California Regional Water Quality Control Board

San Francisco Bay Region

Total Maximum Daily Load for Pathogens in the Napa River Watershed

Project Report
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EXECUTIVE SUMMARY

The Napa River and its tributaries are listed on the Federal Clean Water Act, Section 303(d) list as impaired by pathogens. They are also listed as impaired by sediment and nutrients. The Clean Water Act Section 303(d) requires states to establish Total Maximum Daily Loads (TMDLs) for pollutants causing water quality impairments to ensure that impaired waterbodies attain their beneficial uses. The goal of this TMDL is to assess pathogen sources in this watershed, and to identify and implement measures to reduce pathogen loading.

Problem Definition

Elevated levels of fecal bacteria have been observed in the Napa River since the 1960s. These bacteria indicate the presence of fecal contamination and attendant health risk to recreational users of the river from water-borne pathogens. Past and current bacterial water quality studies in the Napa River watershed provide a consistent picture of widespread, but moderate and somewhat localized pathogen impairment. Water quality objectives are exceeded at a number of locations in the watershed at all times of year.

Numeric Targets

The numeric targets (desired future conditions for the Napa River watershed) proposed for this TMDL are based on U.S. EPA's recommended bacterial criteria for recreational waters as cited in the San Francisco Bay Regional Water Quality Control Board's (Water Board's) Basin Plan:

- Geometric mean E. coli density of 126 CFU/100 mL;

- Ninetieth percentile E. coli density of 406 CFU/100 mL; and

- Zero discharge of untreated human waste to the Napa River and its tributaries or to groundwater with direct through flow to these surface waters.

The third target is consistent with the Basin Plan's region-wide prohibition against the discharge of raw sewage.

Source Assessment

Several studies in the Napa River watershed indicate that the following sources likely contribute significant, controllable pathogen loads in the watershed:

- Faulty on-site sewage treatment systems (OSDSs; septic systems)
- Failing sanitary sewer lines
- Municipal runoff
- Cattle grazing

Equestrian facilities may also contribute to pathogen loading at some locations in the watershed. Monitoring records indicate that discharge from the four publicly owned municipal wastewater treatment works (POTWs) in the watershed do not contribute significant pathogen loads. Wildlife do not constitute a widespread pathogen problem, but may be a significant source on a limited, localized basis.

TMDLs

This report proposes density-based fecal coliform concentrations (number of organisms per unit volume) as Total Maximum Daily Loads for the Napa River watershed. These TMDLs, applicable year-round, are listed in the following table.

Total Maximum Daily Loads for the Napa River Watershed	
Indicator	**TMDL (CFU/100 mL)[a]**
E. coli	Geometric mean < 126 90^{th} percentile < 406
[a]Based on a minimum of five samples collected within a 30-day period.	

Load Allocations

The table below presents the density-based pathogen load allocations proposed for each pathogen source category in the Napa River watershed. These allocations are not additive, and will apply year-round to the different source categories of pollution in the watershed.

Density-Based Pollutant Load Allocations for Different Pollution Source Categories		
Categorical Pollutant Source	**E. coli Density, CFU/100 mL**	
	Geometric Mean	90^{th} Percentile
OSDSs	0	0
Sanitary Sewer Systems	0	0
Municipal Runoff	126	406
Cattle Grazing	126	406
Equestrian Facilities	126	406
Wildlife	126	406

Proposed wasteload allocations for each of the four POTWs that discharge to the Napa River are not specified by source category, but rather by individual discharger. Allocations are the effluent limits specified in each POTW's discharge permit, as shown in the following table:

Pollutant Wasteload Allocations for POTWs	
Facility	**Effluent Limit—Median, CFU/100 mL**
Napa Sanitation District	35 enterococci
Town of Yountville	2.2 total coliform
City of St. Helena	23 total coliform
City of Calistoga	23 total coliform
City of American Canyon	2.2 total coliform
Napa River Reclamation District #2109	240 total coliform

Linkage Analysis
An essential component of developing a TMDL is to establish a relationship (linkage) between pollutant loadings from various sources and the numeric targets chosen to measure the attainment of beneficial uses. For this TMDL, the proposed load allocations protect the beneficial uses (the linkage is established) because:

- The proposed density-based load allocations are the same as, or more stringent than proposed numeric water quality targets;
- The proposed numeric targets are the same as current U.S. EPA recommended bacterial water quality criteria for recreational waters; and
- The U.S. EPA recommend are conservatively based on epidemiological studies (U.S. EPA, 2002) and are protective of beneficial uses.

Implementation Plan
The implementation plan presented in this report provides a general description of proposed actions necessary to achieve water quality objectives. Actions are proposed for each potential controllable pathogen source category identified in the source assessment: septic systems, sanitary sewer line failure, municipal runoff, and livestock. Proposed actions generally involve identification of sources, implementation of actions to reduce these sources, and reporting of progress in source reduction activities. Many of these actions may be accomplished through participation in ongoing or emerging Water Board or third party programs.

A more detailed implementation plan will be presented in the Basin Plan amendment and accompanying staff report for this TMDL. A time schedule for these actions, and a description of the compliance monitoring and surveillance to be undertaken to ensure successful implementation. The final implementation plan will be developed in close coordination with stakeholders. Water Board staff will make an effort to discuss source control actions with all interested stakeholders and seek their input in regard to cost and feasibility.

If after five years the Water Board determines that load and density reductions are being achieved as management measures are implemented, then the recommended appropriate course of action would be to continue management measure implementation and compliance oversight. If it is determined that all proposed control measures have been implemented, yet the TMDL is not achieved, further investigations will be made to determine whether: 1) the control measures are not effective; 2) the high levels of indicator bacteria are due to uncontrollable sources; or, 3) the TMDL is unattainable.

1. INTRODUCTION

The federal Clean Water Act requires states to identify impaired waters and the pollutants causing those impairments. This list of water bodies is often referred to as the "303(d) list" (referencing the requirement in section 303(d) of the Clean Water Act). The Clean Water Act also requires states to establish Total Maximum Daily Loads (TMDLs) for the listed pollutants causing the impairments. The Napa River watershed is listed as impaired by sediment, nutrients, and pathogens. This report addresses pathogen impairment. A separate sediment TMDL project report has been developed for release simultaneously with this report. Data collection and analysis are still being conducted for the nutrient TMDL, with a nutrient project report scheduled for late 2006.

TMDLs are essentially cleanup or restoration plans for a waterbody that target the specific pollutants causing the impairment of the listed water body. Essential components of TMDLs include: numeric target(s) that define the desired condition of the waterbody; the maximum amount of pollutant(s) or stressor(s) the waterbody can tolerate while meeting these targets; identification of the sources of the pollutant(s) reaching the waterbody; and allocations of pollutant loads or load reduction responsibility to these sources. TMDLs must also include implementation plans describing necessary pollution prevention, control, and restoration actions to restore the water body and/or remove the impairment.

The California Regional Water Quality Control Board, San Francisco Bay Region (Water Board) is responsible for developing TMDLs in the San Francisco Bay region. A phased approach is typically employed for TMDL development. Early phases involve identifying key issues concerning the cause of the impairment and the information needed to understand how to resolve the impairment, meeting with stakeholders, and conducting studies and analyses.

This project report presents the results of early phases of the Napa River Pathogen TMDL, describing the water quality problem causing the impairment, sources of the pollutant reaching the impaired water body, and potential actions needed to restore or cleanup the water body. A primary purpose of this report is to provide an opportunity for stakeholders to comment on the scientific basis of the TMDL and on the preliminary implementation strategy. Stakeholder participation is essential for a successful TMDL, helping to ensure that the TMDL provides a "real solution to a real problem."

After obtaining stakeholder input, Water Board staff will develop a proposed amendment to the Water Board's Water Quality Control Plan (Basin Plan) and an accompanying staff report. The Basin Plan amendment is the means by which the Water Board formally establishes the TMDL. The amendment and staff report will contain a detailed implementation plan. They will identify responsible parties and schedules for actions, and specify monitoring to track the actions and attainment of water quality standards in the waterbody. Additional studies may be prescribed to confirm key assumptions made while developing the TMDL, resolve any uncertainties remaining when the TMDL is adopted, and establish a process for revising the TMDL, as necessary, in the future.

The Water Board will hold two public hearings for this TMDL. The first, a testimony hearing, is anticipated to be held in early 2006. This hearing will provide an opportunity for interested parties to comment on the proposed Basin Plan amendment and associated staff report and implementation plan, and for Board members to ask questions of staff and stakeholders. At the second—the adoption hearing, typically scheduled two months after the testimony hearing—the Board will be asked to consider comments and staff responses and establish the TMDL by adopting the proposed Basin Plan amendment. If adopted by the Board, the TMDL will be sent for approval to the State Water Board, the California Office of Administrative Law, and U.S. EPA to become effective.

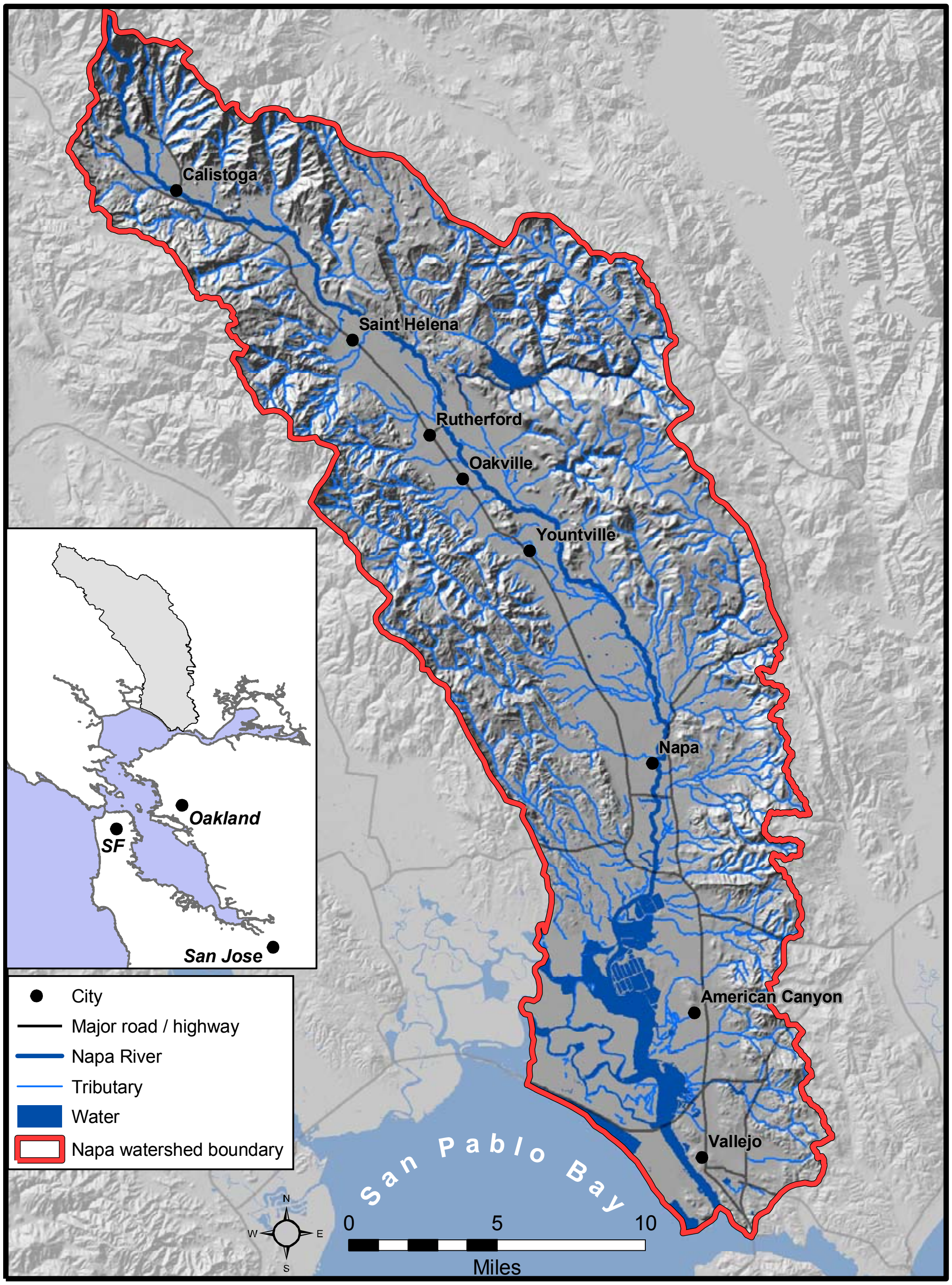
2. WATERSHED DESCRIPTION

The Napa River watershed is located in the California Coast Ranges north of San Pablo Bay (Figure 1), covering an area of approximately 426 square miles (1,103 km^2). The main stem of the Napa River flows approximately 55 miles in a southeasterly direction though the Napa Valley before discharging to San Pablo Bay. Numerous tributaries enter the main stem from the mountains that rise abruptly on both sides of the valley.

Average annual rainfall ranges from 25 to 38 inches in the Napa Valley. Precipitation tends to be somewhat higher in the Mayacanas mountains to the west of the valley, and lower in the eastern mountains. The large majority of rainfall occurs from November through April, with heaviest rainfall occurring from December through February. This rainfall regime results in two distinct seasons in the watershed. During the winter wet season streamflow and pollutant loading are dominated by precipitation-driven surface runoff. In contrast, groundwater inflow or runoff from human activities dominate during the dry summer months.

Major land cover types in the watershed are forest (35%), grassland/rangeland (23%), and agriculture (19%). Approximately two-thirds of agricultural land is in vineyards (13% of total area). Developed land—residential, industrial, or commercial—accounts for approximately 8% of the watershed (Association of Bay Area Governments, 2001).

Figure 1.
Location of the Napa River Watershed



3. PROBLEM DEFINITION

Elevated levels of fecal coliform bacteria have been observed in the Napa River since the 1960s. These bacteria indicate the presence of fecal contamination and attendant health risk to recreational users of the river from water-borne pathogens. Fecal contamination is the primary mechanism for the spread of water-born illness (American Public Health Association, 1998; U.S. EPA, 2001, 2002).

Recent monitoring programs (see Sections 3.3 and 3.4) confirm elevated fecal coliform and Escherichia coli (E. coli) levels in the river and its tributaries. The following sections discuss the use of pathogen indicator bacteria in water quality monitoring and regulation, relevant water quality standards, historic bacterial monitoring in the watershed, and current bacterial water quality studies.

3.1 Use of Fecal Bacteria as Indicators of Pathogens

More than 100 types of pathogenic microorganisms may be found in water polluted by fecal matter and can cause outbreaks of waterborne disease (Havelaar, 1993). Techniques currently available for direct monitoring of specific pathogens in water have several shortcomings that preclude their use in routine water quality monitoring. Some common disease-causing viruses (Hepatitis A virus, Rotaviruses, and Norwalk virus) cannot as-yet be detected practically; techniques for the recovery and identification of human enteric viruses (viruses affecting the intestines) often have limited sensitivity, are time consuming, and expensive (U.S. EPA, 2001).

Due to these difficulties, indicator organisms—principally bacteria—are commonly used to assess microbial water quality for recreational use waters. Indicator bacteria colonize the intestinal tracts of warm-blooded animals (including humans) and are routinely shed in animal feces. These organisms are not necessarily pathogenic, but are abundant in wastes from warm-blooded animals and are easily detected in the environment. The detection of these organisms indicates that the environment is contaminated with fecal waste and that pathogenic organisms may be present.

Commonly used bacterial indicators of fecal contamination include total coliforms, fecal coliforms, E. coli, and fecal enterococci. Total coliforms 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 coliforms are a subset of total coliform and are more specific to wastes from warm-blooded animals, but not necessarily to humans. E. coli are a subset of fecal coliforms, and are thought to be more closely related to the presence of human pathogens than fecal coliforms (U.S. EPA, 2002). Fecal enterococci represent a different bacterial group from the coliforms, and are also regarded to be good indicators of fecal contamination, especially in salt water (U.S. EPA, 2002).

Although fecal bacteria have historically been the indicator organisms of choice, they have three primary shortcomings: 1) the presence of these indicators does not necessarily mean that human pathogens are present—only that they may be present; 2) bacterial indicators may not have the same levels of survival in the environment as the pathogens for which they are intended to serve as sentinels; and 3) these indicators are not human-specific, and therefore do not fully assess the health risk from human enteric viruses and other human-specific pathogens. The third limitation is of less importance than might be assumed, since fecal contamination from a wide range of non-human species—both domesticated and wild—often carry human pathogens (U.S. EPA, 2002). Despite these shortcomings[1], no practical alternative to the use of fecal indicator bacteria is currently available. The Napa River Pathogen TMDL uses fecal coliforms, E. coli, and fecal enterococci as pathogen indicators. Use of these indicators is consistent with state water quality criteria and with federal guidance (U.S. EPA, 2002). If in the future better indicator organisms are identified and new standards are put into place for these organisms, this TMDL will be modified accordingly.

Microbial Source Tracking (MST) methods have recently been used to help identify nonpoint sources responsible for the fecal pollution of water systems. These methods involve examining the DNA or antibiotic resistance properties of fecal indicator bacteria to determine if the bacteria originated from humans, domesticated animals, or wildlife (Santa Domingo et al., 2002). Microbial source tracking was not employed in this TMDL for the following reasons:

- This approach is very expensive and time-consuming;
- Results are often imprecise and equivocal; and
- Since both human and non-human fecal contamination is known to pose human health risks (Atwill, 1995; Graczyk et al., 1998; U.S. EPA, 2001) identification of a pathogen source as non-human does not eliminate the need to control the source.

A more detailed discussion of MST is presented in the Tomales Bay Pathogen TMDL Final Project Report (Water Board, 2005).

[1] An important additional limitation that applies to ambient sampling for any type of microorganism—including both indicator bacteria and actual pathogenic organisms—is that reported sample values are subject to error resulting from limitations in sampling and analytical methods, and should therefore be regarded as approximations. Sources of error can include non-uniform distribution of target organisms in the water being sampled, differential survival of organisms during sample storage and in the test media, clumping of multiple organisms in the test media (with the result that several organisms are counted as just one), and statistical limitations of the testing procedure. Sampling and analytical procedures are designed to minimize these errors, but even in the best of situations the precision of laboratory analysis for bacteria is low relative to chemical analyses. In many cases the true value for a single sample may range from one-third to three times the reported value (American Public Health Association, 1998). This uncertainty can be considerably reduced through repeated sampling and use of geometric means or medians, rather than single-sample values.

3.2 Water Quality Standards

Under CWA authority, the Water Board has established water quality standards for the Napa River and its tributaries. Water quality standards consist of: a) beneficial uses for the waterbody, b) water quality objectives to protect those beneficial uses, and c) the Antidegradation Policy, which requires the continued maintenance of existing high-quality waters. The Water Board's Basin Plan specifies beneficial uses for waterbodies in the Region and the objectives and implementation measures necessary to protect those beneficial uses. The beneficial uses of the Napa River and its tributaries impaired by high levels of pathogens (Table 1) are water contact recreation (REC-1) and non-contact water recreation (REC-2). The purpose of this TMDL is to protect and restore these beneficial uses by reducing the levels of pathogens in this watershed. Water quality objectives for REC-1 use are more stringent than those for REC-2, since REC-1 can involve water ingestion. Since both beneficial uses occur throughout the entire Napa River drainage basin, this TMDL will be driven by the more rigorous REC-1 requirements.

Table 1
Beneficial Uses of the Napa River Watershed
Potentially Impaired by Pathogens

Designated Beneficial Use	Description (as defined in Basin Plan)
Water Contact Recreation (REC-1)	Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs.
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, beachcombing, camping, bathing, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Table 2 lists the Water Board's Basin Plan numerical water quality objectives for fecal and total coliforms for contact recreation (REC-1). The Basin Plan also cites U.S. EPA bacteriological criteria "to supplement objectives for recreational waters" (Water Board, 1995). The U.S. EPA criteria are presented in Table 3.

The percentile criteria in Table 3 were originally expressed as single sample maximums (U.S. EPA, 1986). The 75th percentile value was applied as a single sample maximum at designated beaches, the 82nd at moderately used areas, the 90th at lightly used areas, and the 95th at infrequently used areas. Reconsideration of the epidemiological data on which these criteria are based, and of the statistical implications of these data, led U.S. EPA to revise the single sample maximum interpretation to a percentile-based interpretation (U.S. EPA, 2002). While the Basin Plan citation still reflects the old U.S. EPA interpretation, Table 3 is based on the newer interpretation.

Table 2
Water Quality Objectives For Coliform Bacteria[a]

Beneficial Use	Fecal Coliform (MPN[2]/100 mL)	Total Coliform (MPN/100 mL)
Water Contact Recreation (REC 1)	Log mean[b]<200 90th percentile<400	Median< 240 No sample> 10,000
Non-contact Water Recreation (REC 2)	Mean<2000 90th percentile<4000	N/A

a. Based on a minimum of five consecutive samples equally spaced over a 30-day period.
b. "Log mean" is in this case synonymous with geometric mean, the latter being the preferred term.

Table 3
U.S. EPA Recommended Water Quality Criteria for Bacteria in Fresh-Contact Recreational Waters

	Enterococci (CFU[a]/100 mL)	E. Coli (CFU/100 mL)
Steady State (all areas):	33	126
Percentiles[b]:		
75th	61	235
82nd	89	298
90th	108	406
95th	151	576

a. Colony forming unit (CFU)[3].
b. U.S. EPA does not specify a minimum number of samples upon which to base percentile calculations.

It is noteworthy that U.S. EPA does not specify criteria for total coliforms in contact recreational waters. As discussed in Section 3.1 above, total coliform bacteria can reproduce in the environment outside the bodies of warm-blooded animals, and are therefore a poor indicator for pathogens in ambient water samples. The use of total coliform as indicators in fresh recreational

[2] The Most Probable Number (MPN) method is a multi-step assay consisting of presumptive, confirmed, and complete phases. In the assay, serial dilutions of a sample are inoculated into broth media. Analysts score the number of gas producing tubes, from which the other two phases of the assay are performed, and then use the combinations of positive results to consult a statistical table to estimate the number of organisms present.

[3] Throughout the remainder of this document, bacterial counts are expressed as colony forming units (CFU). The term MPN in Table 2 is used in order to be consistent with Basin Plan language. For practical data interpretation and regulatory purposes, MPN and CFU can be considered equivalent *when used as units of measurement*, both referring to the estimated number of viable bacteria in the sample (U.S. EPA, 2001). The term MPN as defined in footnote 2 describes *an analytical method, not a unit of measurement*.

waters is generally considered obsolete. However, total coliforms are still frequently used to monitor disinfection efficiency in wastewater treatment facilities.

3.3 Summary of Past Bacteriological Water Quality Studies in the Napa River

Beginning in the 1960s, a number of water quality studies have found excessive bacteria densities in the Napa River. Most of these studies focused on the main stem of the river. This TMDL applies to both the main stem and all tributaries within the drainage basin. Current monitoring, described later in this report, addresses both main stem and tributaries.

A 1969 study conducted by the California State Department of Public Health (1969) documented bacterial problems along the main stem of the Napa River. Thirty-nine main stem sites ranging from Kimball Reservoir to the Solano County line were sampled on five successive weeks in the summer of 1969. Median fecal coliform values exceeded the Basin Plan objective of 200 CFU/100 mL at fifteen of these sites, with the highest median (2,300 CFU/100 mL) observed at First Street in Napa. While some of the sites with high bacteria levels were associated with wastewater discharges, many—including the First Street site—were not.

The Napa Sanitation District sampled fecal coliforms in the tidally influenced reaches of the Napa River in 1972 and 1973 (Napa Sanitation District, 1974). Five stations, ranging from Third Street to the Solano County line were sampled approximately monthly from August 1972 though July 1973. Dry season (April though October) geometric means ranged from 13 to 104 CFU/100 mL, all falling below the Water Board objective of 200 CFU/100 mL. Dry season 90th-percentile values ranged from 43 CFU/100 mL to 460 CFU/100 mL. Only the highest of these—the 3rd Street station—exceeded the 90th-percentile Basin Plan objective of 400 CFU/100 mL. Wet season (November though March) geometric means ranged from 387 to 1,189 CFU/100 mL, all exceeding the Water Board objective. All wet season 90th-percentile values exceeded the Water Board objective, with many individual samples greater than 2,000 CFU/100 mL.

A study conducted by the University of California, Berkeley for the Water Board from 1984 and 1985 (Johnson, 1985) monitored E. coli levels at fifteen sites on the Napa River, ranging from Tubbs Lane to Trancas Street. Samples were collected approximately biweekly from May 1984 though April 1985. During the dry season (May through October 1984 and April 1985), geometric means exceeded the U.S. EPA criterion of 126 CFU/100 mL at three stations: Tubbs Lane, Dunaweal Lane, and Trancas Street. Wet season (November 1984 through March 1985) geometric means exceeded the criterion at all fifteen sampling stations.

3.4 Recent and Ongoing Bacterial Water Quality Studies in the Napa River

Two major monitoring efforts provide insights into the current pathogen levels in the Napa River system: An ongoing program implemented by the Napa County Department of Environmental Management initiated in December 2002 in response to a raw sewage spill in Napa; and a study developed specifically in support of the Napa River Pathogen TMDL, cooperatively conducted by the Water Board and the San Francisco Estuary Institute (SFEI), with laboratory support from

U.S. EPA. The two complementary efforts have sufficient overlap in stations to allow each study to serve to verify data collected by the other.

The Napa County monitoring program consists of approximately biweekly sampling for fecal and total coliforms at seven stations on the lower Napa River from Oak Knoll Road, north of Napa, to Kennedy Park, upstream of the Highway 29 bridge (Figure 2). Results obtained to date (through September 2004) are summarized in Table 4. Fecal coliform results are grouped into dry and wet seasons for each of the two sampling years: wet season 2002–2003, dry season 2003, wet season 2003–2004, and dry season 2004. Only two geometric mean values exceed the Basin Plan fecal coliform objective of 200 CFU/100 mL: wet season 2002–03 and dry season 2004, both at China Point. In contrast, many dry season and most wet season 90^{th}-percentile values exceed the Basin Plan fecal coliform objective of 400 CFU/100 mL. The difference between geometric mean and 90^{th}-percentile results reflects high within-season variability in fecal coliform densities. The raw monitoring results (Appendix A) show periods of low bacteria counts interspersed with occasional high counts, which result in fairly low geometric means, but fairly high 90^{th} percentiles. This type of data pattern illustrates one reason for having both geometric mean and 90^{th} percentile objectives: the former is more sensitive to consistently elevated bacterial densities, while the latter is better suited to detecting periodic excursions. Combined, the geometric mean and 90^{th} percentile values indicate moderate, intermittent bacterial impairment of the lower Napa River.

No obvious spatial patterns appear in the Napa County data. This is not surprising, since all but one of the sampling stations are in tidal portions of the river, where rapid bi-directional water movement would be expected to obscure spatial differences. (The study was limited to mostly tidal portions of the river because the sewage spill that precipitated the study only had an influence on this portion of the river.) The lack of spatial patterns does, however, suggest the absence of large, discrete pathogen sources in this portion of the river.

The Water Board/SFEI study was more spatially intensive, but involved fewer sampling events than the Napa County program. Seven main-stem sampling stations were distributed from Tubbs Lane in Calistoga to Third Street in Napa, with sixteen additional tributary stations (Figure 3). Sampling was conducted in October 2002, January 2003, and July 2003. The January sampling began approximately one week following a major winter storm event, and was intended to represent stable-flow wet season conditions. The other two events were selected to represent typical dry season conditions. For most of the sites a single sample was collected during each event. However, for each event a subset of five sites was selected for a more intensive sampling. Intensive sampling consisted of five samples collected at weekly intervals, allowing calculation of geometric means. Selection of sites for intensive sampling was based on suspected bacterial contamination, or on high frequency of recreational use.

Results of the Water Board/SFEI study are summarized in Table 5 (raw data are presented in Appendix B). Exceedances of U.S. EPA recommended criteria (both the geometric mean value of 126 CFU/100 mL and the single-sample 90^{th} percentile value of 406 CFU/100 mL) occurred at several locations, during both wet and dry season sampling. Most exceedances were observed in the lower watershed, and most were in tributaries rather than the main stem. These results will be discussed in greater detail in the source assessment section of this report.

Figure 2.
Sites Monitored by the Napa County Department of Environmental Management

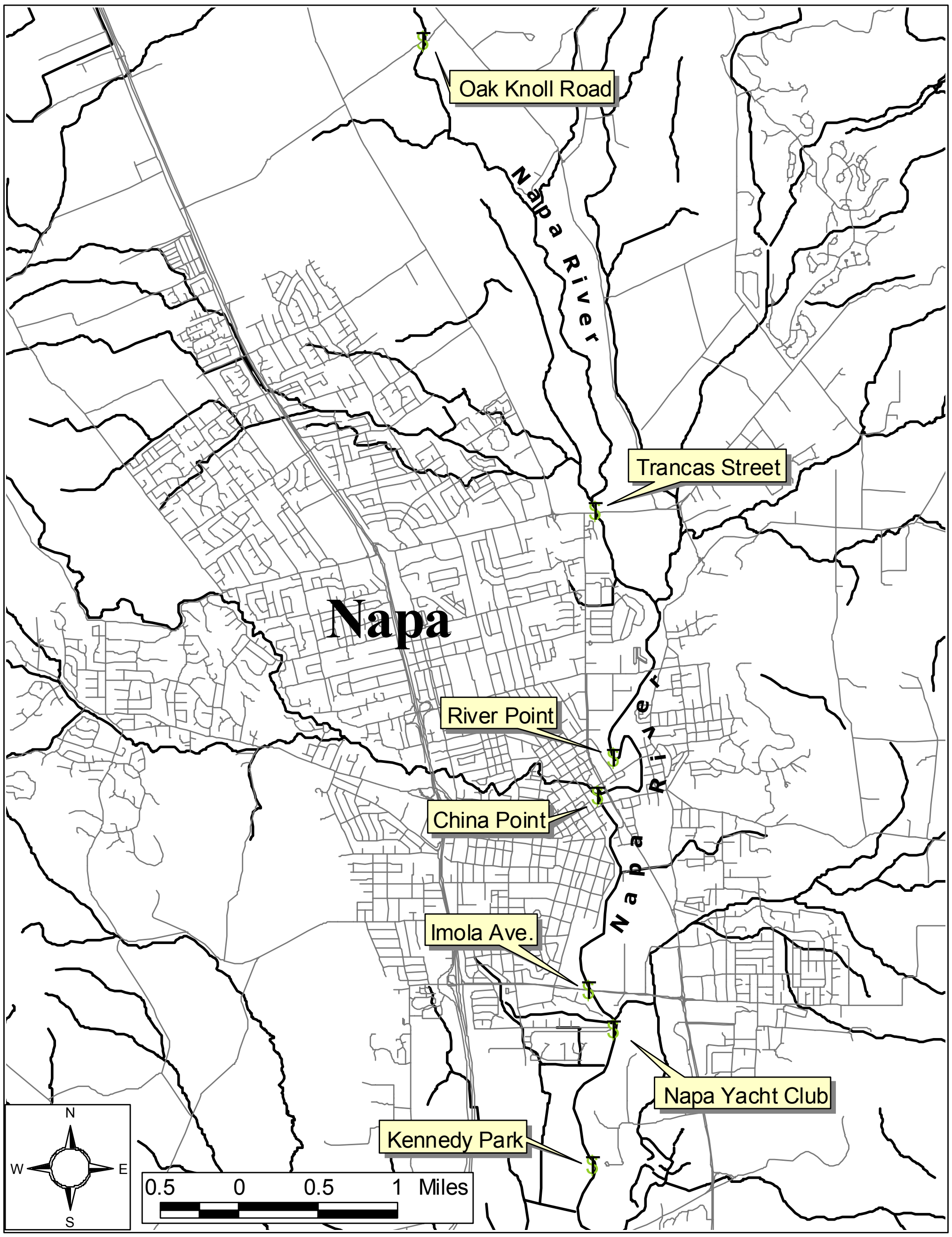


Table 4
Summary of Napa County Department of Environmental Management Fecal Coliform Data

Sample Station	Wet Season 2002–2003[a]			Dry Season 2003		
	Number of Samples	Geometric Mean	90th Percentile	Number of Samples	Geometric Mean	90th Percentile
		CFU/100 mL			CFU/100 mL	
Oak Knoll Road	10	106	*457*[b]	12	27	74
Trancas Street	10	69	305	10	45	110
River Point	10	104	*527*	13	59	205
China Point	10	*220*	*443*	13	157	283
Imola Avenue	10	155	*422*	13	148	298
Napa Yacht Club	4	31	79	13	105	242
Kennedy Park	10	126	*431*	13	169	325
Sample Station	**Wet Season 2003–2004**			**Dry Season 2004**		
	Number of Samples	Geometric Mean	90th Percentile	Number of Samples	Geometric Mean	90th Percentile
		CFU/100 mL			CFU/100 mL	
Oak Knoll Road	10	124	*665*	7	44	140
Trancas Street	11	172	*839*	8	105	*472*
River Point	11	195	*2,359*	5	134	*960*
China Point	10	192	*2,321*	5	*211*	*897*
Imola Avenue	11	115	*464*	6	84	142
Napa Yacht Club	11	129	*657*	8	60	*451*
Kennedy Park	11	87	275	8	140	*510*

a. Wet season 2002–03 consisted of December 2002 through March 2003. Dry season 2003 consisted of April 2003 through October 2003. Wet season 2003–04 consisted of November 2003 through March 2004. Dry season 2004 consisted of April through September 2004.
b. Exceedances of Basin Plan objectives are italicized.

Figure 3
Sites Monitored in the Water Board/SFEI Study

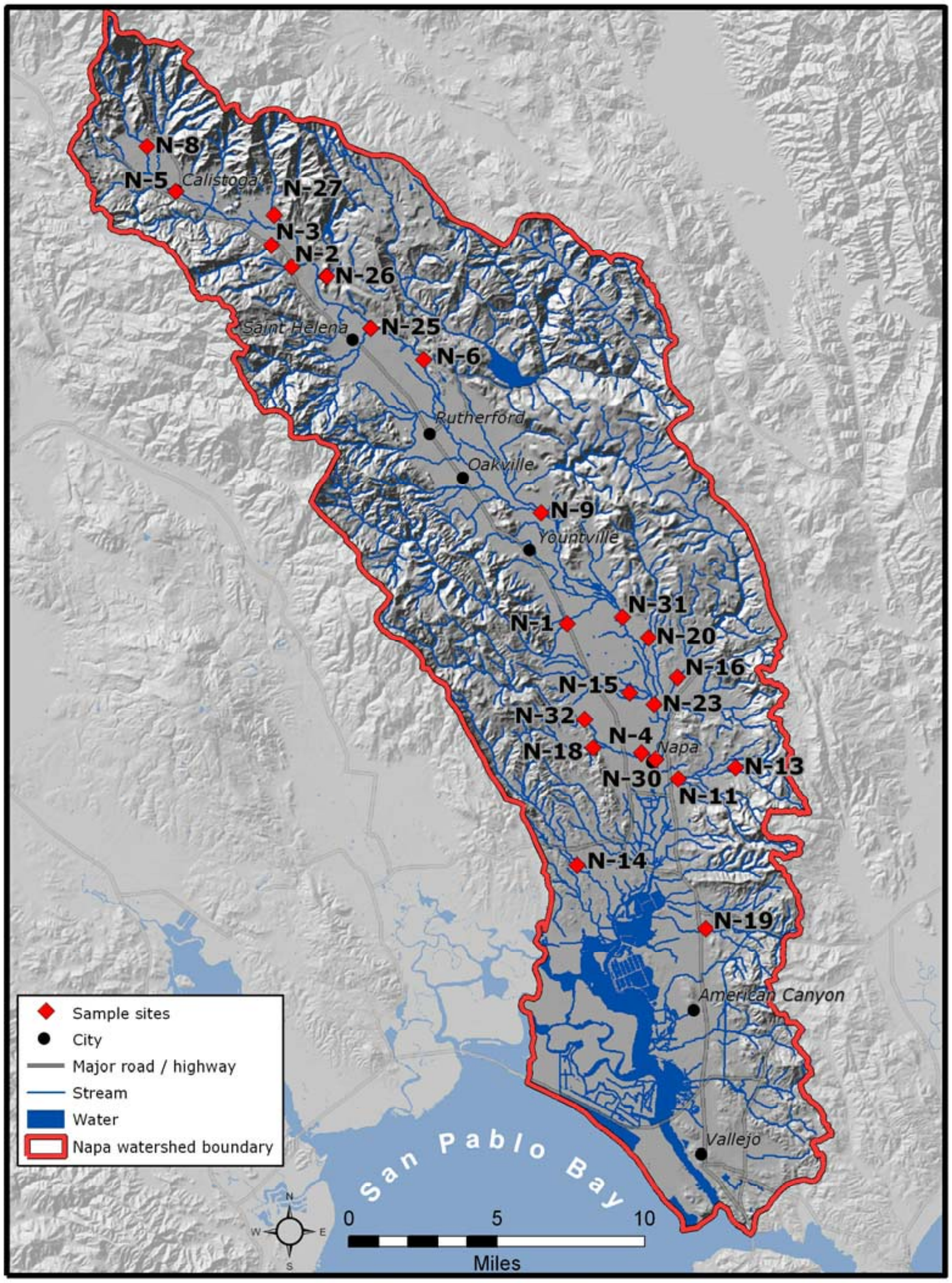


Table 5
E. Coli Densities Observed in the
Water Board/SFEI Study, October 2002–July 2003.

Station	Location	E. coli, CFU/100 ml		
		Jan-03	Jul-03	Oct-02
N-8	**Napa River at Tubbs Ln.**	74	20	[a]
N-5	**Napa River at Calistoga Community Center**	*530*[b]	**28**[c]	63
N-27	**Dutch Henry Creek at Larkmead Lane**	10		
N-3	**Ritchey Creek at State Park Campground**	130	63	98
N-2	**Mill Creek at State Park**	52	20	110
N-26	**Bell Canyon Creek at Silverado Tr.**	**44**	30	**51**
N-25	**Sulfur Creek at Starr Ave.**	*560*	10	10
N-6	**Napa River at Zinfandel Ln.**	84	**15**	10
N-9	**Napa River at Yountville Preserve**	97	**15**	10
N-1	**Dry Creek at Solano Ave.**	31	110	
N-31	**Napa River at Oak Knoll Ave.**	97	31	10
N-20	**Soda Creek at Silverado Tr.**	10		
N-15	**Salvador Channel at Summerbrook Cir.**	*430*	20	63
N-23	**Napa River at Trancas St.**	110	41	*1,100*
N-16	**Milliken Creek at Hedgeside Ave.**	52	150	74
N-30	**Napa River at 3rd St.**	**100**	**100**	***920***
N-32	**Redwood Creek at Redwood Rd.**		120	
N-18	**Browns Valley Creek at Browns Valley Rd.**	***790***	***1,200***	***1,600***
N-4	**Napa Creek at Jefferson St.**	***460***	110	***870***
N-13	**Murphy Creek at Coombsville Rd.**	**80**	*660*	***470***
N-11	**Tulocay Creek at Terrace Ct.**	330	41	
N-14	**Carneros Creek at Withers Rd.**	180	*460*	
N-19	**Fagan Creek at Kelly Rd.**	300	74	160

a. Missing data points indicate that the sampling site was dry, except for the January Redwood Creek sample, where high flows prohibited safe sampling.
b. Exceedances of U.S. EPA recommended E. coli criteria (126 CFU/100 mL for geometric means, and the 406 CFU/100 mL 90th percentile level for single samples) are in italics.
c. Values in bold type represent geometric means of five weekly samples; non-bold values represent single samples.

In sum, past and present bacterial water quality studies in the Napa River watershed provide a consistent picture of widespread, but moderate and somewhat localized pathogen impairment. Data indicate that much of the watershed, including several major tributaries, meets bacterial Water Quality Objectives. However, WQOs are exceeded at a number of locations in the watershed at all times of year.

4. NUMERIC TARGETS

In order to develop a TMDL, a desired or target condition must be established to provide measurable environmental management goals and a clear linkage to attaining the applicable water quality objectives. The numeric targets (desired future conditions for the Napa River watershed) proposed for this TMDL are as follows:

1. Geometric mean E. coli density of 126 CFU/100 mL;

2. Ninetieth percentile E. coli density of 406 CFU/100 mL; and

3. Zero discharge of untreated human waste to the Napa River and its tributaries or to groundwater with direct through flow to these surface waters.

The first two targets are based on U.S. EPA guidance (U.S. EPA; 1986, 2002) and are referenced in the Water Board's Basin Plan. These E. coli targets are at least as protective as the Basin Plan's fecal coliform-based Water Quality Objectives (presented in Table 2) for two reasons. First, U.S. EPA has determined that E. coli densities are more strongly correlated to human illness rates than fecal coliform densities are (U.S. EPA; 1986, 2002). Secondly, as discussed in Section 3.1, E. coli are a subset of the fecal coliform group of bacteria. It has been established that E. coli typically constitute from 80% to more than 90% of fecal coliforms in fecally contaminated ambient water samples (Noble et al., 2000). Assuming the more conservative 80% conversion factor, a geometric mean of 126 CFU/100 mL E. coli is equivalent to approximately 158 CFU/100 mL fecal coliform—lower than the Basin Plan Water Quality Objective of 200 CFU/100 mL fecal coliform. Similarly, a 90^{th} percentile value of 406 CFU/100mL E. coli is approximately equivalent to 507 CFU/100 mL fecal coliform, slightly higher than the Water Quality Objective of 400 CFU/100 mL fecal coliform.

The third target, zero discharge of untreated human waste, is based on the knowledge that fecal bacteria are imperfect indicators of human pathogens. Since direct monitoring of human pathogens is not feasible (see Section 3.1), and since untreated human waste is the most serious potential source of these pathogens, a prohibition of untreated human waste discharge is proposed. This target is consistent with the Basin Plan's region-wide prohibition against the discharge of raw sewage.

These TMDL targets are consistent with water quality objectives or prohibitions included in the Basin Plan. Since these targets are based on conservatively established protective water quality objectives, they contain an inherent margin of safety. The targets are proposed as the desired long-term conditions this TMDL seeks to achieve.

5. POLLUTANT SOURCE ASSESSMENT

Data collected in the Napa River watershed, as well as similar work conducted in the region, suggest a limited list of possible sources that may contribute significant pathogen loads to the system. Primary potential sources are described briefly below.

- **On-site sewage disposal systems (OSDSs; septic systems)** There are an estimated 9,000 OSDSs, or septic systems, in the Napa River watershed (Wang et al., 2004). The majority of soils in the watershed are classified as having severe restrictions for use as septic tank leach fields, due either to low permeability, slope, depth to bedrock, impermeable layers, or wetness (Lambert and Kashiwagi, 1978). Septic systems—especially older systems—located on these soils are especially prone to failure, and may release pathogens to adjacent surface waters even when system failure is not evident.

- **Sanitary sewer systems (sewer lines)**. The cities of Napa, Calistoga, and St. Helena, and the town of Yountville are served by sanitary sewer lines. A major sewer line failure occurred a short distance north of Napa in 2002, resulting in high short-term loading to the river. Chronic minor leakage of lateral lines can produce a less dramatic effect, and can be difficult to distinguish from septic system failure in areas where sewer line service and septic systems are intermixed.

- **Municipal runoff.** Approximately 8% of the watershed is occupied by residential or commercial development (ABAG, 1996). Urban runoff delivers pathogens to surface waters from domestic animal waste, trash, wildlife, failing septic systems, and in some cases human waste from homeless populations. Homeless encampments are readily observed at a number of locations along the Napa River, and may be an important source of waterborne pathogens.

- **Cattle grazing.** Pasture/hayfield covers approximately 5% of the watershed, with an additional 22% in herbaceous grazing land (i.e., rangeland) cover (ABAG, 1996).

- **Equestrian facilities.** Numerous—mostly small, noncommercial—equestrian facilities can be found in the Congress Valley and Coombsville areas in the lower part of the Napa watershed.

- **Wildlife**. Most of the Napa River watershed remains undeveloped, providing habitat for abundant wildlife. Most warm-blooded animals are capable of carrying pathogen indicator bacteria as well as a wide range of actual human pathogens (U.S. EPA, 2001). Wildlife have been identified as significant pathogen sources in other TMDLs in California, but generally in locations where there are concentrated populations of wildlife (Central Coast Water Board, 2004; Water Board, 2005).

- **Domestic wastewater treatment facility discharge.** Six major publicly owned treatment works (POTWs) are permitted to discharge treated municipal wastewater to the Napa River under the National Pollutant Discharge Elimination System (NPDES). Initial concern over potential pathogen impairment of the river impaired was partially based on the presence of these discharges. Treatment plant upgrades since that time have greatly reduced pathogen loading from these sources (Johnson, 1985).

The following sections examine the distribution and relative importance of these sources in the Napa River watershed.

5.1 Permitted Wastewater Discharges

Six Publicly Owned Treatment Works (POTWs) are permitted to discharge treated municipal wastewater to the Napa River watershed, all to the main stem (Table 6) . National Pollutant Discharge Elimination System (NPDES) permits for these facilities limit discharge to wet season conditions when dilution of effluent by river flow is at least 10:1, and require full disinfection of effluent though chlorination/dechlorination. All facilities are subject to stringent effluent limits for enterococci or total coliform (Table 6). Monthly self-monitoring reports for 2003 and 2004 indicate that all facilities currently meet effluent limits, with no reported total coliform values higher than 10 CFU/100mL. The discharges therefore do not contribute measurably to pathogen loading.

Table 6
Publicly Owned Treatment Works Discharging to the Napa River

Facility	Location	Effluent Limit—Median, CFU/100 mL	NPDES Permit #
Napa Sanitation District	Ratto's Landing South of Napa	35 enterococci	CA0037575
Town of Yountville	Access Road East of Yountville	2.2 total coliform	CA0038121
City of St. Helena	Thoman Lane South of St. Helena	23 total coliform	CA0038016
City of Calistoga	Dunaweal Lane South of Calistoga	23 total coliform	CA0037966
City of American Canyon	Elliot Drive, American Canyon	2.2 total coliform	CA0038768
Napa River Reclamation District #2109	Milton Road, South of Napa	240 total coliform	CA0038644

5.2 Analysis of Water Quality Data and Watershed Characteristics

The following section explores relationships between the bacteria data collected in the 2002–2003 Water Board/SFEI study and land uses in the watershed. While the bacterial data are not sufficient in either spatial or temporal resolution to allow quantitative assessment of pathogen loads, the observations presented here support a relative assessment of the importance of different nonpoint source categories.

Different delivery mechanisms drive pathogen loading during the wet and dry seasons. During the wet season, loading is primarily via precipitation-driven surface runoff, and secondarily though groundwater flow into stream channels. Surface runoff is largely absent in the dry season and pathogen delivery is predominantly though groundwater inflow (including in many cases septic system leachate), direct deposition (e.g., animals in the creek), and low-volume runoff from human activities (e.g., lawn and landscape watering, car washing, washing of animal holding areas, etc.). Therefore, dry and wet season pathogen loading are discussed separately below.

5.2.1 General Trends

Figures 4a and 4b show E. coli sampling locations with their catchment areas delineated, locations of major towns, and general land cover categories in the watershed. Land cover information was obtained from 1996 Association of Bay Area Governments (ABAG) data. The broad land-cover categories shown are open space (consisting of natural forest, grassland, and open range), agriculture (vineyards, orchards, row crops, pasture, and animal facilities), and urban (residential, commercial, and industrial).

Several general observations can be made from the Water Board/SFEI E. coli data (Table 5). Bacteria levels were below numeric targets in both dry and wet seasons at sites located in open space-dominated watersheds: Ritchey Creek, Mill Creek, Dutch Henry Creek, and Napa River at Tubbs Lane. Since these sites are relatively unaffected by human activities, wildlife is most likely the predominant pathogen source there. The low bacteria levels indicate that wildlife do not constitute a widespread pathogen problem in the watershed.

Winter E. coli values were notably higher than summer levels at several sites: Napa River at Calistoga, Sulphur Creek, Salvador Channel, and, less clearly, Tulokay Creek. All of these sites receive runoff from heavily urbanized areas, suggesting that urban runoff is a primary wet season pathogen source there. Septic tank failure likely also contributes to wet weather loading at some of these sites.

At the Murphy Creek site, dry season bacteria counts were substantially higher than in the wet season. This effect is seen to a lesser degree at Browns Valley Creek. Both of these sites are in urbanized, primarily residential areas—the Browns Valley area is served by sanitary sewer lines, while the area surrounding the Murphy Creek sampling site relies on individual septic systems. It is hypothesized that pathogen loading at these sites is largely due to septic tank or sanitary sewer failure, and that wet season runoff dilutes loading from these sources, resulting in reduced wet season bacterial densities. These sites are discussed further in Section 5.2.3, below.

Bacteria levels in the main stem of the Napa River upstream of the City of Napa were generally low during both wet and dry seasons. The two farthest downstream sampling sites on the Napa River main stem (Trancas Street and Third Street, both in the City of Napa) showed high E. coli levels during the October 2002 sampling event. In the case of the Third Street site, this may have been due to the large, localized populations of wild and semi-domesticated waterfowl that reside in this part of the river.

5.2.2 Statistical Analysis of Water Board/SFEI Data

Water Board and SFEI staff conducted statistical analysis to examine relationships between wet and dry season bacterial levels and general land cover categories throughout the watershed.

Variables examined in this analysis are presented in Table 7. January 2003 Water Board/SFEI E. coli data (Table 5) were used to represent wet season pathogen loading, and July 2003 E. coli data represented dry season loading. October 2002 data were omitted from this analysis because of the low number of sites sampled at that time.

Land cover variables were calculated using ArcInfo GIS software. Catchment areas (contributing watershed areas) were defined for each water quality sampling point shown in Figures 4a and 4b and the land cover variables described in Table 7 were calculated for each of these catchment areas.

Table 7
Water Quality and Land Cover Variables Used in Statistical Analysis

Variable	Description
E. coli Wet	January 2003 Water Board/SFEI E. coli values
E. coli Dry	July 2003 Water Board/SFEI E. coli values
Popden	Population density of catchment area
Pct_Open	Percent open space in catchment area
Pct_Ag	Percent agricultural land in catchment area
Pct_Urb	Percent urban land in catchment area
Popden_50	Population density within 50 meters of stream
Pct_Open_50	Percent open space within 50 meters of steam
Pct_Ag_50	Percent agriculture within 50 meters of stream
Pct_Urb_50	Percent agriculture within 50 meters of stream

Associations between the bacterial variables and land cover variables were estimated using Kendall's Tau-b statistic (Table 8). This statistic is a non-parametric measure of the degree of correlation—or association—between variables, and is well suited for non-normal, statistically "messy" data sets such as the one considered here (SAS Institute, 1995). The higher the absolute value of Kendall's Tau-b, the stronger the correlation. Positive values indicate a positive relationship between variables (variables increase or decrease together), while negative values indicate an inverse relationship (an increase in one variable is associated with a decrease in the other). The probability column in Table 8 indicates the probability that the calculated Kendall's Tau-b would be exceeded randomly by a set of unrelated variables. In other words, the probability value is an indicator of the statistical significance of the correlation between the variables in question. Probabilities less than 0.05 are regarded by convention to indicate a statistically significant correlation, while probabilities less than 0.01 indicate a highly significant correlation. While a statistically significant correlation does not in and of itself show causality, it can be a useful element of a weight of evidence approach to source assessment.

Figure 4a.
Catchment areas and General Land Cover for Water Board/SFEI Sites—North

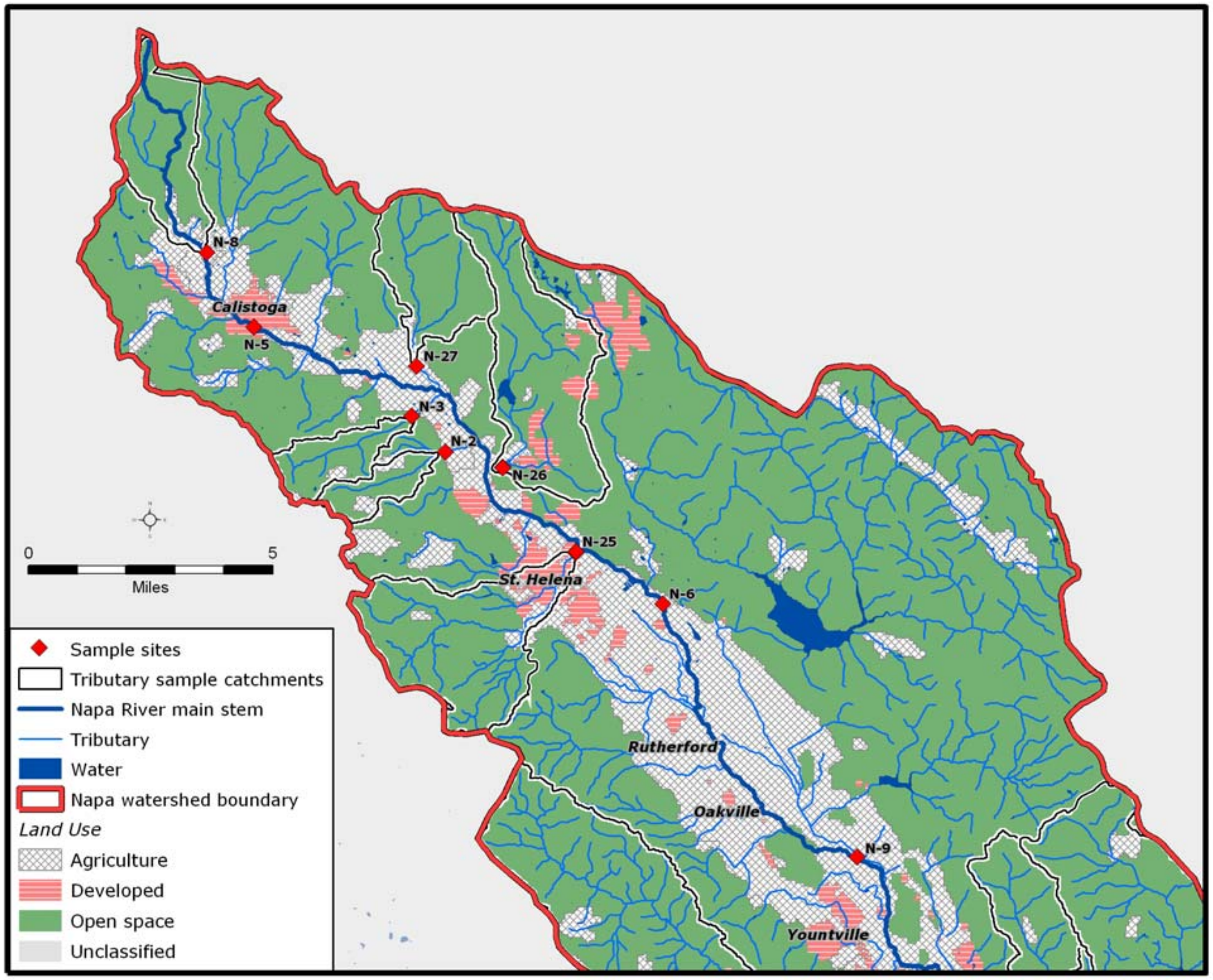
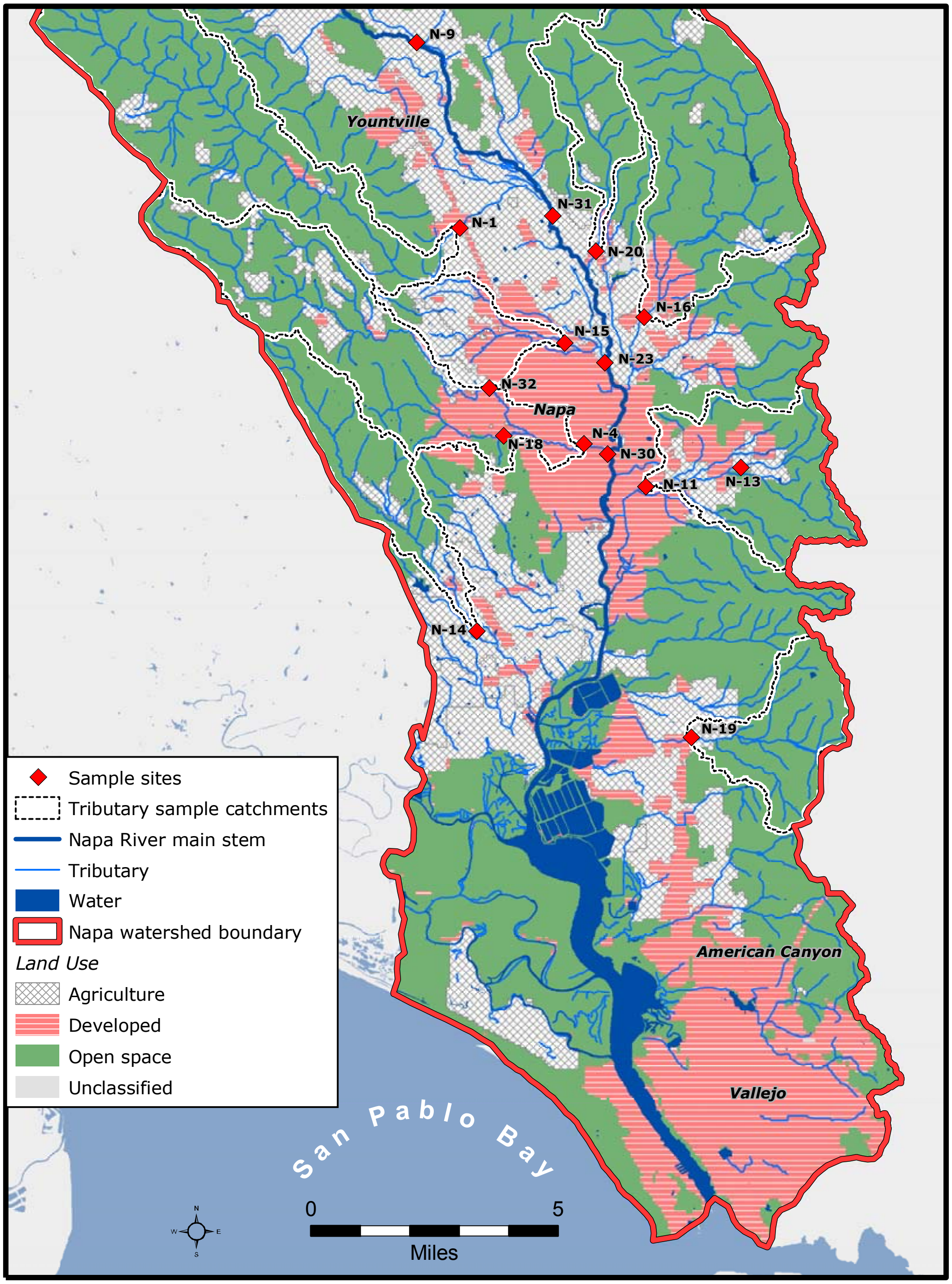


Figure 4b.
Catchment areas and General Land Cover for Water Board/SFEI Sites—South



Wet season bacterial counts were highly correlated with population in the catchment area, and with population density within 50 meters of the stream (Table 8). Percent urban land in catchment area, and within 50 meters of the stream were also correlated with wet season bacteria. These correlations suggest that a large proportion of wet season pathogen loading is from urban runoff, but does not rule out septic tanks or sewer-line failure as an additional source.

Table 8
Correlations Between E. Coli Levels and Land Cover Variables in the Napa River Watershed

Land Cover Variable	E. Coli Wet (22 sites)		E. Coli Dry (20 sites)	
	Kendall's Tau-b	Probability [a]	Kendall's Tau-b	Probability
Popden[b]	0.4585	0.0030**	-0.0533	0.7389
PCT_Open	-0.2227	0.1498	-0.2995	0.0604
PCT_Agric	0.0000	1.0000	0.3189	0.0456*
PCT_Urban	0.3747	0.0152*	0.0000	1.0000
Popden_50	0.4760	0.0021**	-0.0339	0.8320
PCT_Open_50	-0.2092	0.1754	-0.3189	0.0456*
PCT_Agric_50	-0.0174	0.9101	0.2029	0.2033
PCT_Urban_50	0.3799	0.0140*	.0.0823	0.6065

a. Probability values followed by * or ** indicate significant or highly significant correlations, respectively.
b. Refer to Table 8 for descriptions of land cover variables.

Correlations between dry season E. coli values and land cover variables have less clear implications. A significant, negative correlation between bacteria counts and percent open land within the fifty-meter buffer was observed. This is consistent with the widely recognized effectiveness of open space buffers for pollution reduction.

It is difficult to account for the significant, positive correlation observed between dry season bacterial counts and percent agriculture in the catchment area. Vineyards, which are not expected to contribute significantly to pathogen loading, represent the large majority of agricultural land use in the Napa watershed. It is possible that animal facilities, which account for only a small percentage of this broad land cover category, may account for this correlation. Another possible cause may be that, compared to open space, agricultural land cover is frequently associated with scattered, low-density residential and commercial development, which may constitute pathogen sources. The very high, negative correlation observed between open space and agriculture in the Napa watershed may also contribute to this correlation. That is, agricultural land may correlate with dry season bacterial counts simply because agriculture and open land together dominate many of the subwatersheds sampled, and a subwatershed with low open space will naturally be high in agriculture.

Our statistical analysis is limited by such factors as the relatively small number of sample sites, the small number of samples per site, the low precision of bacterial sampling results, and the general nature of the ABAG mapping categories. The analysis is therefore best suited to detecting broad, general relationships. It should be understood that failure to detect a statistically significant correlation between bacteria densities and any given land use variable does not preclude that land use as a pathogen source. For example, failure to detect a relationship between developed land and dry season bacteria levels does not mean that this land use category does not constitute a significant dry season source. It *may* mean that *most* residentially developed land in the watershed does not contribute to dry season loading, but it does not eliminate (or even render less likely) the possibility that *some* residentially developed land constitutes a significant dry season source on a local level. The supplemental monitoring described below addresses localized sources.

5.2.3 Supplemental Monitoring

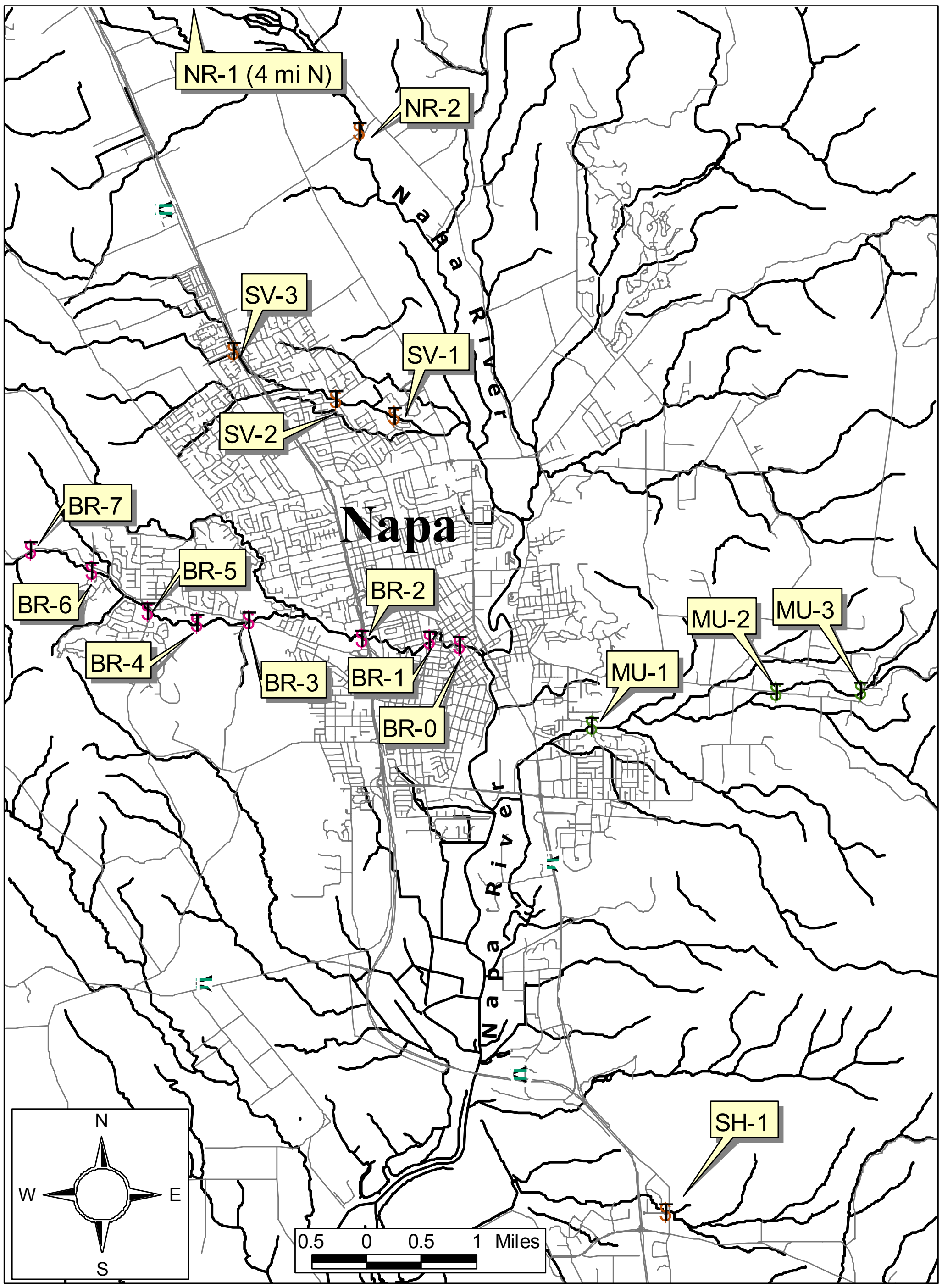
The Water Board conducted a supplemental sampling program in May and June 2004 in order to investigate pathogen sources near hotspots identified in the Water Board/SFEI study. Since no significant rainfall had occurred for more than a month prior to this sampling, the data reflected early dry-season conditions. Sampling focused on Browns Valley Creek (N-18), Murphy Creek (N-13), Napa Creek (N-4), and Salvador Channel (N-15). Samples were collected at additional stations located incrementally upstream—and where possible and appropriate, downstream—of the sites sampled in the earlier study. An additional sampling site in Sheehy Creek was included because of suspected water quality problems at this site. Samples were also collected at two sites on the main stem Napa River to confirm data previously obtained from these sites. Locations of sites monitored in the supplemental sampling effort are shown in Figure 5.

Samples were collected weekly over a five-week period. In order to conserve limited laboratory resources, an adaptive, tiered monitoring scheme was employed. All sites were sampled for the first two weeks and the results used to establish a subset of sites for three additional weeks of sampling. Sampling was discontinued at sites that were consistently very low or high for the first two weeks, or were very similar to either upstream or downstream sites.

The high E. coli levels found at the Browns Valley Creek/Browns Valley Road site (BR-3) in the 2002–2003 sampling continued to be seen in supplemental sampling (Table 9). Counts at downstream sites on Napa Creek were also elevated, but were lower than in Browns Valley Creek. This is most likely due either to bacterial die-off or to dilution from Redwood Creek, which enters a short distance downstream of BR-3. Upstream sites showed elevated counts though site BR-5 (Buhman Ave.), but declined dramatically at BR-6 (Borrette Ln.). Dense residential development exists from BR-6 downstream, while development density declines significantly above BR-6. Information provided by the Napa Sanitation District indicates that most residential parcels adjacent to the creek from site BR-6 downstream are served by city sewer lines, but a few parcels apparently remain on septic tanks. Much of the soil adjacent to the creek in this location is severely limited for septic system applications due to low permeability and wetness. Cattle grazing occurs along Browns Valley Creek between sites BR-4 and BR-5, but the data fail to indicate a significant bacterial source at this location.

Bacteria counts nearly doubled between sites BR-4 on McCormick Lane and BR-3 at Browns Valley Road. A small tributary enters Browns Valley Creek between these sampling sites, but it is not known if there was significant flow in the tributary at the time of sampling. Cattle grazing occurs upstream on this tributary, and a small mixed livestock operation is located very close to the confluence of the tributary and Browns Valley Creek. It is unclear if these potential sources contributed to the elevated bacteria levels at BR-3. It appears then, that septic tank failure, sewer line failure, or possibly illicit discharge of sanitary waste may be the primary source of pathogens upstream of BR-4, while additional loading, possibly from livestock sources, may contribute to pathogen loading above BR-3.

Figure 5
Supplemental Water Board/SFEI Monitoring Sites.



Bacteria levels in Murphy Creek (N-13/MU-2) were moderately elevated in May/June 2004, but were not as high as observed in the 2002 and 2003 dry seasons (Table 5). A possible reason for this is that the 2004 samples were collected earlier in the season than those in 2002 and 2003. The data may reflect a relatively constant loading from septic tank flows together with a diminishing dilution from groundwater inflow as the groundwater table recedes though the dry season. The low wet-season bacteria densities seen in Murphy Creek (Table 5) are consistent with dilution effects. A similar effect has been observed in Sonoma Creek (Water Board, 2005).

Little variation was seen among the three Murphy Creek sites. Land use at the two upper sites (MU-2 and MU-3) is primarily low-density residential development with some small animal facilities and mixed agriculture. Residences in this area depend on OSDSs for sanitary waste disposal. Soils at and upstream of MU-3 are severely limited for septic system application due to excessive slope and shallow depth to bedrock. Septic system limitations are somewhat less severe in the vicinity of MU-2, and are largely related to low soil permeability. The lower site (MU-1) is dominated by higher density residential development and is served by sewer lines. Low density residential development extends upstream of the uppermost site, with some cattle grazing further upstream. In order to distinguish between potential sources of pathogens, sampling upstream of the residential areas and downstream of grazing operations would have been ideal. Unfortunately, upstream access could not be obtained when the sampling was conducted. It is therefore unclear which of these is the primary source of E. coli in the Murphy Creek system.

Bacteria counts in Sheehy Creek (SH-1) were the highest observed in this study, confirming the suspicions that had prompted sampling at this site. Extensive cattle grazing occurs immediately upstream of the sampling site. Fencing is used to exclude cattle from the stream in this area, but it is unclear if the fencing is completely effective. Reclaimed domestic wastewater from the Napa Sanitation District facility is applied to the land upstream of the sampling site. Since reclaimed water receives full disinfection as required by the facility's NPDES permit, cattle are the likely pathogen source at this location.

Salvador Channel was sampled in May/June 2004 not because of high bacteria levels in previous sampling, but because a public park with significant potential for contact recreation use is planned for this creek. The planned park is located adjacent to sites SV-1 and SV-2. Elevated bacteria levels were not observed at either of these sampling locations. However, counts at the upstream site at Solano Avenue (SV-3) were significantly elevated above water quality objectives. Dense residential and commercial development exists above this site. Most of this area is served by sanitary sewer lines, suggesting that sewer line failure may be a source. The low bacteria counts observed at the two downstream sites are likely due to either bacterial die-off or dilution. Since there is dense residential development between the upper and lower sites, but no indication of additional pathogen loading, the low bacteria levels observed at the downstream site suggest a relatively localized source above the upstream site.

Table 9 May 2004 Supplemental E. Coli Sampling Results			
Site Location	**Site Number[a]**	**E. Coli (CFU/100mL, geometric mean)**	**Number of Weeks Sampled**
Napa Creek @ Pearl St.	BR-0	324	2
Napa Creek @ Jefferson St.	BR-1 (N-4)	345	2
Browns Valley @ Highway 29	BR-2	497	2
Browns Valley @ Browns Valley Rd.	BR-3 (N-18)	1,008	5
Browns Valley @ McCormick Ln.	BR-4	523	5
Browns Valley @ Buhman Ave.	BR-5	490	5
Browns Valley @ Borrette Ln.	BR-6	39	5
Browns Valley @ Partrick Rd.	BR-7	10	2
Tulokay Creek @ Shurtleff Ave.	MU-1	170	2
Murphy Creek @ Coombsville Rd.	MU-2 (N-13)	151	5
Murphy Creek @ Shady Brook Ln.	MU-3	122	5
Sheehy Creek @ Kelly Road	SH-1	3,286	2
Salvador Channel @ Summerbrook Cir.	SV-1 (N-15)	51	2
Salvador Channel @ Trower Ave.	SV-2	73	2
Salvador Channel @ Solano Ave.	SV-3	713	5
Napa River @ Yountville Preserve	NR-1 (N-9)	81	2
Napa River @ Oak Knoll Rd.	NR-2 (N-31)	120	2
a. Site numbers from original Water Board/SFEI study are in parentheses.			

May/June 2004 E. coli levels in the main stem of the Napa River (NR-1, NR-2) were somewhat higher than those seen in 2002 and 2003, but were below the numeric target of 126 CFU/100 mL (geometric mean). This may be due to seasonal variability, or to random variation. Upstream or tributary nonpoint sources, or wildlife in the vicinity of the sampling site may be the source of these mildly elevated bacteria counts.

5.3 Source Assessment Summary

Due to data and resources limitations, this report does not quantitatively estimate loads for the different pathogen sources in the Napa watershed. However, the data discussed above allow for general conclusions on the importance and magnitude of the different types of pathogen sources described at the beginning of this section. The following sources likely contribute significant controllable pathogen loads in the watershed, and these sources will be addressed in the preliminary implementation plan presented later in this report:

- **On-site sewage disposal systems (OSDSs)**. This source category appears to be a significant, but relatively localized source of pathogen loading during the dry season. While residential development is widespread throughout the watershed, high indicator bacteria levels were associated with residential development at only a few hot spots. Hot spots have been identified in the Browns Valley and Murphy Creek areas, but additional monitoring may reveal additional locations. Since a single failing septic system can deliver extremely large numbers of bacteria, it is possible that a very small number of systems are responsible for much of the observed impairment. It is likely that septic system failure is also a significant pathogen source during the wet season, but this effect tends to be obscured by wet season stormwater loading.

- **Sanitary sewer systems.** Elevated indicator bacteria levels were found in areas dominated by septic systems, areas served exclusively by sanitary sewer systems, and in mixed areas. Further monitoring during the adaptive implementation phase of this TMDL will be required to assess the relative importance of septic system failure versus sewer line failure and identify additional areas where septic/sewer loading is a concern.

- **Municipal runoff.** Data indicate that urban stormwater is a significant, widespread wet season pathogen source in the watershed. Most of the urban areas in the watershed are associated with elevated wet season indicator bacteria densities.

- **Cattle grazing.** These do not in general appear to constitute a major, widespread pathogen source in the watershed. However, high levels of pathogen loading from cattle grazing was observed at one location, and pathogen loading from additional sites may be identified with further monitoring.

- **Equestrian facilities.** While monitoring data for the Napa River watershed have not to date identified pathogen loading from this source category, horse facilities have been established as significant pathogen sources elsewhere in the region (Water Board, 2005). These facilities are therefore considered potential pathogen sources in this watershed. Further monitoring will be required to establish the locations and magnitude of pathogen loading from this source category.

The following sources appear to be of minor significance (and in the case of wildlife, uncontrollable), and will not be addressed in the implementation plan:

- **Wildlife.** The low indicator bacteria levels observed at all of the sampling sites that are not heavily affected by human activity indicates that wildlife are not, in general, a significant pathogen source in this watershed. Local problems may be present in certain areas where wildlife densities are particularly high.

- **POTW Discharge.** Recent self-monitoring reports from the four plants that discharge to the Napa River indicate that discharges are well below numeric targets, and that the discharges do not significantly contribute to pathogen loading under normal conditions.

6. TOTAL MAXIMUM DAILY LOAD AND LOAD ALLOCATIONS

6.1 General Approach

U.S. EPA guidelines (U.S. EPA, 1991) for developing TMDLs define the maximum allowable pollutant load as the total load of a particular pollutant that can be present in a waterbody while still attaining and maintaining designated beneficial uses. TMDLs for a waterbody are the sum of individual wasteload allocations for point sources and load allocations for nonpoint sources. The sum of these components must not result in the exceedance of water quality standards for that waterbody. In addition, the TMDL must include a margin of safety (MOS), either implicit or explicit, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day, organisms per day). The Code of Federal Regulations (40 CFR § 130.2(1)) states that TMDLs do not need to be expressed as loads (mass per unit time), but may be expressed as "other appropriate measure." For pathogen indicators, it is the number of organisms in a given volume of water (i.e., their density), and not their mass or total number, that is significant with respect to public health and protection of beneficial uses. The density of fecal indicator organisms in a discharge and in the receiving waters is the technically relevant criterion for assessing the impact of discharges, the quality of the affected receiving waters, and the public-health risk. Therefore, this TMDL plan establishes density-based TMDLs and pollutant load allocations, expressed in terms of indicator bacteria densities.

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

6.2 Proposed Total Maximum Daily Loads

Proposed TMDLs for the Napa River watershed are listed in Table 10. These TMDLs will be applicable year-round. As shown, the TMDLs are the density-based REC-I water quality objectives and U.S. EPA-recommended water quality criteria for contact recreation (Tables 2 and 3 [water quality objectives tables from Section 3.2]). This TMDL represents the total number of fecal indicator bacteria that can be discharged from all sources while not causing the water quality in the tributaries to exceed the bacterial densities specified in the Basin Plan.

Table 10 Total Maximum Daily Loads for the Napa River Watershed	
Indicator	**TMDL (CFU/100 mL)[a]**
E. coli	Geometric mean < 126 90^{th} percentile < 406

[a]Based on a minimum of five samples collected within a 30-day period.

6.3 Proposed Load and Wasteload Allocations

Density-based load allocations are proposed for this TMDL. Unlike mass-based load allocations, the density-based load allocations do not add up to equal the TMDL, since the densities of individual pollution sources are not additive. Rather, in order to achieve the density-based TMDL, it is simply necessary to assure that each source meets the density-based overall load allocation (Santa Ana Water Board, 1998; Central Coast Water Board, 2002).

Table 11 presents the density-based pathogen load and wasteload allocations proposed for the Napa River watershed. These load allocations will apply year-round to the different source categories of pollution in the watershed. The attainment of these load allocations will ensure protection of the water quality and beneficial uses of the Napa River and its tributaries.

Table 11
Density-Based Pollutant Load Allocations and Wasteload Allocations for Different Pollution Source Categories[a]

Categorical Pollutant Source	**E. coli Density**	
	Geometric Mean	90^{th} Percentile
OSDSs	0	0
Sanitary Sewer Systems	0	0
Municipal Runoff	126	406
Cattle Grazing	126	406
Equestrian Facilities	126	406
Wildlife	126	406

a. It is important to note that allocations in this table are not additive (see text).

Proposed wasteload allocations for each of the four POTWs that discharge to the Napa River are not specified by source category, but rather by individual discharger. For each discharger the proposed wasteload allocation is the effluent limit for that plant as specified in its NPDES discharge permit. These effluent limits, presented in Table 12, are conservative, and represent minimal pathogen loading to the Napa River and its tributaries.

Table 12 Pollutant Wasteload Allocations for POTWs	
Facility	**Effluent Limit—Median, CFU/100 mL**
Napa Sanitation District	35 enterococci
Town of Yountville	2.2 total coliform
City of St. Helena	23 total coliform
City of Calistoga	23 total coliform
City of American Canyon	2.2 total coliform
Napa River Reclamation District #	240 total coliform

In the case of allocations specified by 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 fecal coliforms in the downstream portion of the nearest waterbody above the proposed load allocations assigned to that source type. This allocation scheme assumes that the concentration of fecal coliforms upstream from the discharge point is not in excess of the assigned load allocations. For example, the geometric mean of fecal coliform concentrations in stormwater runoff samples collected at a residential area's storm drain that discharges into a tributary shall not exceed the allocated loads listed for the urban runoff source category.

OSDSs and sewer line failure, the primary potential sources of untreated human waste to the Napa River and its tributaries, are assigned load allocations of zero 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 load allocation is consistent with the existing Basin Plan prohibition of release of untreated sewage;
- When operated properly and lawfully, OSDSs and sanitary sewer systems should not cause any human waste discharges; and,
- Human waste discharges from these sources are fully controllable and preventable.

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

6.4 Margin of Safety

TMDLs are required to include a margin of safety (MOS) to account for data uncertainty, growth, critical conditions, and lack of knowledge. Virtually all pathogens have a limited ability to survive outside the human (or other host) body (U.S. EPA, 2001). Pathogen densities are therefore expected to only decrease in the outside environment over time, due to factors such as exposure to sunlight, chemical damage, and predation/competition by native nonpathogenic organisms. This effect provides an implicit MOS into the proposed TMDL.

Specification of numeric targets and load allocations in terms of U.S. EPA's E. coli recommendations provides an additional implicit MOS, since these recommendations are conservatively derived, and are more protective of human health than fecal coliform-based Water Quality Objectives. Therefore, no additional and/or explicit margin of safety is needed for this TMDL.

6.5 Seasonal Variation

While pathogen loads are typically greatest during the winter wet season due to high volumes of surface runoff, indicator bacteria densities can be high at any time of year. Dry season densities were higher than wet season densities at a number of sites monitored in the Water Board/SFEI study.

Recreational use of the Napa River and its tributaries is most prevalent during the summertime, but can occur at any time of year. Therefore, no seasonal variations to the above-listed TMDLs and load allocations are proposed.

7. LINKAGE ANALYSIS

An essential component of developing a TMDL is to establish a relationship (linkage) between pollutant loadings from various sources and the numeric targets chosen to measure the attainment of beneficial uses. For this TMDL, the proposed load allocations protect the beneficial uses (the linkage is established) because:

- The proposed density-based load allocations are the same as, or more stringent than proposed numeric water quality targets;
- The proposed numeric targets are the same as current U.S. EPA recommended bacterial water quality criteria for recreational waters; and
- The U.S. EPA recommend are conservatively based on epidemiological studies (U.S. EPA, 2002) and are protective of beneficial uses.

Therefore, achievement of the proposed pollutant load allocations (listed in Section 6) will ensure the protection of the water quality and beneficial uses of the Napa River and its tributaries.

There is no need to perform transport and fate analysis of pathogen loadings because numeric targets apply at all points in the watershed. That is, any potential pathogen source must meet numeric targets at the point at which the source enters the Napa River or any of its tributaries. Since pathogen regrowth is very unlikely in this watershed, and net pathogen die-off is virtually certain, pathogen densities at any point downstream of the initial point of discharge will be lower than at the point of discharge (see Section 6.4, Margin of Safety).

8. PUBLIC PARTICIPATION

Public participation is a requirement of the TMDL process and vital to its success. Release of this TMDL project report is an opportunity for the public to provide input to the Water Board. The TMDL will be formally established when it is adopted as an amendment to the Basin Plan.

8.1 Formal Process for Public Participation

A draft basin plan amendment and the supporting staff report will be presented to the Water Board for review and adoption in the first half of 2006. Two public hearings, a testimony hearing and an adoption hearing, will be held before the Water Board, which will consider adoption of the TMDL into the Basin Plan. This process will allow the public to formally comment on the TMDL.

8.2 Informal Process for Public Participation

Our pathogen TMDL stakeholder process builds upon the existing sediment TMDL stakeholder framework. We have participated in combined sediment-nutrient-pathogen TMDL meetings since early 2003, and presented a status report to the Napa County Board of Supervisors in January 2004. We maintain continuing involvement with the Napa River Watershed Taskforce, the Napa County Resource Conservation District, the Napa Farm Bureau, and with local, county, state, and federal agencies involved in the Watershed. We anticipate holding a CEQA scoping meeting and public meeting to solicit response to this preliminary project report in the summer of 2005. We are available to attend and/or conduct additional meetings as needed or requested.

9. IMPLEMENTATION PLAN

9.1 Overview

TMDLs are strategies to restore clean water. Implementations plans specify actions needed to solve the problem, and are required under California Law. The following implementation plan describes existing regulatory controls and cites relevant sections of the California Water Code (CWC) establishing the Water Board's authority to enforce the provisions set forth in the Implementation Plan. Section 13242 of the CWC requires that an implementation plan be incorporated into the Basin Plan upon Water Board adoption of the final TMDL Basin Plan amendment.

The implementation plan presented in this report provides a general description of proposed actions necessary to achieve water quality objectives. A more detailed implementation plan will be presented in the proposed Basin Plan amendment and accompanying staff report, scheduled for completion in 2006. These documents will contain more detailed descriptions of necessary actions, as well as a time schedule for these actions, and a description of the compliance monitoring and surveillance to be undertaken to ensure successful implementation. The final implementation plan will be developed in close coordination with stakeholders. Water Board staff will make an effort to discuss source control actions with all interested stakeholders and seek their input in regard to cost and feasibility.

The overall intent of this implementation plan is to restore and protect beneficial uses of the Napa River and its tributaries by reducing pathogen loadings. Potential pathogen sources in the watershed include: OSDSs, sanitary sewer line failure, municipal runoff, livestock, and wildlife. The Water Board recognizes the technical, institutional, and monetary challenges that each source category may face in designing and implementing measures to reduce their respective loading. As such, we are trying to be as flexible as possible in the implementation approach for reducing pathogen loading. We anticipate that enforcement mechanisms will only be needed where individuals have chosen not to assess and reduce their potential to impact water quality.

This implementation plan describes the Water Board's regulatory authority (Section 9.2) as well as other plans and policies in the Napa River watershed that affect pathogen source management activities (Sections 9.3 and 9.4). A description of the proposed implementation actions is provided in Section 9.5. Evaluation of progress toward attaining implementation goals is described in Section 9.6, and a long-term water quality monitoring program is discussed in Section 9.

9.2 Legal Authorities and Requirements

The Water Board has the responsibility and authority for regional water quality control and planning per the state's Porter-Cologne Water Quality Control Act. The Water Board regulates point source pollution by implementing a variety of programs, including the NPDES Program for point sources discharging into waters of the United States. The State also controls nonpoint source pollution as specified in the state's *Plan for California's Nonpoint Source Pollution Control Program* (State Board, 2000; hereafter referred to as the State NPS Management Plan). The State's Porter Cologne Water Quality Control Act gives the Water Board authority to issue Waste Discharge Requirements (WDRs) for point and nonpoint sources of contamination.

9.3 California Nonpoint Source Program

California's Nonpoint Source (NPS) Pollution Control Program has been in effect since 1988 (WMI Chapter, 2001). The NPS Program is a regulatory strategy aimed at addressing nonpoint source pollution throughout the State of California. The NPS program is being revised to enhance efforts to protect water quality, and to conform to the Clean Water Act Section 319 (CWA 319) and the Coastal Zone Act Reauthorization Amendments Section 6217 (CZARA). The lead state agencies for the NPS Program are the State Water Board, the nine Regional Water Boards and the California Coastal Commission. The NPS Program's long-term goal is to "improve water quality by implementing the management measures identified in the California Management Measures for Polluted Runoff Report (CAMMPR) by 2013."

The State also has a Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program that requires current and proposed nonpoint source discharges to be regulated under waste discharge requirements (WDRs), waiver of waste discharge requirement, Basin Plan prohibition, or some combination of these tools (State Board, 2004). For each source category that is currently discharging but not yet regulated, a regulatory tool has been identified.

9.4 Plans & Policies in the Napa River Watershed

Below is a description of the current regulations, policies, and plans for each of the categorical pathogen sources in the Napa River watershed. Source categories of concern include:

- Faulty onsite sewage disposal systems (OSDSs)
- Sanitary sewer system failure
- Cattle grazing
- Equestrian facilities
- Municipal runoff

<u>On-site sewage disposal systems</u>
The San Francisco Bay Basin Plan specifically addresses water quality issues related to on-site wastewater treatment and dispersal systems (on-site systems). In 1978, Water Board adopted a Policy on Discrete Facilities enumerating the following principles, which apply to all wastewater discharges:

- 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 a nuisance for the life of the development project;
- 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;
- The responsibility for both of the above must be clearly and legally assumed by a public entity with the financial and legal capability to assure that the system provides protection to the quality of the waters of the State for the life of the development project.

The policy also makes the following requests of city and county governments:

- That the use of new discrete sewerage systems be prohibited where existing community sewerage systems are reasonably available;
- That the use of individual septic systems for any subdivision of land be prohibited unless the governing body having jurisdiction determines that the use of the septic systems is in the best public interest and that the existing quality of the waters of the State is maintained consistent with the State Water Board's Resolution 68-16; and,
- That the cumulative impacts of individual disposal system discharges be considered as part of the approval process for development.

The Water Board has delegated authority for permitting and regulation of individual on-site wastewater treatment systems in Napa County to the county government. Delegation was enacted in 1964 by means of the Board's Resolution No. 596, which waives the requirement for filing reports of waste discharge with the Board for systems that are appropriately permitted by the County. On-site systems in Napa County are regulated by the Napa County Department of Environmental Management in accordance with the Napa County Code. The Code includes specifications for on-site system siting, design, installation, inspection and repair, and provisions for permitting and enforcement of violations.

In 2000, the California Water Code was amended to require the State Water Board to develop statewide regulations or standards for permitting and operation of onsite wastewater treatment systems (CWC Sections 13290 to 13291.7). The regulations are required to address, in part, new systems, systems subject to major repairs, systems adjacent to 303(d)-listed impaired waters, and minimum requirements for monitoring to determine system performance. Following adoption of the regulations, on-site system programs at both the Regional Water Board and County level will need to be updated to incorporate and implement the new requirements. A specific schedule for completion of the regulations is not currently known. The State Water Board is currently developing these regulations and draft regulations have recently been released for public review and comment.

Sanitary sewer systems

An October 2003 Water Board resolution established a collaborative program between the Water Board and Bay Area Clean Water Agencies (BACWA) to reduce sanitary sewer overflows (SSOs). The collaborative program includes four key tasks:

- establish SSO reporting guidelines,

- develop an electronic reporting system,
- establish guidelines for sewer system management plans (SSMP) and
- conduct a series of regional workshops to provide training on the first three tasks.

Reporting guidelines, the electronic reporting system, and regional workshops were completed in 2004. SSMP guidelines are under development, and are expected to be finalized in 2005.

Cattle grazing

The State Water Board and the California Coastal Commission have identified management measures to address nonpoint source pollution from grazing activities. In response to nonpoint source pollution concerns, the Range Management Advisory Committee composed of livestock industry representatives and public members was formed. The Committee developed a California Rangeland Water Quality Management Plan which concludes that ranches should complete rangeland Water Quality Management Plans for their respective ranches. Three approaches for voluntary compliance with the plan include: letter of intent with local Resource Conservation District office, development of a nonpoint source management plan; or adoption of a recognized nonpoint source management plan.

Equestrian facilities

The Water Board has the authority to regulate equestrian facilities as a confined animal facility through use of WDRs or waiver of WDRs. Equestrian facilities are also subject to the Water Board’s comprehensive runoff control program, consistent with federal regulations (40 CFR 122-24).

Municipal runoff

The Water Board has a comprehensive runoff control program that is designed to be consistent with Federal regulations (40 CFR 122-24) and is implemented by issuing NPDES permits to owners and operators of large storm drain systems and systems discharging significant amounts of pollutants. Each stormwater permit requires that the entities responsible for the system develop and implement comprehensive control programs. The cities of Napa, St. Helena, Calistoga, the Town of Yountville, and Napa County are covered by the general stormwater permit issued by the State Board and enforced by the Regional Water Board.

Current municipal runoff program requirements include the following elements:

- Develop, implement, and enforce a stormwater management plan (SWMP) to reduce the discharge of the pollutants to the maximum extent practicable;
- Address specific program areas, including public education and outreach on stormwater impacts, public involvement, illicit discharge detection and elimination, construction site stormwater runoff control, post construction stormwater management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations;
- Evaluation and assessment of measures; and,
- Monitoring and reporting.

9.5 Proposed Pathogen Reduction Implementation Actions

This section describes potential management measures for each source category in the Napa River watershed. In most cases, implementation efforts should focus on these source categories in those portions of the watershed associated with bacterial water quality impairment as identified through the data presented earlier in this report or through future monitoring activities discussed in Section 9.6.

To determine the appropriate level and type of source control and regulatory actions necessary to achieve water quality objectives, the Water Board will consider the following factors:

- The feasibility of achieving the required level of performance (assigned pollutant load allocations) for each source;
- The magnitude of the water quality impairment caused by each source; and
- The history of source control efforts and regulatory requirements.

Feasibility is a function of the technical capability and cost of management measure implementation. Water quality impairment is a function of the type of source (i.e. human versus animal waste) and its potential for causing an exceedance of water quality objectives.

Discharging entities will not be held responsible for uncontrollable coliform discharges originating from wildlife. If wildlife contributions are determined to be the cause of exceedances, the TMDL targets and allocation scheme will be revisited as part of the adaptive implementation program.
Many implementation activities are already underway in the watershed. The Water Board strongly supports these activities and recommends that these efforts be continued. Implementation of pathogen control measures that also reduce sediment and nutrient loads are encouraged, as this may preclude the need for implementation of additional management measures for those sources.

All sources are required to identify potential pathogen sources on their facilities and develop a plan for reducing pathogen runoff. Sources must then implement site-specific management measures to reduce the pathogen run-off and document the measures taken.

Each source category will provide documentation on progress made toward implementation of control measures. In some cases it may be desirable to identify an appropriate third party with expertise in implementation that could help evaluate reports for each source category. Where a third party is not identified, the Water Board will independently assess compliance. In all cases, the discharger is ultimately responsible for implementing identified control measures.

Throughout the TMDL process, the Water Board and stakeholders in the Watershed will need to monitor compliance with management measure implementation and assess whether water quality is improving. The Implementation Plan includes steps for evaluation and follow-up for assessing compliance with the TMDL. Ultimately, the long-term success of the TMDL implementation plan will be measured by attaining the designated TMDL load allocations.

If reasonable progress toward implementing the management practices is not demonstrated, the Water Board will consider additional regulatory control or taking enforcement actions on those source categories and/or individual dischargers that are not participating in good faith. Examples of additional regulation include requiring permits for individual grazing lands or equestrian facilities or requiring operating permits for all OSDSs.

If it is demonstrated that reasonable and feasible management measures have been implemented for a sufficient period of time and TMDL targets are still not being met, the TMDL will be reevaluated and revised accordingly.

Table 13 presents proposed implementation actions to be undertaken by the Water Board. These actions are applicable to all source categories. Tables 14-18 describe proposed actions for responsible parties for reduction of pathogen loading from each major source category. These implementation actions will be described in greater detail in the final staff report that will accompany the Basin Plan Amendment for this TMDL. Details will be developed in close coordination with parties responsible for implementation actions and other interested stakeholders.

Table 13 **Proposed Water Board Implementation Actions to Reduce Pathogen Loading**
1. Work with stakeholders to clearly define the role they can play in assisting with implementation of the TMDL.
2. Provide technical assistance in establishing guidelines and criteria for water quality protection plans and related issues.
3. Assist with permit streamlining for implementation of management practices.
4. Promote studies to evaluate the effectiveness of source control measures.
5. In coordination with responsible parties and interested third parties in the watershed, conduct monitoring program to measure progress toward, attainment of water quality objectives, meeting benchmarks, and compliance with TMDL implementation plan.
6. Assist in establishing funding mechanisms for implementation and monitoring.
7. Report to stakeholders on progress in meeting implementation of management measures and attainment of water quality objectives, including a discussion of options for regulatory action and follow-up, as needed.
8. Implement, as necessary, WDRs or waiver of WDRs related to pathogen reduction.

Table 14 Proposed Implementation Actions to Reduce Pathogen Loading from OSDSs	
Implementing Party	**Action**
Napa County Department of Environmental Management	1. In cooperation with the Water Board and sanitary sewer collection system owners, identify areas of greatest water quality concern from septic system failure based on proximity to impaired reaches, soil type, topography, and other factors.
	2. Submit a plan and implementation schedule to evaluate OSDS performance for the watershed and to bring identified OSDSs up to appropriate repair standards. Priority should be given to systems identified as posing water quality risks.
	3. Report progress on implementation of pathogen reduction measures.

Table 15 Proposed Implementation Actions to Reduce Pathogen Loading from Sanitary Sewer Systems	
Implementing Party	**Action**
Napa Sanitation District; City of Calistoga; City of St. Helena; Yountville Joint Treatment Plant; City of American Canyon; Napa River Reclamation District #2109	1. In cooperation with the Water Board and Napa County DEM, identify areas of greatest water quality concern from collection system failure based on proximity to impaired reaches, soil type, topography, and other factors.
	2. Develop Sanitary Sewer Management Plan in accordance with Water Board/BACWA guidelines (see Section 9.4, pages 36-37). Plan should include provisions to identify and repair collection system failures. Priority should be given to areas identified as posing water quality risks.
	3. Report progress on implementation of pathogen reduction measures.

Table 16 Proposed Implementation Actions to Reduce Pathogen Loading from Municipal Runoff	
Implementing Party	**Action**
Napa County; City of Napa; Town of Yountville; City of St. Helena; City of Calistoga	1. Implement Phase II stormwater management plan.
	2. Update/amend stormwater management plan to include specific measures to reduce pathogen loading.
	3. Report progress on implementation of pathogen reduction measures.

Table 17 Proposed Implementation Actions to Reduce Pathogen Loading from Cattle Grazing	
Implementing Party	**Action**
Owners of Cattle Grazing Operations	1. Participate in ongoing RCD/NRCS conservation programs.
	2. Implement management measures that reduce pathogen runoff.
	3. Where water quality impacts are identified, implement site-specific source control measures and conservation practices.
	4. Report on progress of pathogen loading reduction measures.

Table 18 Proposed Implementation Actions to Reduce Pathogen Loading from Equestrian Facilities	
Implementing Party	**Action**
Equestrian Facility Owners	1. Participate in ongoing RCD/NRCS conservation programs.
	2. Implement management measures that reduce pathogen runoff.
	3. Where water quality impacts are identified, implement site-specific source control measures and conservation practices.
	4. Report on progress of pathogen loading reduction measures.

9.6 Evaluating Progress Towards Attaining Implementation Goals

It is important to monitor water quality progress, track TMDL implementation, and modify TMDLs and implementation plans as necessary, in order to:

- assess trends in water quality to ensure that improvement is being made;
- address any uncertainty in various aspects of TMDL development;
- oversee TMDL implementation to ensure that implementation measures are being carried out; and
- ensure that the TMDL remains effective, given changes that may occur in the watershed after TMDL development.

The primary measure of success for this TMDL is attainment or continuous progress toward attainment of the TMDL targets and load allocations. However, in evaluating successful implementation of this TMDL, attainment of trackable implementation actions (i.e., BMPs) will also be heavily relied upon. Therefore, two types of monitoring are proposed for this TMDL: 1) water quality monitoring, and 2) monitoring of implementation of actions.

A formal water quality monitoring program for pathogen indicator bacteria will be developed by Water Board staff in coordination with stakeholders. Monitoring should begin as soon as possible, and should initially focus on previously identified hot spots and tributaries not assessed in previous work.

If after five years the Water Board determines that load and density reductions are being achieved as management measures are implemented, then the recommended appropriate course of action would be to continue management measure implementation and compliance oversight. If it is determined that all proposed control measures have been implemented, yet the TMDL is not achieved, further investigations will be made to determine whether: 1) the control measures are not effective; 2) the high levels of indicator bacteria are due to uncontrollable sources; or 3) the TMDL is unattainable.

10. GLOSSARY

Bacteria: Single-celled microorganisms that lack a cell nucleus and contain no chlorophyll. Bacteria of the coliform and enterococcus groups are considered the primary indicators of fecal contamination and are often used to assess water quality.

Beneficial uses: Designated uses of water, including, but are not limited to, domestic, municipal, agricultural, and industrial water supply; power generation; recreation; aesthetic enjoyment; navigation; preservation and enhancement of fish, wildlife, and other aquatic resources and preserves. (California Water Code [CWC] section 13050[f])

Best management practices (BMPs): Methods, measures, or practices selected by an agency to meet its nonpoint source control needs. BMPs include, but are not limited to, structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters.

Catchment area: The area draining into a lake, reservoir, or stream; contributing watershed.

Coliform bacteria: See total coliform bacteria.

Colony-forming unit (CFU): A single bacterial cell capable of reproducing and giving a positive test response in the laboratory. As used in this document, CFU is functionally synonymous with "bacteria count."

Discharge: Flow of surface water in a stream or canal or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to the discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.

Effluent: Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, and the like.

Enterococci: A subgroup of the fecal streptococci that includes S. faecalis and S. faecium. The enterococci are differentiated from other streptococci by their ability to grow in 6.5 percent sodium chloride, at pH 9.6, and at 10°C and 45°C. Enterococci are a valuable bacterial indicator for determining the extent of fecal contamination of recreational surface waters.

Escherichia coli: A subgroup of the fecal coliform bacteria. E. coli is part of the normal intestinal flora in humans and animals and is, therefore, a direct indicator of fecal contamination in a waterbody. The O157:H7 strain, sometimes transmitted in contaminated waterbodies, can cause serious infection, resulting in gastroenteritis. See also fecal coliform bacteria.

Fecal coliform bacteria: A subset of total coliform bacteria that are present in the intestines or feces of warm-blooded animals. They are often used as indicators of the sanitary quality of water. See also total coliform bacteria.

Gastroenteritis: An inflammation of the stomach and the intestines.

Indicator: Measurable quantity that can be used to evaluate the relationship between pollutant sources and their impact on water quality.

Indicator organism: Organism used to indicate the potential presence of other (usually pathogenic) organisms. Indicator organisms are typically associated with the other organisms, but are usually more easily sampled and measured.

Load allocation (LA): The portion of a receiving waterbody's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources.

Loading capacity (LC): The greatest amount of loading that a waterbody can receive without violating water quality standards. The LC equals the TMDL.

Margin of safety (MOS): A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody (CWA section 303[d][1][C]).

Most probable number (MPN): A assay procedure that yields a statistically estimated bacterial count for a sample. MPN is often used as the reporting unit for these assays, in which case it is functionally synonymous with "bacteria count."

National Pollutant Discharge Elimination System (NPDES): The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.

Nonpoint source: Pollution sources that are diffused and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by stormwater runoff. Commonly used categories for nonpoint sources are agriculture, forestry, urban, mining, construction, land disposal, and saltwater intrusion.

On-site sewage disposal system (OSDS): A septic system in which wastewater is treated at the site on which the wastewater is generated. This is in contrast to a centralized wastewater treatment facility that receives wastewater piped in from remote sources.

Pathogen: A microorganism capable of causing disease.

Point source: Any discernible, confined, and discrete conveyance including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture or agricultural stormwater runoff (40 CFR 122.2).

Protozoa: Single-celled organisms that reproduce by fission and occur primarily in the aquatic environment. Waterborne pathogenic protozoans of primary concern include Giardia lamblia and Cryptosporidium, both of which affect the gastrointestinal tract.

Septic system: An on-site system designed to treat domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a system of tile lines or a pit for disposal of the liquid effluent. Sludge that remains after decomposition of the solids by bacteria in the tank must be pumped out periodically.

Stakeholder: Those parties likely to be affected by, or that can affect, the TMDL.

Total coliform bacteria: A group of bacteria found in the feces of warm-blooded animals. Note that the total coliform group also includes many common soil bacteria, which do not indicate fecal contamination. See also fecal coliform bacteria.

Total Maximum Daily Load (TMDL): The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, and a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standards.

Virus: Submicroscopic pathogen consisting of a nucleic acid core surrounded by a protein coat. Requires a host in which to replicate (reproduce).

Waste load Allocation (WLA): The portion of a receiving waterbody's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation (40 CFR 130.2[h]).

Wastewater treatment: Chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.

Water Quality Criteria: Elements of water quality standards expressed as constituent concentrations, levels, or a narrative statement, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use. In California, water quality criteria are referred to as water quality objectives (WQO).

Water Quality Objective (WQO): See water quality criteria.

Water Quality Standard (WQS): Provisions of state and federal law that consist of: 1) a designated use or uses for the waters of the United States; 2) water quality criteria for such waters to protect such uses; and 3) statements to prohibit degradation (antidegradation policy). Water quality standards are to protect public health or welfare, enhance the quality of the water, and serve the purpose of the Clean Water Act (40 CFR 131.3).

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

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12. APPENDICES

Appendix A. Fecal coliform data collected by Napa Count Department of Environmental Management.

Date	SAMPLE LOCATION Oak Knoll Rd.	Trancas Bridge	River Point	China point	Imola Bridge So.	Napa Yacht Club	Kennedy Park
	Fecal coliforms, CFU/100 mL						
21-Dec-02	450	278	512	689	530	—	620
30-Dec-02	240	122	145	201	300	—	310
6-Jan-03	20	31	97	100	110	—	52
13-Jan-03	520	350	663	416	185	—	410
21-Jan-03	410	300	122	410	410	—	148
28-Jan-03	41	10	100	310	95	—	84
10-Feb-03	63	100	30	74	30	30	100
24-Feb-03	52	52	85	187	52	100	410
10-Mar-03	30	41	10	100	200	10	5
24-Mar-03	100	10	100	259	200	31	100
7-Apr-03	20	5	5	100	100	100	41
21-Apr-03	74	100	310	74	52	200	200
5-May-03	146	197	203	146	288	309	262
19-May-03	31	30	31	240	187	10	161
2-Jun-03	52	95	41	197	109	31	285
23-Jun-03	20	41	86	216	85	97	146
7-Jul-03	—	—	31	62	122	158	84
21-Jul-03	74	30	10	305	109	74	335
4-Aug-03	20	52	52	253	301	253	581
18-Aug-03	10	40	52	95	198	92	269
15-Sep-03	30	—	156	97	143	187	156
29-Sep-03	10	—	107	291	424	164	128
27-Oct-03	5	52	206	247	134	122	74
10-Nov-03	2,400	520	4,611	472	213	657	197
24-Nov-03	10	41	31	5	20	5	5
8-Dec-03	472	839	886	467	464	419	238
22-Dec-03	187	158	213	450	419	573	275
5-Jan-04	86	122	85	160	109	350	135
20-Jan-04	110	109	146	74	85	63	85
2-Feb-04	—	2,909	2,359	2,987	98	836	122
17-Feb-04	311	350	305	—	663	350	594
1-Mar-04	63	52	63	2,247	158	84	110
15-Mar-04	52	63	52	86	20	20	74
29-Mar-04	41	31	20	20	30	20	5
12-Apr-04	10	30	41	—	20	5	52
10-May-04	20	41	41	63	86	20	52
24-May-04	41	171	52	74	86	5	98
21-Jun-04	31	63	—	—	142	63	140
19-Jul-04	63	41	—	—	—	177	213
2-Aug-04	83	106	—	1,203	—	687	1,203
16-Aug-04	—	384	368	169	119	350	118
8-Sep-04	226	677	1,354	437	141	122	134

Appendix B. E.coli data collected in the 2002-2004 Water Board/SFEI study.

		OCTOBER 2002 SAMPLING EVENT				
Site #	**LOCATION**	10/2/02	10/8/02	10/17/02	10/23/02	10/29/02
2	Mill Creek@121	110	—	—	—	—
3	Ritchey Creek	98	—	—	—	—
4	Napa Crk@ Jefferson	610	930	150	>24,000	240
5	Napa River@Calistoga	63	—	—	—	—
6	Napa River@Zinfandel	10	—	—	—	—
9	Napa R.@Yountville Preserve	10	—	—	—	—
13	Murphy Creek	440	390	620	500	430
15	Salvador@Ball park	63	—	—	—	—
16	Miliken@Hedgside Rd.	74	—	—	—	—
18	Browns Valley Creek	980	17,000	800	150	6,100
19	Fagan Creek@Kelly Road	160	—	—	—	—
23	Napa River@Trancas	1,100	—	—	—	—
25	Sulfur Creek	10	—	—	—	—
26	Bell Canyon Creek	210	< 1	41	120	340
30	Napa River@ 3rd St.	2,600	3,400	310	470	500
31	Napa River@Oak Knoll	10	—	—	—	—

		JANUARY 2003 SAMPLING EVENT				
Site #	**LOCATION**	1/6/03	1/13/03	1/22/03	1/29/03	2/6/03
1	Dry Creek@RR Bridge	31	—	—	—	—
2	Mill Creek@121	52	—	—	—	—
3	Ritchey Creek	130	—	—	—	—
4	Napa Crk@ Jefferson	380	240	1,400	440	360
5	Napa River@Calistoga	530	—	—	—	—
6	Napa River@Zinfandel	84	—	—	—	—
8	Napa River@Tubbs	74	—	—	—	—
9	Napa R.@Yountville Preserve	97	—	—	—	—
11	Tulokay Creek	330	—	—	—	—
13	Murphy Creek	380	31	86	74	41
14	Carneros @Wither	180	—	—	—	—
15	Salvador@Ball park	430	—	—	—	—
16	Miliken@Hedgside Rd.	52	—	—	—	—
18	Browns Valley Creek	4,400	170	930	440	990
19	Fagan Creek@Kelly Road	300	—	—	—	—
20	Soda Creek@Silverado	10	—	—	—	—
23	Napa River@Trancas	110	—	—	—	—
25	Sulfur Creek	560	—	—	—	—
26	Bell Canyon Creek	230	20	41	31	20
27	Dutch Henry Creek	10	—	—	—	—
30	Napa River@ 3rd St.	31	150	120	140	160
31	Napa River@Oak Knoll	97	—	—	—	—

Appendix B., continued.

Site #	LOCATION	JULY 2003 SAMPLING EVENT				
		7/7/03	7/16/03	7/23/03	7/30/03	8/6/03
1	Dry Creek@RR Bridge	110	—	—	—	—
2	Mill Creek@121	20	—	—	—	—
3	Ritchey Creek	63	—	—	—	—
4	Napa Crk@ Jefferson	110	—	—	—	—
5	Napa River@Calistoga	110	<10	41	41	10
6	Napa River@Zinfandel	20	20	20	10	10
8	Napa River@Tubbs	20	—	—	—	—
9	Yountville Eco-Reserve	41	20	10	<10	<10
11	Tulokay Creek	41	—	—	—	—
13	Murphy Creek	660	—	—	—	—
14	Carneros @Wither	460	—	—	—	—
15	Salvador@Ball park	20	—	—	—	—
16	Miliken@Hedgside Rd.	150	—	—	—	—
18	Browns Valley Creek	1,400	170	2,100	1,500	3,200
19	Fagan Creek@Kelly Road	74	—	—	—	—
23	Napa River@Trancas	41	—	—	—	—
25	Sulfur Creek	10	—	—	—	—
26	Dell Canyon Creek	30	—	—	—	—
30	Napa River@ 3rd St.	63	72	74	120	270
31	Napa River@Oak Knoll	31	—	—	—	—
32	Redwood Crk.@Redwood Rd.	120	—	—	—	—

Site #	LOCATION	MAY-JUNE 2004 SUPPLEMENTAL SAMPLING				
		5/5/04	5/12/04	5/19/04	5/26/04	6/2/04
BR-0	Napa Creek @ Pearl St.	250	420	—	—	—
BR-1	Napa Creek @ Jefferson St.	350	340	—	—	—
BR-2	Browns Valley @ Highway 29	330	750	—	—	—
BR-3	Browns Valley @ Browns Valley Rd.	2,900	540	3,100	290	240
BR-4	Browns Valley @ McCormick Ln.	380	330	680	720	640
BR-5	Browns Valley @ Buhman Ave.	2,600	810	330	340	120
BR-6	Browns Valley @ Borrette Ln.	150	160	<10	20	20
BR-7	Browns Valley @ Partrick Rd.	<10	<10	—	—	—
MU-1	Tulokay Creek @ Shurtleff Ave.	160	180	—	—	—
MU-2	Murphy Creek @ Coombsville Rd.	97	51	330	280	160
MU-3	Murphy Creek @ Shady Brook Ln.	400	280	74	63	51
NR-1	Napa River @ Yountville Preserve	160	41	—	—	—
NR-2	Napa River @ Oak Knoll Rd.	170	85	—	—	—
SH-1	Sheehy Creek @ Kelly Road	2,700	4,000	—	—	—
SV-1	Salvador Channel @ Summerbrook Cir.	86	30	—	—	—
SV-2	Salvador Channel @ Trower Ave.	41	130	—	—	—
SV-3	Salvador Channel @ Solano Ave.	160	1,100	340	790	3,900