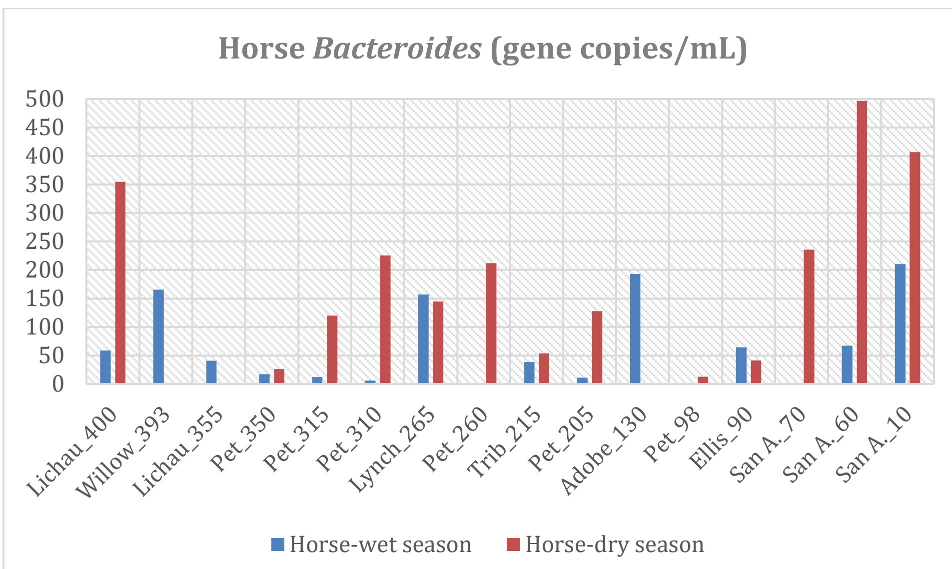

Figure 7.2. Horse-associated *Bacteroides* genetic marker concentrations in the Petaluma River Watershed, February & June 2016.

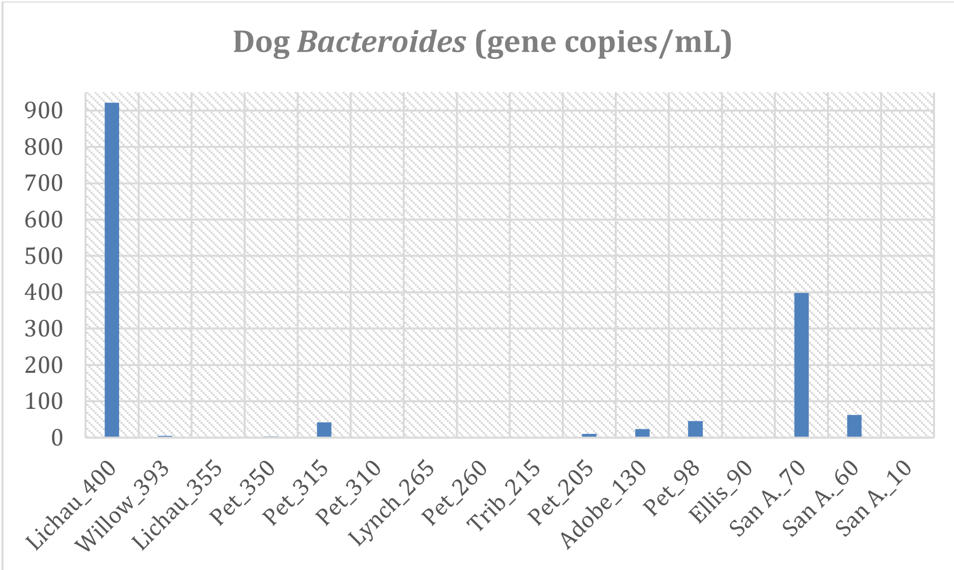

Figure 7.3. Dog-associated *Bacteroides* genetic marker concentrations in the Petaluma River Watershed, February 2016. No dog Bacteroides were detected in the dry season.

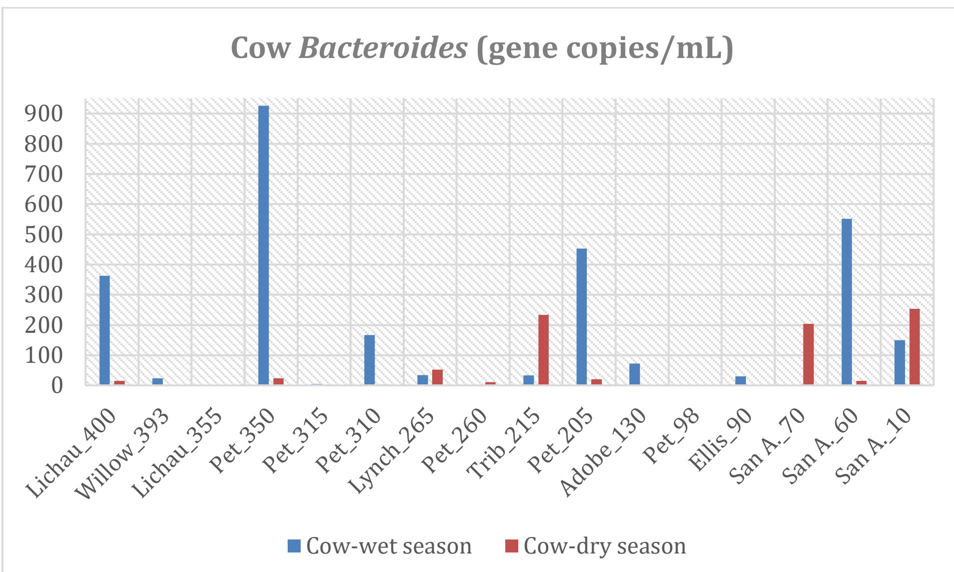

Figure 7.4. Cow-associated *Bacteroides* genetic marker concentrations in the Petaluma River Watershed, February & June 2016.

Table 7.3 and Figure 7.5 summarize the results of the *Bacteroidales* analysis in terms of percentage of samples turning up “positive” for a given marker. For each marker type, the total number of samples, the number of samples in which the marker was detected, and the percent of samples in which the marker was detected, are provided. Further, the data are grouped into February samples, June samples, and all sampling dates combined. For the purposes of this project, any positive number in Table 4.5 is considered a positive detection. Universal *Bacteroides* markers were detected in all samples and are not included in the table.

Table 7.3. Number and Percent of Positive Samples for Various Host-Associated *Bacteroides* Genetic Markers in the Petaluma River Watershed (2016)				
Sample Date	**Human *Bacteroides* Marker**	**Horse *Bacteroides* Marker**	**Dog *Bacteroides* Marker**	**Cow *Bacteroides* Marker**
All Dates (29 samples)	19/29 = 66%	28/29 = 97%	11/29 = 38%	24/29 = 83%
February 2016 (16 samples)	14/16 = 88%	15/16 = 94%	11/16 = 69%	13/16 = 81%
June 2016 (13 samples)	5/13 = 38%	13/13 = 100%	0/13 = 0%	11/13 = 85%

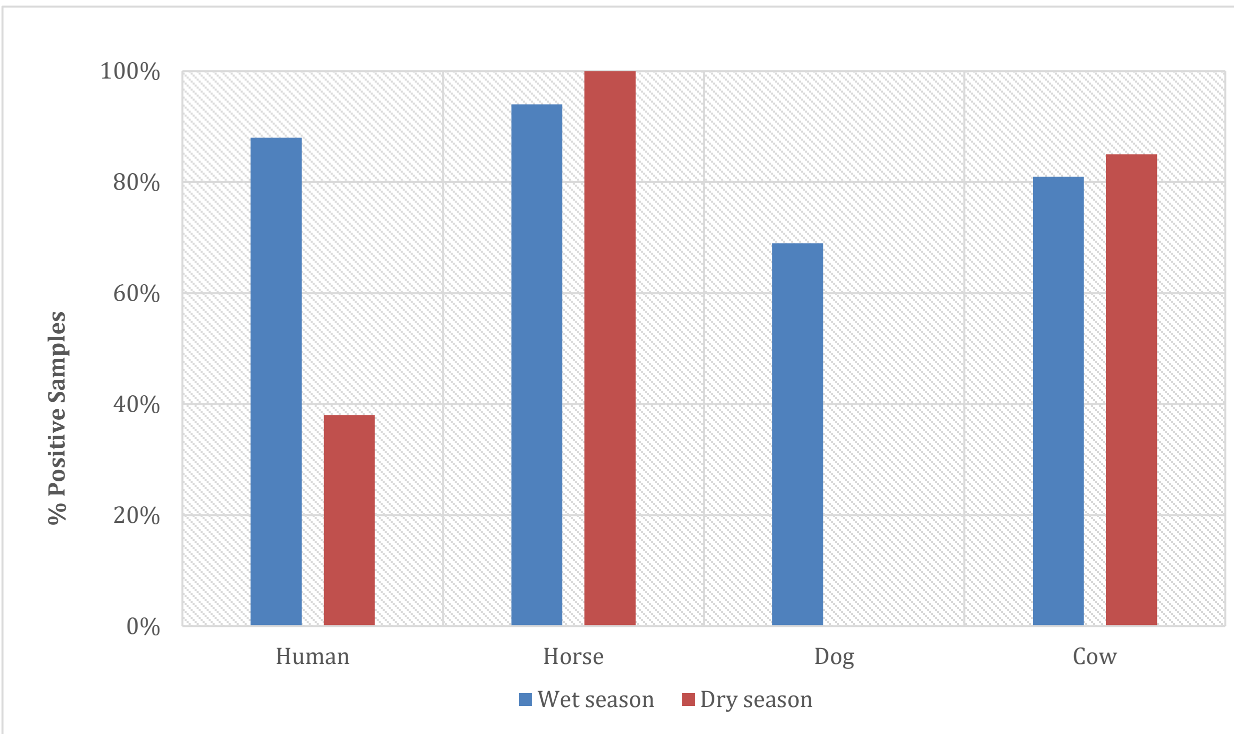

Figure 7.5. Percent of positive samples for various host-associated *Bacteroides* genetic markers in the Petaluma River Watershed (2016).

All four host-specific *Bacteroides* markers were detected in a significant percentage of the samples collected (Table 7.3). Of these, horse, cow, and human markers were detected in the highest percentage of samples. With the exception of the horse-associated marker, both concentrations and percent of positive samples for all other host-associated markers were higher during the wet season than in the dry season (Tables 7.2 & 7.3). This is to be expected as during wet season stormwater runoff can wash off and transport fecal waste and associated bacteria into the nearby waterbodies.

Sampling stations in Lichau (Lichau_400) and San Antonio Creeks (San A._10, San A._60, and San A._70), are located downstream of several horse facilities in the rural areas of the watershed and showed the highest concentrations of horse marker. Horse markers were measured at higher concentrations and detected at a higher rate during the dry season than the wet season; however, both rates were quite high. Further, the concentrations of horse marker in the dry season were noticeably higher than in the wet season. These observations indicate that horse waste inputs are more prevalent during the dry season than in the wet season.

Cow marker was detected in a high percentage of both dry and wet season samples. Sampling stations number 205 & 350 on the main stem, which are influenced by upstream grazing lands and dairies, as well as those on Lichau and San Antonio Creeks (10 & 60), which are mainly associated with grazing lands and dairies exhibited the largest concentrations of cow marker measured (Figure 7.11).

Sampling stations number 315, 310, and 205, which are primarily associated with the urban areas of the watershed exhibited the highest human marker concentrations.

Sampling stations in Lichau (Lichau_400) and San Antonino Creeks (San A._10, San A._60, and San A._70) exhibited the highest concentrations of dog marker and were in rural areas. No dog marker was detected at any locations during the dry season samples. The fact that no dog marker was detected during the dry season indicates that dog waste input into the Petaluma River and its tributaries are predominantly stormwater runoff/wet-weather driven.

7.3 Wastewater Treatment Plant

The City of Petaluma (Discharger) owns and operates a domestic wastewater treatment plant, the Ellis Creek Water Recycling Facility (plant) and its associated wastewater collection system (collectively, the Facility). The plant provides secondary treatment of wastewater collected from its service area and discharges treated effluent to the Petaluma River when flows exceed the capacity of the recycled water distribution and storage system.

The Discharger is regulated pursuant to National Pollutant Discharge Elimination System (NPDES) Permit No. CA0037810, and Water Board's waste discharge requirements Order No. R2-2016-0014.

The plant treats about 5.3 million gallon per day (MGD) (average daily flow rate from March 2011 through April 2015) of wastewater from the City of Petaluma and adjacent areas, including the community of Penngrove. The wastewater is primarily residential, although there are six industrial facilities that contribute about 0.6 MGD to this flow.

Facility influent from the collection system is treated by screening and grit removal, secondary treatment using activated sludge, and secondary clarification. After secondary clarification, some of the water is pumped to the Discharger's tertiary treatment system (flocculation, filtration, and UV disinfection) and subsequently recycled offsite. The Discharger's water recycling activities are regulated under Regional Water Board Order No. 96-011. Remaining flows are directed through a series of oxidation ponds (146 acres) and constructed wetlands (16 acres) for additional biological treatment (Figure 7.6). After the constructed (treatment) wetlands, the water is chlorinated and then flows to either polishing wetlands (31 acres) or a chlorine contact chamber. Wastewater from the chlorine contact chamber and/or polishing wetlands is dechlorinated and discharged to the Petaluma River (Figure 7.6).

During wet weather, when influent flows exceed 16 MGD, the Discharger routes a portion of wastewater directly to the oxidation ponds for treatment and then to constructed wetlands for additional biological treatment. After the constructed wetlands, the water is chlorinated and then flows to either polishing wetlands or a chlorine contact chamber, dechlorinated and discharged to the Petaluma River.

Plant effluent is discharged into the Petaluma River through a shallow water outfall. This occurs typically only during wet weather when irrigation fields are saturated. Normally during dry weather, plant effluent is used as recycled water and goes to nearby pastures, golf courses, and vineyards.

If not properly managed, maintained, and operated, wastewater treatment plants could have the potential to discharge untreated or inadequately treated wastewater containing pathogens into the receiving water bodies. In the case of the plant, under normal circumstances, the discharge is not a source of FIB (pathogens) because it is disinfected.

Figure 7.6. Ellis Creek Wastewater Treatment and Water Recycling Facility Map

7.4 Sanitary Sewer Collection Systems

The City of Petaluma's sanitary sewer collection system (the system of sewer pipelines and pump stations that collect raw sewage from residential, commercial, and industrial properties and transfer it to the wastewater treatment plant for treatment and eventual discharge) comprises approximately 196 miles of public sewer pipelines ranging in diameter from 6 to 48 inches and serving a population of 61,200 (CIWQS 2017). The collection system also includes four primary pump stations: C Street, Wilmington, Payran, and Copeland Street. In addition to the collection system serving the City of Petaluma, the Sonoma County Water Agency (SCWA) owns and operates a sewer collection system that serves the community of Penngrove, also located within the TMDL project boundary. The Penngrove collection system is comprised of approximately 14.5 miles of public sewer pipelines and serves a population of approximately 1,300 (CIWQS 2017).

Sanitary sewer overflows (SSOs) from these collection systems are a potential source of both FIB and nutrients to the Petaluma River. Sewer line backups, overflows and leaks occur, frequently during periods of wet weather, creating a potential source of bacteria and nutrients on land surface that may be transported via urban runoff to the nearby water bodies.

SSOs are commonly caused by either plugged pipes or infiltration and inflow (I/I) (Figure 7.7). Infiltration is groundwater seepage into sewer pipes through holes, cracks, joint failures, and faulty connections. This can be common in areas with high groundwater elevation. Inflow is rainwater that enters the sewer system from sources such as yard and patio drains, roof gutter downspouts, uncapped cleanouts, pond or pool overflow drains, footing drains, cross-connections with storm drains, and holes in manhole covers. Inflow is greatest during heavy rainfall and can cause excessive flows and sewage spills. Most I/I is caused by aging infrastructure that needs maintenance or replacement.

In addition to plugged pipes and I/I, any major sewer line break could result in a high short-term loading of untreated human waste to the river and its tributaries. In the Bay Area, fault movements contribute to loss of integrity of sewer pipes.

The Statewide General Waste Discharge Requirements for Sanitary Sewer Systems (General Collection System WDRs), State Water Board Order No. 2006-0003 DWQ, has requirements for operation and maintenance of sanitary sewer collection systems and for reporting and mitigating SSOs from the sanitary sewer collection systems. Table 7.4 lists the number of reported SSOs from the publicly-owned portion of Petaluma and Penngrove's sanitary sewer collection system (i.e., it does not include any discharges from private sewer laterals) for the period from May 2, 2007, to October 20, 2017. During this period, 91 sanitary sewer overflows with a total volume of 1,358,193 gallons were reported for both collection systems combined. Of this amount, a reported 1,352,806 gallons of untreated wastewater reached surface waters (CIWQS 2017).

Tables 7.5 & 7.6 summarize the spill rates and volumes for the two collection systems and compare them to the State and Regional municipal averages. As shown, City of Petaluma Collection System Spill rates and net volumes are below the State and Regional municipal averages, while those of the community of Pengrove (for category 1 spills) are above the State and Regional municipal averages.

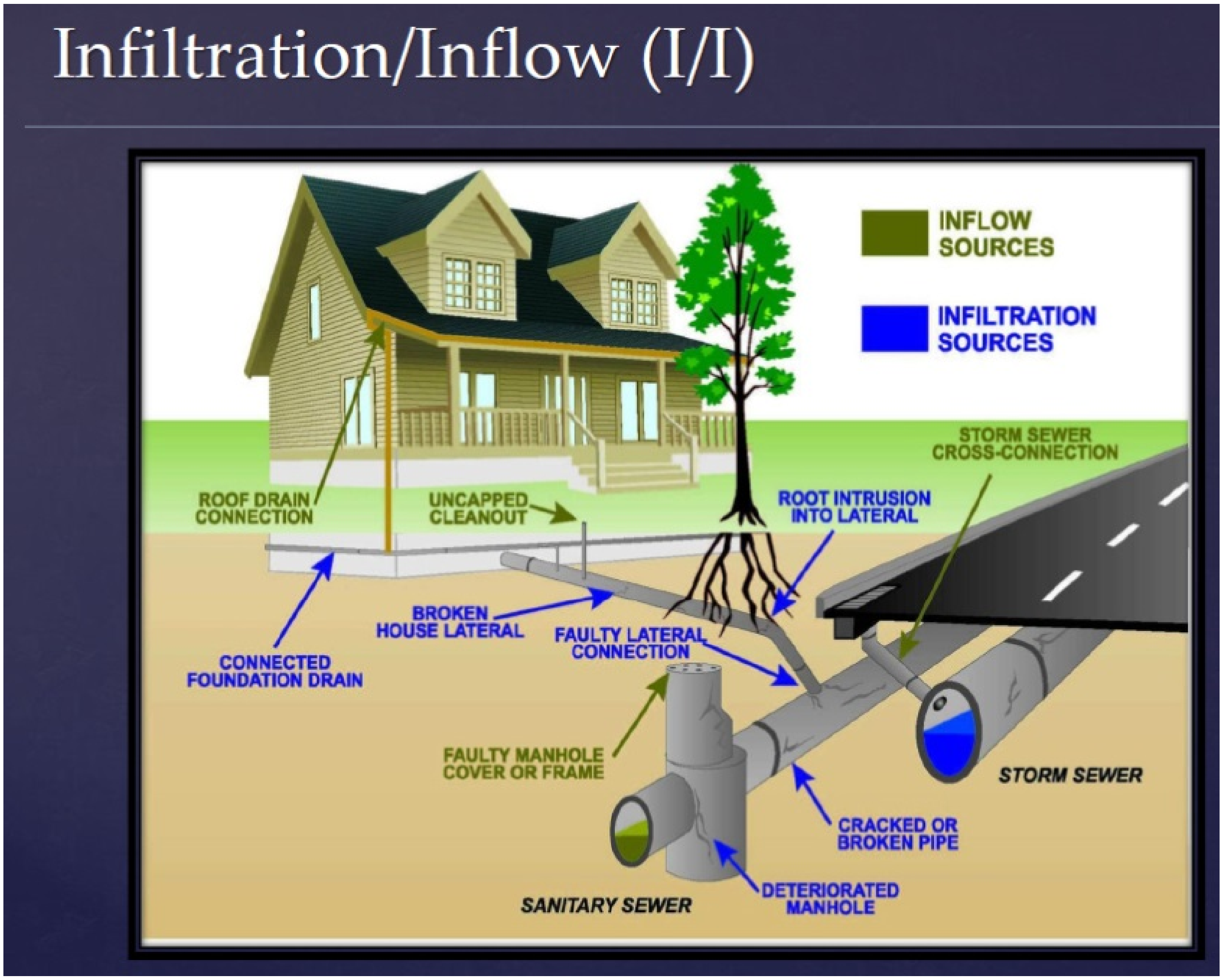

Figure 7.7. Example causes of inflow and infiltration

As discussed above, the MST study conducted in the watershed in 2016-2017 detected fecal bacteria of human origin at many sites throughout the watershed, which could point to discharges from the sanitary sewer collection systems is a likely source. The reported SSO incidents further demonstrate the sanitary sewer collection systems as a potentially significant source of pathogens (FIB) within the watershed.

Table 7.4. Summary Report of Sanitary Sewer Overflows (SSOs) for the Petaluma River Watershed (05/02/2007- 10/20/2017)

	City of Petaluma	Penngrove
Total Number of SSO locations	77	17
Total Volume of SSOs (gallons)	821,177	537,016
Total Volume Recovered (gallons)	2,425	85
Total Volume Reached Surface Water (gallons)	818,475	534,331
Percent Recovered	1	1
Percent Reached Surface Water	99	99
Miles of Pressure Sewer	4.0	2.0
Miles of Gravity Sewer	193.0	12.5
Miles of Public Laterals	196.0	14.5

Table 7.5. City of Petaluma Collection System Spill Indices

Spill Rate Indice (#spills/100mi/yr)									
	Category 1			Category 2			Category 3		
	Mainlines	Laterals	Not Specified	Mainlines	Laterals	Not Specified	Mainlines	Laterals	Not Specified
Petaluma City CS	1.03	N/A	0.23	0.0	N/A	0.0	1.50	N/A	0.33
State Municipal (Public) Average	1.59	N/A	0.59	0.56	N/A	0.43	3	N/A	0.81
Region Municipal Average	3.05	N/A	0.39	0.56	N/A	1	8.91	N/A	0.80
Net Volume Spills Indice (Net Vol in gallons/1000 Capita/yr)									
	Category 1			Category 2			Category 3		
	Mainlines	Laterals	Not Specified	Mainlines	Laterals	Not Specified	Mainlines	Laterals	Not Specified
Petaluma City CS	883.45	N/A	17.58	0.0	N/A	0.0	1.06	N/A	0.1
State Municipal (Public) Average	932.23	N/A	6546.59	295.58	N/A	206.46	22.3	N/A	10.14
Region Municipal Average	1643.62	N/A	200.99	52.24	N/A	27.55	7.62	N/A	1.59

1) The number of Category 1, 2 and 3 SSOs[1] resulting from a failure in the enrollee sewer system per 100 miles sewer system owned by the enrollee per year.

2) Net Volume (volume spilled minus volume recovered) of SSOs, for which the reporting enrollee is responsible, per capita (i.e. the population served by your agency's sanitary sewer system), per year.

3) Value calculated using miles of force mains and other pressure systems and miles of gravity sewers the agency is responsible for.

4) Value calculated using miles of laterals the agency is responsible for. For collection systems with no lateral responsibility a N/A is shown.

5) Value Calculated using total miles of collection system pipe the agency is responsible for.

6) Comparison made between similar collection systems type (e.g. municipal) and lateral responsibility for the entire state over the selected time period. Comparison indices are calculated for all similar collection systems and averaged for comparison.

Table 7.6. Community of Penngrove Collection System Spill Indices

Spill Rate Indice (#spills/100mi/yr)									
	Category 1			Category 2			Category 3		
	Mainlines	Laterals	Not Specified	Mainlines	Laterals	Not Specified	Mainlines	Laterals	Not Specified
Sonoma County Water -Penngrove CS	7.02	11.57	1.21	0.0	11.57	0.0	1.28	0.0	0.0
State Municipal (Public) Average	1.59	4.06	0.59	0.57	1.41	0.43	3.73	15.34	0.81
Region Municipal Average	3.05	2.56	0.39	0.56	2.05	0.21	8.91	29.77	0.80
Net Volume Spills Indice (Net Vol in gallons/1000 Capita/yr)									
	Category 1			Category 2			Category 3		
	Mainlines	Laterals	Not Specified	Mainlines	Laterals	Not Specified	Mainlines	Laterals	Not Specified
Sonoma County Water - Penngrove CS	39107.71	7.32	22.92	0.0	146.43	0.0	27.82	0.0	0.0
State Municipal (Public) Average	932.23	298.9	6546.59	295.58	55.26	206.46	22.3	4.55	10.14
Region Municipal Average	1643.62	102.29	200.99	52.24	25.29	27.55	7.62	4.42	1.59

[1] Category 1 SSO: all discharges of sewage resulting from a failure in an enrollee's sanitary sewer system that equal or exceed 1000 gallons; or result in a discharge to a drainage channel and/or surface water; or discharge to a storm drainpipe that was not fully captured and returned to the sanitary sewer system. Category 2 SSO: all discharges of sewage resulting from a failure in an enrollee's sanitary sewer system not meeting the definition of Category 1. Category 3 SSO: all other discharges of untreated or partially treated wastewater resulting from an enrollee's sanitary sewer system failures or flow conditions.

7.5 Private Sewer Laterals

In addition to the publically owned portions of sanitary sewer collection systems, private sewer laterals connect plumbing from residential, commercial, or industrial properties to the public sewer main, which is usually located in the street (Figure 7.8). There are an estimated 19,000 private sewer laterals in the City of Petaluma, and 350 in the community of Penngrove (CIWQS 2017).

Similar to the public portions of sanitary sewer collection systems, the private sewer laterals can also discharge untreated sewage due to blockage or breakage and therefore are a potential source of pathogens (FIB) to the nearby waterbodies such as the Petaluma River and its tributaries.

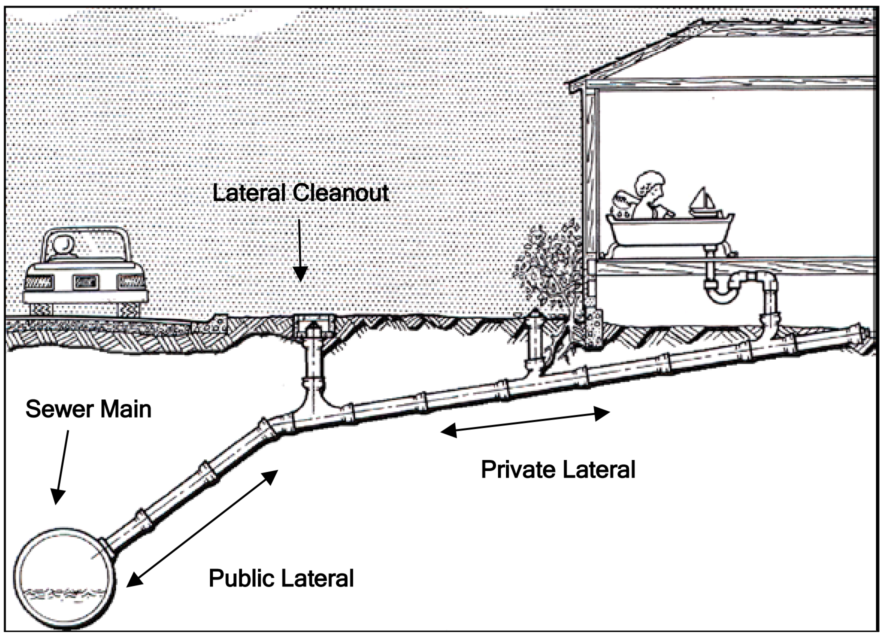

Figure 7.8. Schematic Drawing of Public vs. Private Sewer Laterals

A private lateral is the pipe that connects indoor plumbing to the public sewer main. The proper maintenance, functioning, and, if needed, replacement of the private sewer laterals are the responsibility of the private property owners. While discharges from private sewer laterals are not directly regulated by the Water Boards, many municipalities have ordinances and programs in place to oversee proper functioning of these laterals. In addition, some municipalities also have grant or other financial assistance programs in place to help property owners with the costs associated with repair or replacement of their laterals.

The City of Petaluma Public Works and Utilities Department has a Sewer Lateral Replacement Grant Program (SLRGP). The SLRGP provides financial assistance to property owners for the replacement of their private sewer lateral, which, due to their age or condition, are often a source of groundwater infiltration and surface water inflow (I/I) to the sewer collection system. The maximum amount of assistance for a sewer lateral replacement or repair is 50% of the approved cost, up to a maximum reimbursement of $2,000. Only complete replacement of the sewer lateral or a repair that completely eliminates infiltration and inflow is eligible for the program.

Sonoma County, which has jurisdiction over the unincorporated community of Penngrove, currently has no ordinances or grant programs for addressing discharges from faulty private sewer laterals in this area.

7.6 Onsite Wastewater Treatments Systems (OWTS)

In areas that do not have a municipal sanitary sewer system, OWTS are used to primarily treat domestic wastewater from a home or business and return treated wastewater back into the receiving environment by employing subsurface disposal. Most OWTS involve a septic tank that gravity flows to a soil absorption field (leach field) for final treatment and dispersal. The septic tank allows particulate matter to settle to the bottom of the tank so that large solids do not plug the drain field. Final treatment and dispersal of the wastewater takes place in the leach field. OWTS that are poorly installed or maintained, improperly located, or are in close proximity to water bodies are potential sources of FIB and nutrients to both surface and ground waters.

Figure 7.9 shows the general location and estimated density of all existing OWTS within the Petaluma River watershed. Though, information on the exact number and location of OWTS in the watershed is not readily available, we estimate that there are approximately 595 systems within the watershed.

The OWTS within the Petaluma River watershed could potentially be a significant source of FIB and nutrients discharges due to the following reasons:

- The MST study indicates that human waste markers are present in the river and its tributaries; which points to OWTS as one of the potential sources of pollution;
- Even a few faulty systems could cause severe pollution of the nearby waterbodies;
- 10 to 25 percent of all OWTS nationwide fail to function properly;
- The exact number and location of OWTS in the watershed are not known with certainty, nor are they routinely inspected or evaluated by the local responsible authorities (i.e., Sonoma and Marine Counties); and
- Due to their usually isolated locations, any potential sewage discharge from OWTS is unlikely to be noticed and reported.

Figure 7.10 shows the estimated number and location of OWTS within a 100 and 200-feet buffer of the river and its tributaries. These systems would potentially pose a higher risk to water quality and are, therefore, of higher priority to address.

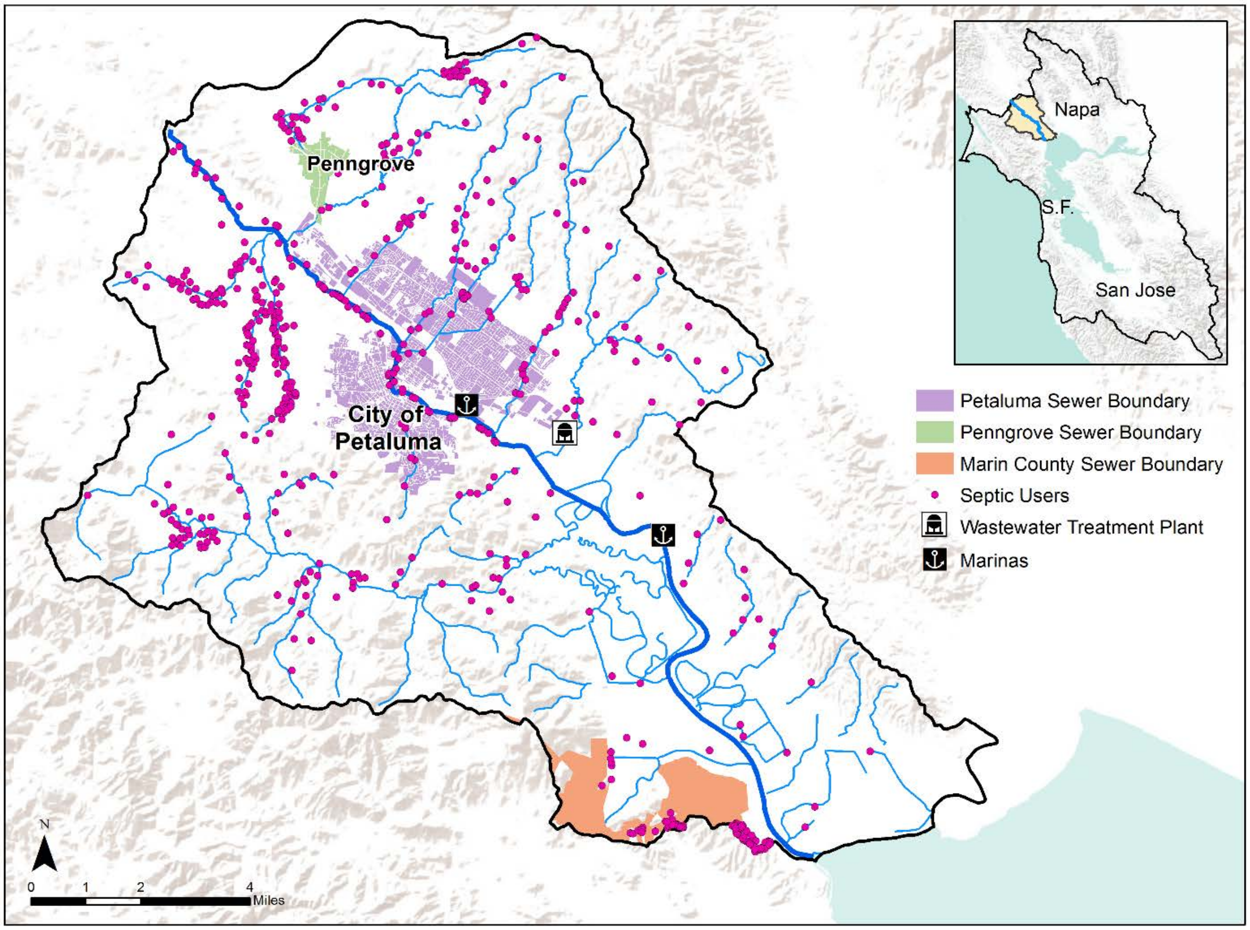

Figure 7.9. Location and Density of Various Human sources of Bacteria in the Petaluma River Watershed

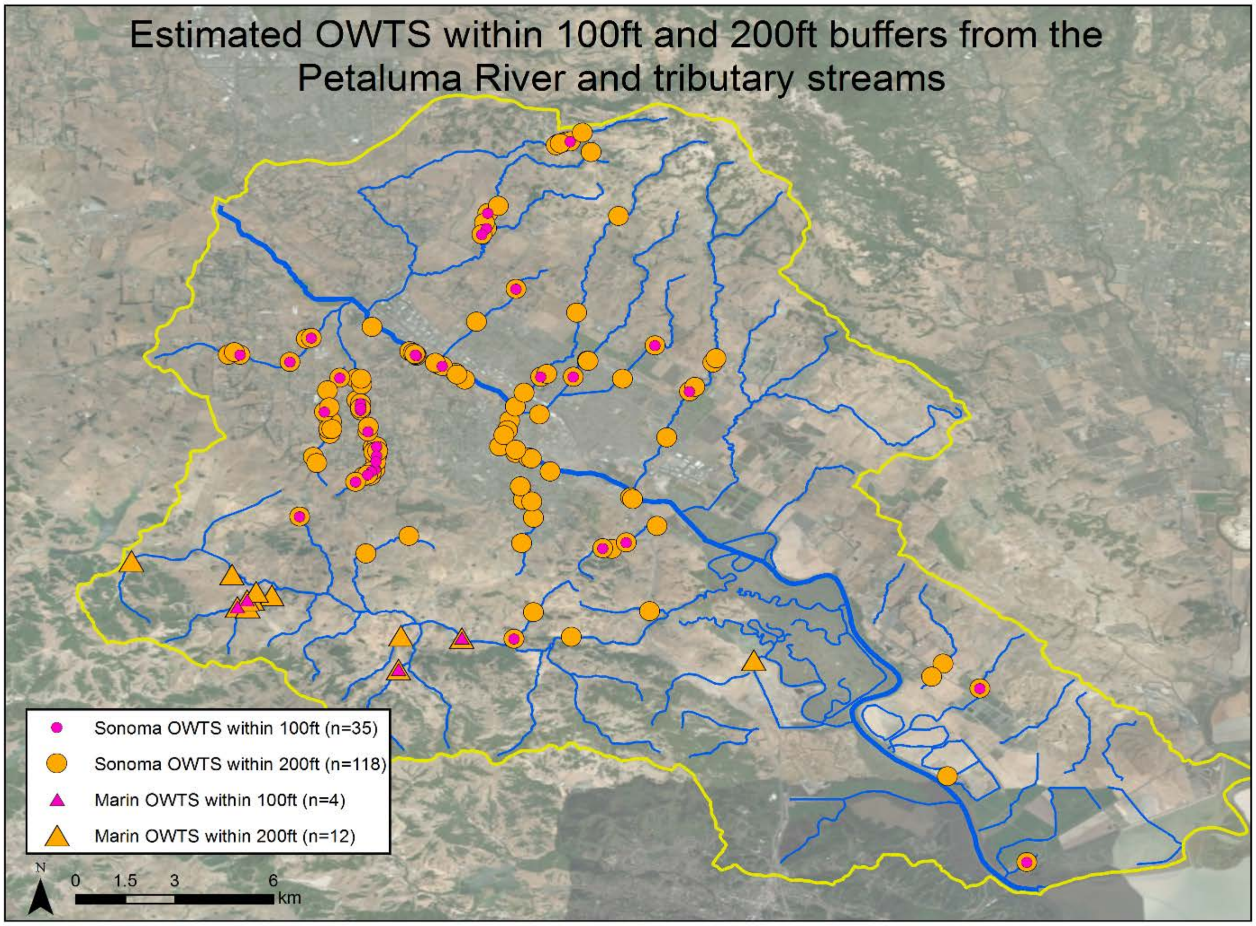

Figure 7.10. Estimated number of OWTS within 100 and 200-feet buffers of the Petaluma River and its tributaries

7.7 Vessel Marinas

There are currently two working vessel marinas within the Petaluma River watershed, the Petaluma Marina and the Gilardie's Lakeville Marina (Figure 7.9). Table 7.7 provides basic information about these marinas and their waste handling capabilities. This information was collected as part of a marina survey conducted by the California Department of Boating and Waterways in August 2004. More recent data are not readily available. (California Department of Boating and Waterways 2004).

Table 7.7. Marina Information and Recommendations for Vessel Waste Disposal Facilities														
	Dump Stations[1]			Sewage Pumpouts[2]			Total Marina Capacity			Boats	# of	Transient Boats	# of Live	
	Existing	Min.	# to	Existing	Min.	# to	Permanent	Size (Feet)		Requring	Portable	Requiring Pumpout	Aboards[3]	Onshore
Facility	Units	Need	Install	Units	Need	Install	Slips	Min	Max	Pumpout	Toilets	(boats/yr)	at Marina	Restroom
Gilardi's Lakeville Marina	0	1	**1**	0	1	**1**	14	20	50	4	2	50	3	Yes
Petaluma Marina	0	1	**1**	1	1	**0**	196	22	65	35	30	250	0	Yes

1. A dump station is a place where raw sewage may be deposited into a sanitary sewer system in a safe and responsible way. Dump stations are often used by owners of recreational boats that are equipped with toilet facilities and a sewage holding tank. The holding tank can be safely emptied at a dump station.
2. Typically pumpout stations empty the on-board holding tanks into a landside sewage system or to a municipal sewage line. These facilities typically consist of a pump unit with an associated suction hose and shut off valve.
3. Boats that are used as long-term private residences as well as for navigation are referred to as "live-aboards."

Improper disposal of human waste by boaters is a direct source of FIB to the waters they are moored at and can result in human health hazards and loss of recreational opportunities. In a more recent boating survey of the boaters statewide (question not broken down by area) 64% of the respondents stated that California boaters frequently discharge untreated sewage into the water (California Department of Boating and Waterways 2011).

Given their location—directly on the river—any illicit or accidental discharge of human waste from vessels or the marina facilities could be a significant and acute source of pollution to the river. Further, the 2004 boating survey identified lack of adequate waste disposal facilities at both marinas, which to date has not been addressed at either marina. As such, vessel marinas are considered a significant potential source of FIB in the river.

7.8 Homeless Encampments

Homeless encampments and gathering areas can be a source of human waste and therefore FIB, posing potential human health risks in the environment, including in recreational waters. An example of this threat is the 2017 hepatitis A illness outbreak in the San Diego County, believed to have been cause by the lack of proper sanitation and hygiene in the homeless population.

Figure 7.11 shows the location of homeless encampment areas within the City of Petaluma, as of July 2017. As seen, almost all of the encampments are located along the Petaluma River or its tributaries. When homeless encampments are located along waterways, where human waste is disposed of in make-shift latrines near the stream or thrown into the stream itself, they can be a direct sources of human waste to waterways. Human waste deposited at homeless camps in areas further away from the streams, can still be washed away and enter the streams through stormwater runoff. Therefore, homeless encampments represent a significant sources of FIB in the Watershed that need to be addressed.

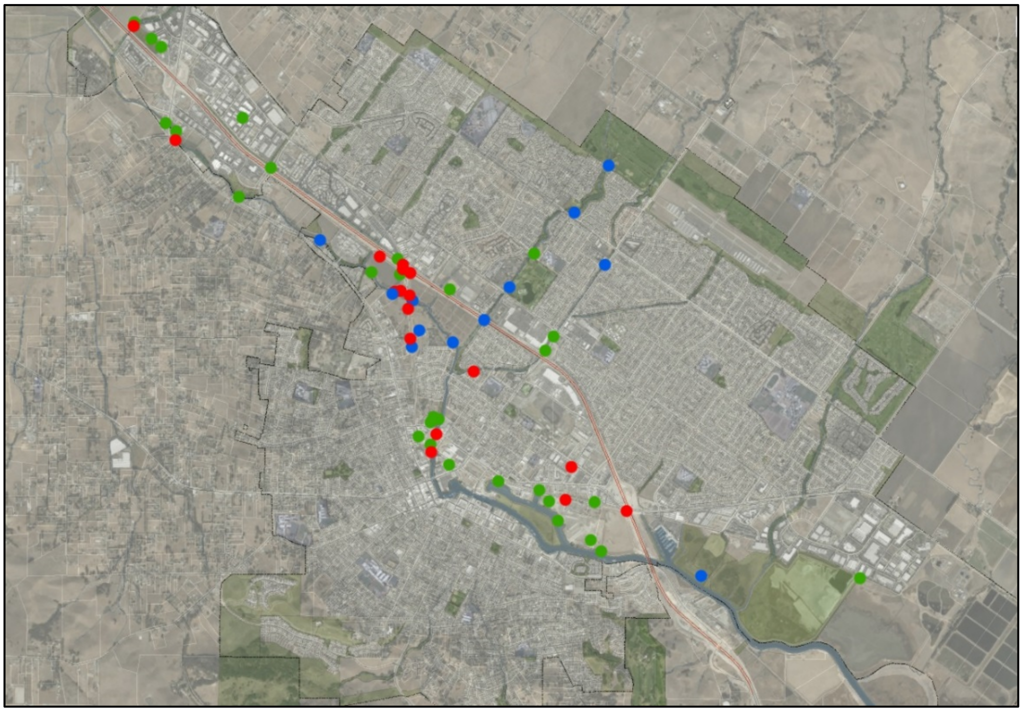

Figure 7.11. Homeless encampments areas within the City of Petaluma. The red circles indicate current encampments, green circles indicate past encampments, and blue circles indicate a possible encampment that need to be verified. Source: City of Petaluma

7.9 Livestock-Confined Animal Facilities (CAFs)

CAFs are livestock operations where animals are confined and fed in an area that has a roof or is devoid of vegetation, generating solid and liquid manure wastes that are collected and disposed of on land (crops and pastures) or offsite. Within the Petaluma River watershed, the primary types of CAFs are cow dairies and horse boarding facilities (Table 7.8, Figure 7.12). The majority of animal waste is produced by cow dairies (Water Board 2016). There are currently 17 cow dairies operating within the watershed with an estimated 11,000 head of cows. However, given the high number of horse facilities within the watershed (approximately 28 facilities), they could generate a significant amount of waste as well.

Table 7.8. Type and Number of Confined Animal Facilities in the Petaluma River Watershed		
Facility Type	Cow Dairies	Horse Facilities
No. of facilities	17	28
No. of animals	11,000	8,600
Waste produced	59-80 lb./1000 lb. animal weight/day	50 lb./day/animal

CAFs generate wastes that include manure, process wastewater, animal wash water, and any water, precipitation, or rainfall runoff that contacts animal confinement areas and/or raw materials, products, or byproducts such as manure, compost piles, feed, bedding materials, silage, eggs, or milk. Wastewaters may also contain certain chemicals such as detergents, disinfectants, and biocides. Waste from such facilities can contain significant amounts of pathogens, oxygen-depleting organic matter, sediment, nitrogen compounds, and other suspended and dissolved solids that can impact both groundwater and surface water if not properly managed.

CAF wastes are usually stored in retention ponds, in corrals, and/or in waste piles. These wastes are then applied to onsite cropland or pastures or transported offsite. The applied wastes are a source of nutrients to crops and pastures but, if improperly managed, can create nuisance conditions and cause pollution of surface and groundwaters.

Adverse aquatic habitat impacts associated with improper waste management and application may include: nutrient enrichment resulting in algal blooms, organic waste loading resulting in lowered oxygen levels, high levels of ammonia that are toxic to fish and aquatic invertebrates, and elevated levels of nitrates and other salts in groundwater.

As discussed above, fecal bacteria originating from cow and horse waste were identified by the MST study at very high rates throughout the watershed, in both dry and wet seasons. Considering the large number of CAFs and the quantity of animals they typically house, as well as the amount of waste they tend to produce, they are a significant potential source of fecal pollution (FIB) in the watershed.

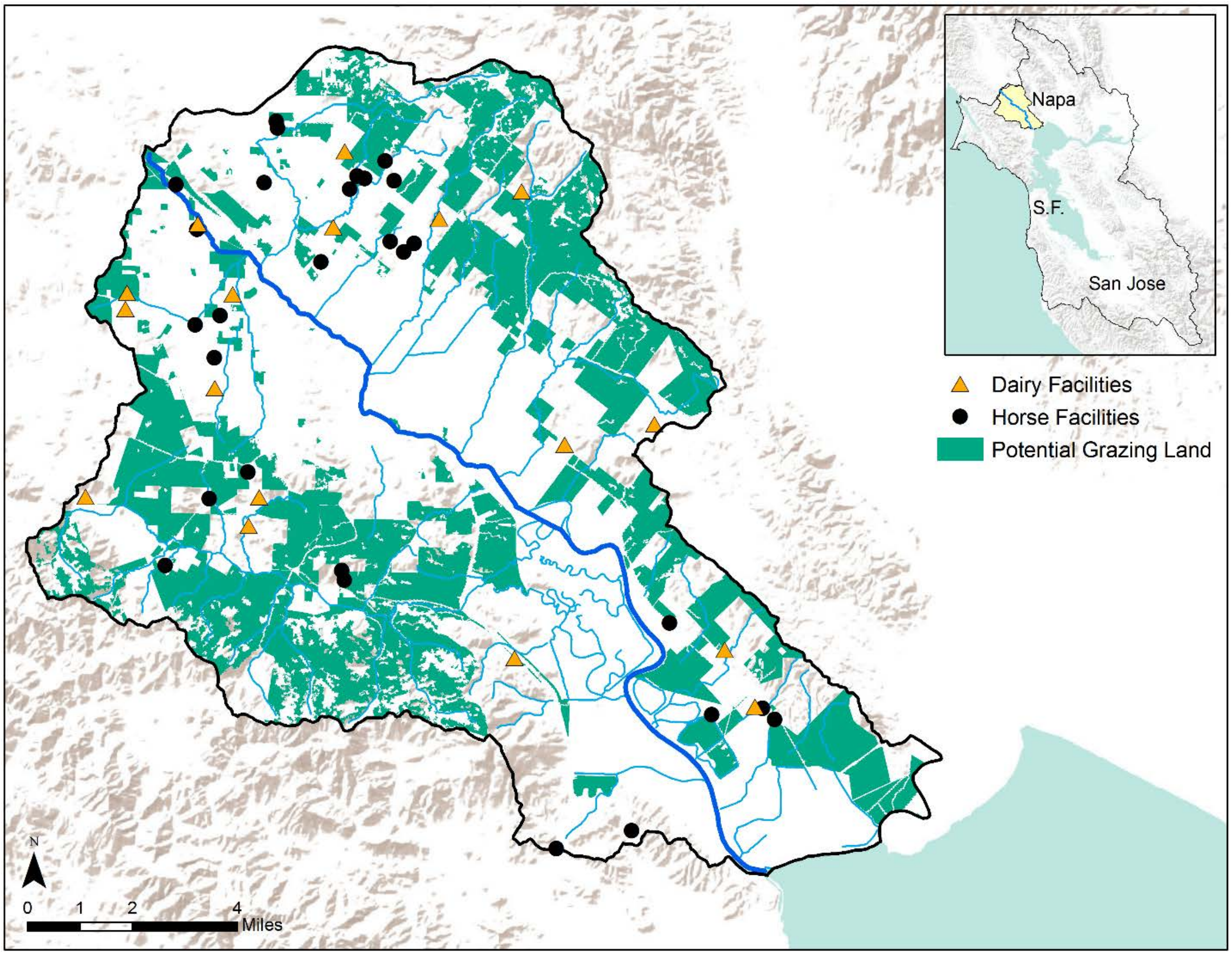

Figure 7.12. Location and Density of Various Animal sources of Bacteria in the Petaluma River Watershed

7.10 Livestock-Grazing Lands/Grazing Operations

Grazing lands are all lands grazed by livestock or where livestock have access to, including ranchlands, riparian areas, and pasturelands. Grazing operations are those facilities where animals are fed or maintained on irrigated vegetation or rangeland forage for a total of 45 days or more in any 12-month period, and vegetation forage growth is sustained over the lot or facility during the normal growing season (Water Board 2017).

As seen on Figure 7.12, we determined that grazing is a dominant land use in the watershed comprising 31% of the total lands use in the watershed. To date, we have obtained no detailed information from the grazing operations themselves, or third parties, as to the number and location of these operations within the watershed.

If improperly managed, grazing lands/operations can pose a threat to both surface and ground water quality, irrespective of herd size. Animal waste discharges, including contaminated stormwater, may contribute pathogens, nutrients (e.g., ammonia), and excess fine sediment to nearby streams. The deleterious properties of animal wastes to aquatic organisms have been well documented, contributing to decreased in-stream dissolved oxygen levels, and causing acute and chronic toxicity due to un-ionized ammonia levels. Furthermore, grazing operations located on steep hillsides and/or near creeks and streams require diligent management practices to protect water quality.

As discussed above, the results of the MST study revealed the presence of fecal bacteria from bovines (cows), the most common type of livestock found on grazing lands, in the river and its tributaries. As such, like the CAFs, grazing lands are also a potential source of FIB in the Petaluma River watershed.

7.11 Pet Waste

The waste from pets such as dogs can contain bacteria and parasites like *E. coli*, Salmonella, Giardia, and tape worms, which can cause a variety of infectious diseases to humans, as well as to wildlife and other dogs. Pet waste left on the ground either passes through storm sewers untreated or washes directly into water bodies. Petaluma River and its tributaries, are likely receiving waters for pet waste disposed of on adjacent lands.

Pet dogs are common in the residential parts of the watershed and on public park trails. In addition, there are a number of dedicated dog parks in the watershed.

The MST study identified dog waste as a prevalent source of bacteria in the watershed. Also, Water Board staff has observed prevalence of dog waste at some of the public parks and urban areas. Therefore, pet waste is a potential source of FIB in the watershed that needs to be controlled.

7.12 Wildlife

A variety of wildlife, such as the birds, deer, raccoons, and rodents that inhabit the open space lands adjacent to Petaluma River and its tributaries, can contribute bacteria to these water bodies through stormwater runoff or direct deposit of waste. No accurate information as to the magnitude and geographic distribution of this waste source is available. Because of the great variety, complex distribution and dispersal patterns, and fluctuating populations of wildlife, it is not feasible to assess their exact impact on water quality in the Petaluma River.

Even though wildlife is identified as a contributing source of FIB in the watershed, we do not think it is a controllable source. For that reason, it will not be explicitly addressed in the Implementation Plan.

7.13 Municipal Stormwater Runoff

Petaluma River and its tributaries receive stormwater runoff from the surrounding urban land uses including residential, commercial, industrial, and recreational areas. As seen in Figure 2.2, urban land uses dominate the central portion of the Petaluma River watershed. Overall, urban areas account for approximately 17% of all land use in the watershed.

Stormwater runoff from these developed areas can be a significant source of bacterial pollution to the river. Potential sources of bacteria in stormwater runoff from urban areas include illicit sanitary sewer connections to storm drains, sanitary sewer spills, pet waste, wildlife waste, trash, and biofilms and bacteria regrowth in storm drains.

The link between stormwater runoff and bacterial pollution is well established. Field studies conducted in other watersheds to assess the coastal water quality impact of stormwater runoff during the wet season have shown that stormwater runoff leads to FIB concentrations exceeding water contact recreation water quality objectives by up to 500% in the immediate vicinity of the discharge (Ahn et al., 2005).

In addition, as shown by the bacteria monitoring and the MST study results, the concentrations of FIB and host-specific genetic markers were generally higher during wet seasons and lower in the dry seasons. These observations indicate that stormwater runoff is a source and means of transportation for FIB. Therefore, municipal stormwater runoff is considered a high priority source of bacterial pollution in the watershed that needs to be controlled.

7.14 Caltrans Stormwater Runoff

As shown on Figure 7.10, several existing homeless camps appear to be located along or adjacent to Highway One within Caltrans' right-of-way. Also, future encampments are likely to take hold on these areas. Therefore, stormwater discharges from Caltrans' roads in the Petaluma River watershed are a potential source of FIB due to discharges of waste from existing or future homeless encampments.

8. TOTAL MAXIMUM DAILY LOAD AND POLLUTANT ALLOCATIONS

8.1 General Approach for Density-Based Fecal Indicator Bacteria TMDL and Allocations

U.S. EPA's protocol for developing Pathogens TMDLs (U.S. EPA, 2001) defines a total maximum daily load as the allowable loadings, of a specific pollutant, that a water body can receive without exceeding water quality standards. A TMDL is the sum of the individual wasteload allocations (for point sources) and load allocations (for nonpoint sources) for a given water body. The total amount of pollutant contributed by point and nonpoint sources must not exceed water quality standards for the water body. In addition, the TMDL must include a margin of safety, either implicit or explicit, which accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving water body.

For most pollutants, TMDLs are expressed on a mass-load basis (e.g., kilograms per year). For FIB, however, it is the number of organisms in a given volume of water (i.e., their density), and not their total number (or mass) that is significant with respect to public health risk and protection of beneficial uses. The density of FIB in a discharge and/or in the receiving waters is the technically relevant criteria for assessing the impact of discharges, water quality, and public-health risk. U.S. EPA guidance recommends establishing density-based TMDLs for pollutants that are not readily controllable on a mass basis. Therefore, the TMDLs and wasteload allocations (WLAs) and load allocation (LAs) in this project are expressed in terms of FIB densities.

Establishment of a density-based, rather than a mass-based TMDL for FIB carries the advantage of eliminating the need to conduct a complex and potentially error-prone analysis to link loads and projected densities. A load-based FIB TMDL would require calculation of acceptable loads based on acceptable bacterial densities and anticipated discharge volumes, and then back-calculation of expected densities under various load reduction scenarios. Since discharge volumes in the Petaluma River watershed are highly variable and difficult to measure, such an analysis would inevitably involve a great deal of uncertainty with no increased water quality benefit.

8.2 Total Maximum Daily Load

Table 8.1 lists the FIB TMDL for the Petaluma River and its tributaries. The TMDL is identical to the FIB numeric targets for water contact recreation beneficial use presented in Section 5, and is expressed as the total density of either *E. coli* or *Enterococcus* indicator bacteria, depending on the water body segment type (freshwater or estuarine, respectively), that can be discharged from all sources while not causing the water quality in the river and its tributaries to exceed the protective standards. This TMDL will be applicable year-round.

Table 8.1. Total Maximum Daily Load for Fecal Indicator Bacteria in Petaluma River and its Tributaries

Indicator/Applicable Waters	Numeric Target	
	GM[a] (cfu/100 mL)[c]	STV[b] (cfu/100 mL)
Enterococcus (for estuarine portions where the salinity is greater than 1 ppth[d] more than 5 percent of the time)	30	110
E. coli (for fresh water portions where the salinity is equal to or less than 1 ppth[d] 95 percent or more of the time)	100	320

a. Geometric mean

b. Statistical threshold value

c. Colony forming unit per 100 milliliters of sample, which is equivalent to Most Probable Number (MPN) per 100 milliliters of sample.

d. Parts per thousand

Duration: The water body geometric mean value is calculated based on a minimum of five samples equally spaced over a six-week period. The water body Statistical Threshold Value is evaluated over a 30-day interval.

Frequency: The water body GM shall not be greater than the applicable GM magnitude in any six-week interval, calculated weekly. The applicable STV shall not be exceeded by more than 10 percent of the samples collected in a single month's time.

Attainment: To determine the attainment of the bacteria water quality standards, the GM values shall be applied based on a statistically sufficient number of samples, which is generally not less than five samples equally spaced over a six-week period. If a statistically sufficient number of samples are not available to calculate the GM, then attainment of the water quality standard shall be determined only based on the STV.

8.3 Load and Wasteload Allocations

U.S. EPA regulations require that a TMDL include load allocations (LAs), which identify the portion of the total acceptable pollutant loading allocated to nonpoint sources of pollution, and wasteload allocations (WLAs), which identify the portion of the pollutant loading allocated to existing and future point sources of pollution. Together, load and wasteload allocations are referred to as "allocations." Density-based allocations are proposed for this TMDL. Unlike mass-based allocations, where the mass of pollutant from each source adds up to the total allocation, density-based allocations do not add up to equal the TMDL. Rather, in order to achieve the density-based TMDL, each source must meet the density-based allocation.

Table 8.2 presents the density-based FIB load and wasteload allocations for the Petaluma River. The attainment of these allocations will ensure protection of the water quality and applicable beneficial uses of the river. These allocations apply year-round to the different source categories of FIB in the watershed.

Table 8.2. Load and Wasteload Allocations [a] of FIB for Petaluma River			
Pollutant Source Category and Associated NPDES Permits	**Allocation Type**	**<u>Estuarine waters</u>** ***Enterococcus*** **(MPN/100 mL)**	**<u>Fresh waters</u>** ***E. coli*** **(MPN/100 mL)**
Grazing Lands/Operations (e.g., cattle ranches)	LA	Geometric mean [c] < 30 STV [d] = 110	Geometric mean [c] < 100 STV [d] = 320
Confined Animal Facilities (e.g., dairy, horse facilities)	LA	Geometric mean [c] < 30 STV = 110	Geometric mean [c] < 100 STV = 320
Wildlife [e]	LA	Geometric mean [c] < 30 STV = 110	Geometric mean [c] < 100 STV = 320
Municipal Stormwater Runoff (MS4) [b] (NPDES No. CAS000004)	WLA	Geometric mean [c] < 30 STV = 110	Geometric mean [c] < 100 STV = 320
Caltrans Stormwater Runoff (NPDES No. CAS000003)	WLA	Geometric mean [c] < 30 STV = 110	Geometric mean [c] < 100 STV = 320
City of Petaluma Wastewater Treatment Plant (NPDES No. CA0037810)	WLA	Geometric mean [c] < 30 STV = 110	Not Applicable
Sanitary Sewer Collection Systems-City of Petaluma collection system; Sonoma County Water Agency collection system	WLA	0	0
Onsite Wastewater Treatment Systems (e.g., Septic Systems) within Petaluma River watershed	LA	0	0
Vessel Marinas (recreational, live-aboards, houseboats)	LA	0	0

a. All allocations apply year-round and will be measured in the ambient water (e.g., Petaluma River or its tributaries), with the exception of wasteload allocation for the City of Petaluma Wastewater Treatment Plant, which would be measured at any point in the outfall pipe between the point of discharge to the Petaluma River (Discharge Point No. 001) and the point at which all flow contributing to the outfall is present.

b. Wasteload allocation for discharges from municipal stormwater runoffs includes contributions from pet waste.

c. Calculated based on a minimum of five samples equally spaced over a six-week period.

d. Statistical Threshold Value (STV) will only be used in the absence of adequate geometric mean data. No more than 10% of total samples during any 30-day period may exceed this value.

e. Wildlife is believed to be an uncontrollable source of bacteria and its contribution is considered natural background. No management measures will be required for wildlife sources.

For allocations specified by pollutant source category, it is the responsibility of individual facility or property owners within a given source category to meet these allocations. In other words, individual facilities and property owners shall not discharge or release a load of pollution that will increase the density of FIB in the downstream portion of the nearest water body above the proposed load or wasteload allocation assigned to that source type. This allocation scheme assumes that the concentration of FIB upstream from the discharge point is not in excess of the assigned allocations.

We assign load allocations of zero to sanitary sewer collection systems, OWTS, and vessel marinas for the following reasons:

- As sources of human waste (as opposed to animal waste) they pose the greatest threat to the public health;
- The zero wasteload allocation is consistent with the existing Basin Plan prohibition of release of untreated sewage (Prohibition #15, Table 4-1, Basin Plan);
- When operated properly and lawfully, sanitary sewer collection systems, OWTS, and vessel marinas are designed to not cause any human waste discharges;
- Human waste discharges from these sources are fully controllable and preventable.

For these reasons, zero wasteload allocations for these source categories are both feasible and warranted.

All permittees or entities that discharge indicator bacteria or have jurisdiction over such dischargers are collectively responsible for meeting these allocations. Water quality monitoring data at the river and its tributaries will be used to demonstrate achievement of the allocations.

8.4 Margin of Safety

TMDLs are required to include a margin of safety to account for data uncertainty, critical conditions, and lack of knowledge. Because the load allocations in this TMDL are identical to the latest U.S. EPA criteria established as protective standards and inclusive of all uncertainties, the margin of safety is included in the TMDL targets, so it is implicitly incorporated into the proposed TMDL and allocations. Therefore, staff asserts that no additional or explicit margin of safety is needed for this TMDL.

8.5 Seasonal Variation and Critical Conditions

TMDLs are set to meet the numeric target under "critical conditions," which are extreme (or above average) environmental conditions, such as high or low flows or temperatures. Although analyzed separately from the margin of safety for data uncertainty and lack of knowledge, the consideration of critical conditions may be thought of as an additional margin of safety because it ensures the targets are met despite volatility in environmental conditions. While FIB densities can be greater during the winter wet season due to factors such as stormwater runoff, they can be high at any time of year. For example, we observed higher FIB densities in the dry season compared to the wet season at a number of sites monitored in winter 2016.

Recreational uses of the river are most prevalent during the summer time, but can also occur at any time of year. Therefore, we are not proposing seasonal variations to the above-listed TMDLs and allocations.

9. LINKAGE BETWEEN WATER QUALITY TARGETS AND POLLUTANT SOURCES

This section presents the linkage analysis, which establishes the relationship between the pollutant loadings from identified sources and existing water quality. This relationship can then be used to set numeric targets that ensure attainment of beneficial uses.

For this TMDL, the proposed FIB load and wasteload allocations will protect the water contact recreation beneficial use because:

- Fecal waste from warm-blooded animals can contain pathogens;
- FIB are present in fecal waste from warm-blooded animals and are routinely used as a monitoring surrogate for fecal pathogens. Thus, it is appropriate to use FIB as a surrogate to measure pathogen impairment of beneficial uses;
- The proposed numeric targets are based on U.S. EPA's bacterial water quality objectives for water contact recreation waters; and,
- The proposed FIB allocations are based on the proposed numeric targets for FIB for water contact recreation;
- U.S. EPA's bacterial water quality objectives are based on an acceptable health risk for recreational waters of 32 illnesses per 1,000 exposed individuals, and therefore are protective of the water contact beneficial use.

Therefore, achievement of the proposed pollutant load and wasteload allocations listed in Table 8.2 will ensure the protection of the water quality and water contact beneficial use of Petaluma River.

10. IMPLEMENTATION PLAN

10.1 Overview

TMDLs are strategies to restore clean water. Implementation Plans, which specify actions needed to restore water quality and protect beneficial uses, are required under section 13242 of the Water Code. The Implementation Plan for reducing bacteria in the Petaluma River watershed relies on existing regulatory controls and the Water Board's authorities under the Water Code. The Plan specifies actions needed to attain the designated objectives or other protective targets (Section 6).

The Implementation Plan specifies actions needed to attain the TMDLs and the allocations for FIB. The Implementation Plan includes actions for which requirements are already in place, and some additional new actions. The new actions include requirements for:

- Confined animal facilities not currently enrolled under the Water Board's CAF WDR (Order No. R2-2016-0031) (e.g., horse boarding facilities);
- Grazing lands/grazing operations;
- Private sewer laterals;
- Vessel marinas;
- Homeless encampments; and
- Additional requirements for management of Onsite Wastewater Treatment Systems (OWTS), and municipal and Caltrans stormwater runoff.

Those actions for which requirements are already in place include:

- Compliance with wasteload allocations as effluent limitations as required by NPDES permit for the Ellis Creek Wastewater Treatment Facility;
- Reduction of sanitary sewer discharges by the measures required under the General Waste Discharge Requirements (WDRs) for sanitary sewer systems (State Water Board Order No. 2006-0003 DWQ); and
- Reduction of discharges from cow dairy facilities by measures required under the CAF WDR (Order No. R2-2016-0031) or conditional waiver of CAF WDR (Order No. R2-2015-0031).

The following sections provide additional detail on the actions expected under existing authorities, while also explaining new requirements.

10.2 Legal Authorities

The Water Board has the responsibility and authority for regional water quality control and planning according to the Water Code. The Water Board regulates point source pollution and nonpoint sources of pollution. The Water Board regulates point sources by implementing the National Pollutant Discharge Elimination System (NPDES) permit program, which permits point sources of pollution that discharge into waters of the United States. Nonpoint sources of pollution are addressed in California's Policy for Implementation and Enforcement of the Nonpoint Source Program (NPS Policy) (State Water Board 2004), which requires regulation of current and proposed nonpoint source discharges under Waste Discharge Requirements Orders (WDRs), conditional waivers of WDRs, Basin Plan discharge prohibitions, or some combination of these tools. The Water Code gives the Water Board authority to issue WDRs for both point and nonpoint sources of contamination.

10.3 Implementing Parties

Responsibility for reducing bacteria discharges will fall on several parties, including:

- Confined animal facilities owners/operators,
- Grazing lands owners/operators,
- Vessel marina owners/operators,
- Sonoma County,
- Marin County,
- City of Petaluma, and
- Caltrans.

The responsibility for achieving the TMDL and pollutant load allocations shall be shared among all the implementing parties. Cooperation is necessary not only to attain the TMDL targets but also to avoid duplicate actions, such as monitoring and reporting. To the extent possible, responsible entities should try to coordinate BMPs and ambient monitoring efforts.

10.4 Regulatory Tools

The Implementation Plan may be implemented through any of the following regulatory tools, or a combination of them, as needed, to address the sources of bacteria pollution causing or contributing to the impairment:

- California regulations governing discharges from confined animal facilities (Cal. Code Regs., tit. 27, § 22560 et seq.);
- The Water Board's General WDR Order for Confined Animal Facilities (Order No. R2-2016-0031) and waiver of WDR Order for existing Confined Animal Facilities (Order No. R2-2015-0031);
- The State Water Board's NPDES General Permit and WDRs for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (Order No. 2013-0001-DWQ; NPDES Permit No. CAS000004);
- The State Water Board's NPDES General Stormwater Permit and WDRs for State of California Department of Transportation (Order No. 2012-0011-DWQ, as amended

by Order No. WQ 2014-0006-EXEC, Order No. WQ 2014-0077-DWQ, and Order No. WQ 2015-0036-EXEC; NPDES No. CAS000003);

- The NPDES permit for wastewater discharges by the Ellis Creek Water Recycling Facility and its wastewater collection system (Order No. R2-2016-0014; NPDES permit No. CA0037810);
- The WDRs for Nutrients from Municipal Wastewater Discharges to San Francisco Bay (Order No. R2-2014-0014; NPDES permit No. CA0038873);
- The Statewide General Waste Discharge Requirements for Sanitary Sewer Systems, State Water Board Order No. 2006-0003 DWQ;
- The State Water Board's Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy) (Order NO. 2012-0032);
- The Water Board's guiding principles to all wastewater discharges from discrete sewerage systems, which states:
  - o The system must be designed and constructed so as to be capable of preventing pollution or contamination of the waters of the state or creating nuisance;
  - o The system must be operated, maintained, and monitored so as to continually prevent pollution or contamination of the waters of the state and the creation of a nuisance (Water Board 2018);
- Enforcement of Basin Plan Discharge Prohibition No. 15, which states: "it shall be prohibited to discharge raw sewage or any waste failing to meet waste discharge requirements to any waters of the Basin;"
- The provisions of Water Code section 13267, which authorizes the Regional Water Board's Executive Officer to require technical or monitoring program reports from dischargers; and
- The provisions of Water Code section 13263, which authorizes the Regional Water Board to issue individual WDRs to regulate discharges of waste from both point and nonpoint sources.

10.5 Implementation Actions

This Implementation Plan builds on management measures required by existing regulations and orders to reduce or eliminate bacteria discharges from identified potential sources of bacteria within the watershed (Table 7.1). Subsections below describe the implementation actions for controlling discharges from each of these sources (Table 10.1).

10.5.1 Ellis Creek Wastewater Treatment Plant

As discussed in Section 6, wastewater discharges from the Ellis Creek Wastewater Treatment Plant are not a likely source of FIB (pathogens) to the river because they are disinfected to levels well below the applicable bacterial water quality objectives. The current bacterial effluent limit for these discharges specifies that the geometric mean of *Enterococcus* concentration of all effluent samples in each calendar month shall not exceed 35 MPN/100 mL. However, the effluent monitoring results from March 2011 through April 2015 show the maximum geometric mean of *enterococcus* concentrations measured in the Plant's effluents discharges to the river never exceeded 7 MPN/100 mL, which is far below the applicable effluent limits or bacterial water quality standards.

As such, the Elis Creek Wastewater Treatment Plant is not expected to implement any additional FIB abatement measures beyond what is already required by its existing wastewater discharge permit.

10.5.2 Sanitary Sewer Collection Systems

10.5.2.1 Public Portions

Implementation of actions to eliminate sanitary sewer system leaks is supported by the Basin Plan's prohibition of discharges of raw sewage or any waste failing to meet waste discharge requirements to any waters of the Basin (Water Board 2018). In addition, a regulatory program is in place to address sanitary collection system releases, the Statewide General Waste Discharge Requirements (WDR) for Sanitary Sewer Systems, State Water Board Order No. 2006-0003 DWQ. All public entities that own or operate sanitary sewer systems greater than one mile in length and that collect and/or convey untreated or partially treated wastewater to a publicly owned treatment facility in the State of California are required to apply for coverage under the WDR and comply with its requirements.

The WDR contains provisions for SSO prevention and reduction measures, including the following:

- Development and implementation of sanitary sewer system management plans (SSMPs);
- Prohibition of any SSO that results in a discharge of untreated or partially treated wastewater to waters of the United States, or creates a nuisance as defined in California Water Code Section 13050(m);
- Requirement for dischargers to take all feasible steps to eliminate SSOs and to properly manage, operate, and maintain all parts of the collection system; and
- Requirement for a monitoring and reporting plan.

In short, sewer collection system authorities are responsible for finding and repairing causes of leaks and overflows of sanitary waste, regardless of the existence of an applicable TMDL. To achieve the TMDL numeric targets for Petaluma River, responsible entities must amend their SSMPs (or other sewer collection system Operations and Maintenance Plans required by applicable permits or orders) as needed to prioritize the investigation and repair of faulty sewer pipes, pumps, and other infrastructure according to their proximity to the river and its tributaries, the magnitude of leak or overflow risk, and similar considerations.

Further, inspectors for both the sewer collection system and the municipal stormwater entity must identify cross-connections between sewer and stormwater piping and take action to eliminate them. Details and timelines of the implementation are found in Table 10.1.

10.5.2.2 Private Sewer Laterals

In order to achieve the TMDL targets, it is also necessary to address leaks from private sewer laterals. Creation of private sewer lateral repair/replacement ordinance(s) or management programs by the local responsible parties (City of Petaluma and County of Sonoma) are a necessary implementation element and needed to prevent sewage discharges from this source category.

10.5.3 Onsite Wastewater Treatment Systems (OWTS)

Implementation of actions to eliminate OWTS waste discharges is supported by Prohibition 15 of the Basin Plan, which prohibits discharges of raw sewage or any waste failing to meet waste discharge requirements to any waters of the Basin. In addition, we will use the statewide regulatory program for siting, design, operation, and maintenance of OWTS (OWTS Policy) and provisions of Water Code section 13267 to address potential waste discharges from the OWTS in the Petaluma River watershed.

The OWTS Policy provides a multi-tiered strategy for management of OWTS in California. For all OWTS located near a water body that has been listed as impaired due to FIB or nutrients pursuant to Section 303(d) of the Clean Water Act (e.g., Petaluma River), an Advanced Protection Management Program (APMP) is the minimum required management program. Local agencies who are responsible for regulating OWTS (e.g., Sonoma and Marin Counties) are authorized to implement APMPs in conjunction with an approved Local Agency Management Program (LAMP) (State Water Board 2012). The geographic area for each water body's APMP is defined by the applicable TMDL (e.g., Petaluma River Bacteria TMDL). The requirements of an APMP will be in accordance with a TMDL Implementation Plan, if one has been adopted to address the impairment (State Water Board 2012). This TMDL outlines a framework for creating an APMP by Sonoma and Marin Counties for incorporation into their respective LAMPs in order to address OWTS discharges in the Petaluma River watershed (see Table 10.1).

Utilizing the above regulatory tools, the entities with regulatory jurisdiction over the OWTS in the Petaluma River watershed--the Counties of Sonoma and Marin--must inspect, evaluate, and require any needed maintenance or repairs to these systems to ensure they are not and will not be discharging any waste that could cause or contribute to bacteria impairment of the river.

Some potential control measures for preventing waste discharges from OWTS are:

- Requiring and conducting routine inspection of the systems by a licensed professional;
- Requiring and conducting regular maintenance of the systems per industry standards;
- Requiring and conducting any necessary repairs of the systems; and
- Educating the system owners on how to properly maintain their systems as well as how to look for signs of failing systems.

Given the relatively large number of OWTS in the watershed (approximately 595), the implementing entities are expected to develop a prioritized plan that addresses these systems in multiple phases according to the level of risk they present to the water quality of the river. Some potential factors that can be used to rank and prioritize the OWTS are:

- Proximity to the river or its tributaries,
- System's age and maintenance history
- Significance of site constraints (slope, substrate, etc.)

10.5.4 Vessel Marinas

The Basin Plan discharge prohibition 15 also applies to vessel marinas in the Petaluma River, and prohibits any discharge of human waste, including raw sewage or inadequately treated waste, to the river from these sources. Section 4431 of the Health and Safety Code prohibits dumping of sewage into marinas and yacht harbors from any vessel tied to a dock, slip, or wharf that has toilet facilities available for persons on such vessels.

Further, the Water Board has the authority to require all vessel terminals be equipped with adequate sewage disposal facilities (Harbors and Navigation Code Section 775-786). As discussed in Section 6, a study of the adequacy of sewage disposal facilities at the marinas in the San Francisco Bay Area conducted by the California Department of Boating and Waterways in 2004 recommended installation of additional sewage pumpout or dump stations at the two marinas on the Petaluma River (Department of Boating and Waterways 2004). To our knowledge, these actions have not yet occurred.

To reduce bacteria loads related to vessels, the marina owners or operators are required to evaluate and ensure the adequacy and proper performance of sewage collection and disposal systems for the two vessel marinas. Further, these entities should enhance their education and enforcement of "no dumping" and cleanout rules.

10.5.5 Homeless Encampments

Currently, the City of Petaluma has a program called the Homeless Outreach Services Team (HOST) to address homeless encampments issues. This team started in January of 2016 with one full time police officer dedicated to outreach and enforcement of the day to day issues that involve Petaluma's homeless community. It has grown to two officers and received a Cal-Recycled grant to assist in the removal of trash. In addition to providing the homeless resources and support, they locate encampments throughout the City of Petaluma and enforce laws violated in those camps such as possession of controlled substances, possession of stolen property, trespassing, camping, littering and disposing of hazardous waste when appropriate. Each camp, when located, is posted with a 72 hour notice to vacate before the site is scheduled for cleanup (Wilson 2017).

Homelessness is a serious social issue in many communities and often a sensitive public policy issue that stormwater and water resource managers have limited experience in addressing. Based on experience gained in Southern California addressing this issue (Geosyntec 2012), recommendations for an effective homeless encampment enforcement/outreach program may include:

- Collaboration with other agencies;
- Targeted MS4 channel cleanups;
- Enhancing programs to reduce the number of homeless people in encampments;
- Establishing ordinances that reduce encampments near water bodies; and
- Enforcing new and existing laws to decrease the negative impact on water quality.

Additional stormwater control management strategies include:

- Support of city shelters and services to reduce homelessness;
- Periodic cleanup of homeless camps near streams with BMPs for trash, and human waste management;
- Police enforcement;
- Providing public restrooms; and
- Partnering with non-governmental organizations to address homelessness.

10.5.5.1 BMPS for Disinfection/Sanitation of Homeless Encampments

In regards to proper BMPs for the sanitation of public right of-ways (e.g., sidewalks, streets, and gutters), there are long-proven and simple BMPs that are available. In short, these established practices include the following sequence of actions: plug stormdrains and surround the area with berms; sweep up solids, trash, and debris; power wash the area; collect all wash water; and lastly, disposal of wash water to sanitary sewer (and when appropriate, disposal to landscaping).

These BMPs do not include the use of chemicals for sanitization purposes. Where it is necessary to use chlorine bleach or other chemicals to sanitize these areas, typically, sanitation procedures include a final application of chemical solution (e.g. disinfectant). Subsequent rainfall could carry the chemical into the storm drain. Therefore, the procedures must include appropriate measures to prevent such chemicals from entering stormdrains or waterbodies. More information and details about this can be found in a notification letter we issued to municipalities within the region regarding homeless camp cleanup, in 2017 (https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/Sidewalk-Sanitizing-Hep-A October 2017.pdf).

The responsible entities with jurisdiction over encampment areas (e.g., City of Petaluma, and Caltrans) are required to implement appropriate measures to prevent contamination of the river and its tributaries by waste discharges from homeless encampments.

10.5.6 Confined Animal Facilities (CAFs)

We intend on controlling waste discharges from confined animal facilities (CAFs) including horse facilities, and cow dairy facilities, using the Water Board's General Waste Discharge Requirements Order for Confined Animal Facilities, Order No. R2-2016-0031 (CAF Order). The CAF Order applies to existing and any future CAFs in the Petaluma River watershed, and owners or operators of the CAFs within the watershed are required to obtain coverage and comply with its requirements.

The management measures required by the CAF Order include the following waste discharge prohibitions:

- The collection, treatment, storage, discharge, or disposal of waste at the facility shall not cause a condition of nuisance, contamination, or pollution of surface water or groundwater as defined in Water Code section 13050;
- The discharge of waste from a CAF, which causes or contributes to an exceedance of any applicable water quality objective in the Basin Plan, or any applicable State or federal water quality criteria, or violation of any applicable State or federal policies or regulations, is prohibited;
- The direct and indirect discharge of waste, including stormwater contacting wastes, from the animal production or housing area to any surface waters, or tributary thereof, is prohibited; and
- The application of manure or process water to a land application area in a manner that results in the discharge of waste to surface water is prohibited.

The CAF Order provisions require property owners or operators to develop and implement at a minimum a Ranch Water Quality Plan (Ranch Plan) and a Monitoring and Reporting Program. The purpose of the Ranch Plan is to ensure that the CAF is designed, constructed, operated, and maintained so that wastes, nutrients, and contaminants generated by the facility are managed to prevent adverse impacts to surface water and groundwater quality. The Ranch Plan must evaluate existing facilities and pollutant sources/problems and describe how these sources will be controlled utilizing BMPs depending on the type and size of the confined animal facility. The plan must detail how the facility owner or operator maintains compliance with CAF Order discharge prohibitions and discharge specifications for all confined areas, pastures, and waste/compost application areas.

At a minimum, the Ranch Plan must demonstrate how the facility complies with or will comply with the detailed requirements concerning following elements:

- Facility design,
- Pasture and land management,
- Application of manure to land, and
- Flood protection.

The Monitoring and Reporting Program component of the CAF Order allows the Regional Water Board to evaluate compliance with the terms and conditions of the Order by requiring that CAF owners and operators comply with regular monitoring, sampling, and record-keeping requirements. If sampling data indicate that pollutant concentrations are above established benchmarks, then the CAF owners or operators must take immediate actions to identify causes of pollution and correct the problem.

10.5.7 Grazing Lands/Operations

Currently, the grazing lands/operations in the Petaluma River watershed are not regulated by the Water Board. However, as stated above, Water Board has the authority to regulate nonpoint source discharges, such as these, under Waste Discharge Requirements Orders (WDRs), conditional waivers of WDRs, Basin Plan discharge prohibitions, or some combination of these tools.

Since 2008, the Water Board has implemented a grazing program for the control of discharges from grazing lands in the Tomales Bay watershed, and in 2011 created another for the Napa River and Sonoma Creek watersheds, as part of implementing bacteria and sediment TMDLs completed for these watersheds. Therefore, regulatory options for grazing management in the Petaluma River watershed include extending the geographic scope of either existing grazing program to include the Petaluma River watershed, or to develop a new program specific to the Petaluma River watershed.

The details of a Grazing Program for the Petaluma River watershed, including the compliance schedule and appropriate management practices, will be determined during permit development, which will include participation and input from local stakeholders.

Based on available information and experience gained implementing other grazing programs and in keeping with the NPS Policy and the Water Code, the Petaluma River watershed Grazing Program could require owners or operators of grazing lands to:

- Complete a comprehensive inventory and assessment of natural resources, rangelands, and management practices through a ranch plan assessment process. This includes documenting all bacteria sources and evaluating stream and river riparian corridors and water bodies;

- Inventory and assess all BMPs being implemented such as: animal fencing, providing off-stream water sources, maintaining adequate amounts of residual dry matter (RDM);
- Identify where changes to management practices are necessary to control bacteria and nutrients discharges, or where new or additional BMPs are needed; and
- Develop an implementation schedule for actions identified in the ranch plan.

10.5.8 Domestic Pets

Proper disposal of pet waste (e.g., dog and cat waste) is a basic component of FIB control plans in developed areas, such as the Petaluma River watershed. This is especially true for the residential and parkland areas of the watershed near the river or its tributaries. The responsible parties with jurisdictions over these areas—City of Petaluma and Counties of Sonoma and Marin--must implement appropriate BMPs to control FIB and nutrient discharges caused by improper pet waste disposal in accordance with the General Permit for Waste Discharge Requirements for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems (MS4) (Order No. 2013-0001-DWQ, NPDES No. CAS000004) and/or Water Code section 13267.

Elements of pet waste control programs may include:

- Posting park, trail, and sidewalk signs regarding pet waste disposal requirements and leash laws;
- Providing disposal bags and providing and servicing waste cans at convenient intervals on sidewalks, trails, and in open space areas;
- Developing and implementing a visual inspection and cleanup plan for high pet waste accumulation areas, especially before winter rains;
- Allowing natural riparian buffers to grow alongside streams to dissuade pet access;
- Providing education and outreach to pet owners on proper pet waste disposal by:
    - Distributing a mailer with an informational brochure to residents and businesses describing proper pet waste management,
    - Providing educational materials regarding the impact of improperly disposed pet waste,
    - Establishing a public pet waste management stakeholder group (e.g., formal or informal dog owners club), and
    - Creating and implementing a pre-rain pet waste cleanup email alert to residents;
- Developing pet waste ordinances and leash laws; and
- Cleaning out storm drain systems.

In association with FIB control measures in Southern California, the degree of behavior change resulting from pet waste outreach campaigns has been measured. A report on the Dog Waste Management Plan for Dog Beach and Ocean Beach found that public compliance with the "scoop the poop" policy was highly dependent on awareness of the policy and availability of waste disposal bags and trash cans (City of San Diego 2004). Studies in San Diego have shown that installation of pet waste stations have resulted in a 37% reduction in the total amount of pet waste in city parks (Urban Water Resources Research Council 2014).

10.5.9 Municipal Stormwater Runoff

The federal Clean Water Act requires municipalities to obtain NPDES permits for discharges of municipal runoff from their Municipal Separate Storm Sewer Systems (MS4s). For the City of Petaluma, County of Sonoma, and County of Marin (permittees) MS4 requirements have been adopted in the General Permit for Waste Discharge Requirements for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems (MS4) (Order No. 2013-0001-DWQ; NPDES Permit No. CAS000004).

Under this permit, each Permittee is individually responsible for adoption and enforcement of ordinances and policies, for implementation of control measures or best management practices (BMPs) needed to prevent or reduce pollutants in stormwater, and for funding its own capital, operation, and maintenance expenditures necessary to implement such control measures or BMPs.

The MS4 permit has requirements related to bacteria pollution prevention, including "illicit discharge detection and elimination" provisions that require Permittees to (1) address stormwater and non-stormwater pollution associated with, but not limited to sewage, wash water, discharges of pet waste, etc., and (2) prohibit, investigate, and eliminate illicit connections and discharges to storm drains.

The MS4 permit requires Permittees to notify the Water Board promptly when discharges are causing or contributing to an exceedance of an applicable water quality standard. Additionally, it requires treatment units for reducing pollutants in runoff to be installed at the time the property is developed or redeveloped, and requires water quality monitoring.

The bacteria control measures required by MS4 permits can be helpful in identifying and controlling bacteria inputs in stormwater discharges and dry weather flows. However, the numbers and locations of control measures required by the current MS4 permit may not achieve sufficient pollution reduction to achieve the TMDL numeric targets. As such, MS4 permittees are required to develop a plan that describes BMPs currently being implemented, and additional BMPs that will be implemented to prevent or reduce discharges of bacteria to storm drain systems to attain TMDL wasteload allocations. The San Francisco Bay Water Board will include requirements from this plan in reopened or reissued permits to attain wasteload allocations based on implementation of specified BMPs. The Water Board will not include numeric limits, based on the wasteload allocations, in the MS4 permit provided the permittees demonstrate that they have fully implemented technically feasible, effective, and cost-efficient BMPs to control all controllable sources of FIB to, and discharges from, their storm drain systems.

A menu of BMPs to address bacteria and nutrient discharges in urban runoff could include:

- Structural BMPs
    - Vegetated treatment systems
    - Local infiltration and rainwater capture systems
    - Media filtration
    - Diversion of runoff to sanitary sewer
- Non-structural BMPs
    - Storm drain system and structural BMP cleaning and maintenance
    - Street cleaning
    - Administrative controls
        - Better enforcement of existing pet or domestic animals waste disposal ordinances;
        - Better enforcement of existing litter ordinances, posting additional signage and proposing stricter penalties for littering;
        - Enforcing ordinances for commercial, industrial and multi-family garbage control, including requirements to cover trash enclosures;
        - Developing and enforcing guidelines for portable toilets and recreational vehicle dumping, and other actions of an administrative nature.
    - Outreach and Education.

10.5.10 Stormwater Discharges from Caltrans' Roads/Properties

As stated above, pursuant to the Federal Clean Water Act, storm water permits are required for discharges from a municipal separate storm sewer system (MS4). U.S.EPA defines an MS4 as a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned or operated by a State (40 CFR 122.26(b)(8)). The California Department of Transportation (Caltrans) is responsible for the design, construction, management, and maintenance of the State highway system, including freeways, bridges, tunnels, Caltrans' facilities, and related properties, and is subject to the permitting requirements of the Clean Water Act. Caltrans' discharges consist of storm water and non-storm water discharges from State owned rights-of-way.

The State Water Resources Control Board has issued a statewide Permit for Caltrans which regulates all discharges from Caltrans MS4s, maintenance facilities, and construction activities (NPDES No. CAS000003). As discussed in Section 6, stormwater discharges from Caltrans' roads in the Petaluma River watershed are a potential source of FIB due to discharges of human waste from existing or future homeless encampments. Therefore, Caltrans is required to implement appropriate BMPs to ensure waste discharges from homeless encampments within its right-of-way are appropriately addressed.

Such BMPs may include:

- Measures to prevent establishment of homeless encampments;
- Periodic cleanup of homeless camps near streams with BMPs for trash, and human waste management;
- Targeted MS4 channel cleanups; and,
- Providing public restrooms facilities.

10.6 Adaptive Implementation

Periodically, the Water Board staff will holistically evaluate information from the implementation actions, water quality monitoring results, and scientific literature, and assess progress toward attaining TMDL targets and load allocations. The Water Board staff will also determine if additional implementation actions would be beneficial or practicable to achieve water quality objectives. The Water Board may choose to adapt the TMDL and Implementation Plan, as needed, to incorporate new and relevant information such that effective and efficient measures can be taken to achieve the allocations.

10.7 Water Quality Monitoring

Ongoing water quality monitoring in the watershed will be needed to:

- Further identify and characterize the source areas or land uses with the greatest bacteria contributions,
- Determine if implementation actions effectively reduce bacteria and nutrients discharges from source areas,
- Assist responsible entities as they adaptively implement this plan, i.e., as they take additional actions to reduce bacteria discharges from different sources over time, and
- Determine if progress towards attainment of the TMDL numeric targets are being made.

To that end, the responsible parties are individually or jointly responsible for developing and implementing a comprehensive monitoring plan to 1) better characterize FIB contributions from their sources/jurisdictions, identify hotspots, and assess BMP effectiveness; and 2) assess compliance with the wasteload allocations in the TMDL. The responsible parties are required to submit a monitoring plan for achieving these monitoring tasks within one year of the TMDL plan adoption by the Water Board. The general expectations for the two types of monitoring are discussed below.

10.7.1 Pollution Characterization and BMP Effectiveness Monitoring

The purpose of the characterization and effectiveness monitoring is to better characterize FIB contributions from specific sources/areas and to evaluate control measure effectiveness. The characterization monitoring should provide data to:

- Characterize FIB discharges in subwatersheds and storm drain outfalls. Results of the investigation may be used to drive future control measure actions.
- Establish baseline (or current) conditions against which future monitoring results can be compared following new or ongoing control measure implementation.

The characterization and effectiveness monitoring plan should commence two years after the effective date of the TMDL and be conducted every other year thereafter. The monitoring should assess the magnitude of applicable FIB constituents used as the TMDL numeric targets (i.e., *E.coli* and *Enterococcus*), however source-specific fecal bacteria (e.g., *Bacteroides*) sampling can also be included to better identify and track sources of fecal pollution in the watershed. It is anticipated that a minimum of ten monitoring events per year would be necessary to adequately characterize FIB levels during various flow conditions in both dry and wet seasons. At a minimum, one sampling station should be located in each creek reach/subwatershed, such that FIB contributions from each of the Petaluma River's major tributaries/subwatersheds are distinguished. In addition, monitoring of FIB discharges from some of the stormwater outfalls within the watershed is needed to characterize and identify their contributions and reductions resulting from BMPs.

Spatially intensive hotspot monitoring along particular reaches with consistent exceedances could be used to identify proximate sources in urban areas such as urban stormwater runoff, dry season discharges from storm drains, dog walking areas or parks, and homeless encampments.

The characterization and effectiveness monitoring should be iterative in nature and allow for flexibility of design and details in future years. In subsequent years of monitoring, based on the results of the previous monitoring, alternative sampling stations may be targeted, sampling intensities may be modified, and sampling frequencies may be adjusted, as necessary.

10.7.2 Compliance Monitoring

The compliance monitoring will assess attainment of the TMDL numeric targets and allocations for the river. The compliance points for these assessments will be at main stem stations: 98, 205, 260, and 350(Figure 5.1). The compliance monitoring should commence and be completed two years after the effective date of the TMDL and be conducted every other year thereafter. It should include appropriate constituents (i.e., *Enterococcus for stations 98, 205, and 260; and, E. coli* for station 350) and sampling event frequencies (i.e., six-week sampling series to assess compliance with the geometric mean targets) to allow parties to determine whether the TMDL numeric targets and allocations for FIB are attained in both dry and wet season conditions.

10.8 Implementation Plan Summary and Schedule

Table 10.1 summarizes implementation and monitoring actions, lists the implementing parties, and provides the schedule for implementation. The implementation schedule allows time for the implementing parties to identify and implement measures that are necessary to control FIB discharges resulting in exceedances of water quality objectives. The plan allows a 10 (ten) year timeframe to fully implement the TMDL and to meet the load and wasteload allocations.

Table 10.1. Implementation Actions and Schedule

Source/ Activity	Implementation Actions	Implementing Party	Schedule
Ellis Creek Wastewater Treatment Plant	Comply with the NPDES permit for waste discharge	City of Petaluma	Ongoing
Sanitary Sewer Collection Systems	Comply with Statewide General Waste Discharge Requirements for sanitary sewer systems	City of Petaluma; County of Sonoma	Ongoing
	Phase I-Submit an enhanced Sewer System Management Plan (SSMP) that prioritizes sewer system inspections and repairs in areas within 0.2 mile (1000 feet) of the river or its major tributaries. Include a diagram of prioritized infrastructure, a time schedule for implementing short- and long-term plans, and, as necessary, a schedule for developing the funds needed for the capital improvement plan	City of Petaluma; County of Sonoma	Within one year of the effective date of the TMDL
	Complete inspections and repairs identified in Phase I.	City of Petaluma; County of Sonoma	Within five years of the effective date of the TMDL
	Establish and implement a private sewer lateral inspection/repair/replacement program	City of Petaluma; County of Sonoma	Within five years of the effective date of the TMDL
	Phase II-If TMDL targets are not met, submit an enhanced SSMP that prioritizes sewer system inspections and repairs in areas within 0.4 mile (2000 feet) of the river or its major tributaries. Include a diagram of prioritized infrastructure, a time schedule for implementing short- and long-term plans, and, as necessary, a schedule for developing the funds needed for the capital improvement plan	City of Petaluma; County of Sonoma	Within six years of the effective date of the TMDL
	Complete inspections and repairs identified in Phase II.	City of Petaluma; County of Sonoma	Within 10 years of the effective date of the TMDL
	Report results of implementation activities to the Water Board	City of Petaluma; County of Sonoma	Annually, beginning on the second year after the effective date of the TMDL

Table 10.1. Implementation Actions and Schedule			
Source/ Activity	**Implementation Actions**	**Implementing Party**	**Schedule**
Sanitary Sewer Collection Systems & Urban Stormwater Runoff	Develop and initiate a protocol to enhance efforts to identify and correct illicit connections to the storm drain system	Sanitary sewer collection systems authorities; Municipal stormwater entities	Within two years of the effective date of the TMDL
	Report results of implementation activities to the Water Board	Sanitary sewer collection systems authorities; Municipal stormwater entities	Annually starting after the effective date of the TMDL
Onsite Wastewater Treatment Systems (OWTS)	Comply with the State Water Board's Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy)	County of Sonoma; County of Marin	Ongoing
	Submit an Advanced Protection Management Plan (APMP) that prioritizes OWTS evaluations/inspections in areas within 100 feet of the river or its major tributaries. Include a map and list of prioritized OWTS and a time schedule for their evaluation/inspections and reporting of the results	County of Sonoma; County of Marin	Within one year of the effective date of the TMDL
	Complete evaluations/inspections and ensure proper functioning and compliance of at least 50% of the OWTS in areas within 100 feet of the river or its major tributaries	County of Sonoma; County of Marin	Within 3 years of the effective date of the TMDL
	Complete evaluations/inspections and ensure proper functioning and compliance of all OWTS in areas within 100 feet of the river or its major tributaries	County of Sonoma; County of Marin	Within five years of the effective date of the TMDL
	If TMDL targets not met, submit a revised APMP that prioritizes OWTS evaluations/inspections in areas within 200 feet of the river or its major tributaries. Include a map of prioritized OWTS and a time schedule for their evaluation/inspections and reporting of the results	County of Sonoma; County of Marin	Within six years of the effective date of the TMDL

Table 10.1. Implementation Actions and Schedule			
Source/ Activity	**Implementation Actions**	**Implementing Party**	**Schedule**
	Complete evaluations/inspections and ensure proper functioning and compliance of at least 50% of the OWTS in areas between 100 and 200 feet of the river or its major tributaries	County of Sonoma; County of Marin	Within 8 years of the effective date of the TMDL
	Complete evaluations/inspections and ensure proper functioning and compliance of all OWTS in areas within 200 feet of the river or its major tributaries	County of Sonoma; County of Marin	Within 10 years of the effective date of the TMDL
	Report results of all implementation activities to the Water Board	County of Sonoma; County of Marin	Per timeline specified in the APMP
Vessel Marinas	Begin or boost "no dumping" education efforts to vessel owners	Marina owners or operators	Within six months of the effective date of the TMDL
	Submit a plan and implementation schedule, acceptable to the Executive Officer, for: 1) Evaluating and ensuring adequacy and proper performance of sewage collection systems (sewage dump stations, sewage pumpout stations, sewer lines, etc.) for vessel marinas, 2) Installing, as needed, an adequate number of sewage pumpout and dump stations. If no new sewage pumpout and dump stations are needed, provide justification as to why they are not needed.	Marina owners or operators	Within one year of the effective date of the TMDL
	Complete implementation of the above plan	Marina owners or operators	Within five years of the effective date of the TMDL
	Report results of implementation activities to the Water Board	Marina owners or operators	Annually, beginning on the second year after the effective date of the TMDL

Table 10.1. Implementation Actions and Schedule			
Source/ Activity	**Implementation Actions**	**Implementing Party**	**Schedule**
Confined Animal Facilities (CAFs)	Obtain coverage and comply with the Regional Water Board's General Waste Discharge Requirements Order for Confined Animal Facilities (CAF Order)	Owners or operators of CAFs, as applicable (including but not limited to dairies, and horse facilities)	Obtain coverage no later than 120 days from the effective date of the TMDL; Comply with Order requirements per timeline specified in the Order
	Produce a Ranch Water Quality Plan, or other plans, in compliance with the updated CAF Order	Owners or operators of CAFs	Per timeline specified in the Order
	Implement BMPs and management actions specified in the previously developed Ranch Water Quality Plan, or other plans, if required	Owners or operators of CAFs	According to schedule in the Ranch Water Quality Plan(s) or other plans
Grazing Lands/ Operations	Obtain coverage and comply with the Regional Water Board's upcoming General Waste Discharge Requirements Order for grazing lands/operations in the Petaluma River watershed (Grazing Order)	Owners or operators of grazing lands/operations	Obtain coverage no later than 120 days from Grazing Order adoption by the Water Board; Comply with Order requirements per timeline specified in the Order
	Produce a Ranch Water Quality Plan, or other relevant plans, in compliance with the upcoming Grazing Order	Owners or operators of grazing lands/operations	Per timeline specified in the Grazing Order
	Implement BMPs and management actions specified in the previously developed Ranch Water Quality Plan, or other plans, if required	Owners or operators of grazing lands/operations	Per timeline specified in the Grazing Order

Table 10.1. Implementation Actions and Schedule

Source/ Activity	Implementation Actions	Implementing Party	Schedule
Municipal Stormwater Runoff	Submit a plan, based on provisions of the MS4 permit and Water Code section 13267, to the Regional Water Board, acceptable to the Executive Officer, which describes BMPs being implemented and additional BMPs that will be implemented to prevent or reduce discharges of bacteria to storm drain systems to attain TMDL numeric targets. The plan shall include implementation methods, an implementation schedule, and proposed milestones. At a minimum, the plan should consider enhancing the following programs: • Illicit discharge detection • Pet waste management • Storm system cleaning • Site design (e.g., Low Impact Development)	Municipal MS4 Permittees (City of Petaluma; County of Sonoma, County of Marin)	Within one year of the effective date of the TMDL
	Complete implementation of the initial stormwater BMP plan	Municipal MS4 Permittees (City of Petaluma; County of Sonoma, County of Marin)	Within five years of the effective date of the TMDL
	If TMDL targets not met, submit an enhanced plan describing BMPs being implemented and additional BMPs that will be implemented to reduce discharges of bacteria to the river. The plan shall include an implementation schedule and milestone.	Municipal MS4 Permittees (City of Petaluma; County of Sonoma, County of Marin)	Within six years of the effective date of the TMDL
	Complete implementation of the enhanced stromwater BMP Plan.	Municipal MS4 Permittees (City of Petaluma; County of Sonoma, County of Marin)	Within 10 years of the effective date of the TMDL
	Provide a report on the status of the implementation activities. This may be accomplished as part of the annual reporting required by the MS4 permit.	Municipal MS4 Permittees (City of Petaluma; County of Sonoma, County of Marin)	Annually, beginning on the second year after the effective date of the TMDL

Table 10.1. Implementation Actions and Schedule			
Source/ Activity	**Implementation Actions**	**Implementing Party**	**Schedule**
Homeless Encampments	Implement appropriate pollution prevention measures related to homeless encampment abetment and cleanup on City of Petaluma and Caltrans properties within the Watershed	City of Petaluma; Caltrans	Commence activities within one year of the effective date of the TMDL
	Report results of implementation activities to the Water Board	City of Petaluma; Caltrans	Annually, beginning on the second year after the effective date of the TMDL
Water Quality Monitoring	Submit a bacteria water quality monitoring plan for the Petaluma River and its tributaries, acceptable to the Water Board's Executive Office, to 1) better characterize bacteria contributions from different sources/areas; 2) evaluate effectiveness of the corrective measures; and, 3) assess attainment of the TMDL targets. The responsible parties should collaborate on a single cooperative plan. The monitoring plan shall be acceptable to the Executive Officer.	Municipal MS4 Permittees (City of Petaluma; County of Sonoma, County of Marin)	Within one year of the effective date of the TMDL
	Submit a report on the status of all water quality monitoring activities. Include an assessment of water quality monitoring data and any newly developed, enhanced, or implemented water quality monitoring actions	Municipal MS4 Permittees (City of Petaluma; County of Sonoma, County of Marin)	Every other year, starting one year after the commencement of the water quality monitoring program

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