CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

SAN FRANCISCO BAY REGION

TOTAL MAXIMUM DAILY LOAD FOR PATHOGENS IN TOMALES BAY

Preliminary Project Report
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TABLE OF CONTENTS

LIST OF FIGURES ..... **IV**

LIST OF TABLES ..... **V**

DEFINITION OF ACRONYMS AND ABBREVIATIONS ..... **VI**

EXECUTIVE SUMMARY ..... **VII**

1. INTRODUCTION **1**

1.1 INTRODUCTION 1

2. BACKGROUND **2**

2.1 DESCRIPTION OF TMDL PROCESS 2
2.2 REGULATORY CONTEXT 4
2.3 WATERBODY DESCRIPTION 4
2.4 WATERSHED DESCRIPTION 5
2.5 LAND USE 7
2.6 AQUACULTURE 8

3. PROBLEM DEFINITION **11**

3.1 FECAL COLIFORMS AS INDICATORS OF HUMAN PATHOGENS 11
3.2 WATER QUALITY STANDARDS 12
3.3 OTHER REGULATORY AUTHORITIES/WATER QUALITY STANDARDS 14
3.4 RAINFALL CLOSURE RULES 14
3.5 FORMATION OF TOMALES BAY SHELLFISH TECHNICAL ADVISORY COMMITTEE 15
3.6 SUMMARY OF PAST BACTERIOLOGICAL WATER QUALITY STUDIES 16
1974 Study – California Department of Health Services *16*
1976-78 Study – Regional Water Quality Control Board *17*
1980 Study – U.S. Food and Drug Administration *17*
1994-95 Pilot Study – Department of Health Services *18*
1995-96 Study – TBSTAC, SWRCB, DHS, RWQCB *18*
Watershed Results 19
Bay Results 19
Shellfish Results 20
2000-01 Study – TBSTAC, RWQCB *20*
Sampling Frequency 21
Sampling Stations 21
Flow/Discharge Measurements 22
Watershed Results 23
Bay Results 24
Overall Fecal Coliform Contributions 24
Conclusions 25
3.7 ILLNESS OUTBREAK 26
3.8 PROBLEM STATEMENT 27

4. NUMERIC TARGETS 28

4.1 PROPOSED NUMERIC TARGETS 28
4.2 PROPOSED INTERIM TARGETS 29

5. POLLUTANT SOURCE ASSESSMENT 30

5.1 AGRICULTURAL RUNOFF 30
Location: 30
Magnitude: 32
Significance: 34
5.2 FAULTY ON-SITE SEWAGE DISPOSAL SYSTEMS 34
Location: 34
Magnitude: 35
Significance: 37
5.3 BOAT DISCHARGES 38
Location: 38
Magnitude: 38
Significance: 39
5.4 WILDLIFE 39
Location and Magnitude: 39
Significance: 40
5.5 RESIDENTIAL RUNOFF 40
Location and magnitude: 40
Significance: 40
5.6 SMALL WASTEWATER TREATMENT FACILITIES AND SEWAGE HOLDING PONDS 41
Location: 41
Magnitude: 41
Significance: 44
5.7 SOURCE ASSESSMENT SUMMARY 44

6. TOTAL MAXIMUM DAILY LOAD AND LOAD ALLOCATIONS 46

6.1 GENERAL APPROACH 46
6.2 PROPOSED TOTAL MAXIMUM DAILY LOADS 46
6.3 PROPOSED LOAD ALLOCATIONS 47
6.4 MARGIN OF SAFETY 49
6.5 SEASONAL VARIATION 49
6.6 CRITICAL CONDITIONS 49

7. LINKAGE ANALYSIS 51

7.1 LINKAGE BETWEEN WATER QUALITY TARGETS AND POLLUTANT SOURCES 51
7.2 WATER QUALITY MODELING 51

8. PUBLIC PARTICIPATION 52

8.1 FORMAL PROCESS FOR PUBLIC PARTICIPATION 52
8.2 INFORMAL PROCESS FOR PUBLIC PARTICIPATION 52

9. IMPLEMENTATION PLAN 54

9.1 OVERVIEW OF PROPOSED TMDL IMPLEMENTATION PLAN 54

9.2 SUMMARY OF IMPLEMENTATION PLAN PHASES AND ACTIONS 54
9.3 LEGAL AUTHORITIES AND REQUIREMENTS 58
9.4 CALIFORNIA NONPOINT SOURCE PROGRAM 58
9.5 PLANS & POLICIES IN THE TOMALES BAY WATERSHED 58
Grazing/Rangeland 59
Confined Animals (Dairy and Equestrian Facilities) 59
Onsite Sewage Disposal Systems 60
Small Wastewater Facilities 61
Storm water Management Program 62
9.6 COOPERATING STAKEHOLDERS 62
County of Marin 62
Shellfish Technical Advisory Committee 63
UC Cooperative Extension/Tomales Bay Agricultural Group 63
Marin Resource Conservation District (RCD) 63
Government Agencies 63
Tomales Bay Watershed Council (TBWC) 64
9.7 WATERSHED-WIDE IMPLEMENTATION ACCORDING TO SOURCE OF POLLUTION 64
9.8 IMPLEMENTATION ACTIONS TO REDUCE PATHOGENS 64
9.9 FUTURE PLANS AND POLICIES 73
9.10 EVALUATION OF REGULATORY MEASURES 73
9.11 MONITORING PROGRAM 74
9.12 CONCLUSION 75
10. REFERENCES 76

LIST OF FIGURES

Figure 1. Tomales Bay, Marin County, California 5

Figure 2. Tomales Bay Watershed 6

Figure 3. General Location of Commercial Shellfish Growing Area Leases in Tomales Bay, California 9

Figure 4. Location of Sampling Stations for the 2001 Tomales Bay Bacterial Monitoring Study..... 22

Figure 5. Summary of 2001 Tomales Bay Bacterial Monitoring Results..... 24

Figure 6. Land Use in the Tomales Bay Watershed..... 31

Figure 7. Septic Parcels Within 150 Feet of a Stream in Tomales Bay Watershed..... 35

Figure 8. Septic System Performance Rating for Town of Marshall 37

Figure 9. Small Wastewater Treatment Facilities Within Tomales Bay Watershed..... 42

LIST OF TABLES

Table 1. Tomales Bay Watershed Area Estimates, Including Reservoirs (Adapted from Fischer, 1996) 6
Table 2. Area Estimates for the gauged Portions of the Tomales watershed, Including Release and Spill From Catchment Reservoirs and Unimpaired Flow from the Watershed Below the Reservoirs (Fischer, 1996) 7
Table 3. Estimates of Watershed Contributions to Runoff into Tomales Bay (Fischer, 1996) 7
Table 4. Commercial Shellfish Growers and Wet Storage Operators in Tomales Bay. .. 10
Table 5. Beneficial Uses of Tomales Bay Relevant to Pathogen TMDL 13
Table 6. Water Quality Objectives For Coliform Bacteria 14
Table 7. Summary of Closure Rules for Shellfish Growing Areas in Tomales Bay 15
Table 8. List of Sampling Sites for the 2001 Tomales Bay Bacterial Monitoring Study . 21
Table 9. Summary of 2001 Tomales Bay Bacterial Monitoring Results 23
Table 10. Ranking of Tomales Bay's Subwatersheds Based on Their Overall Fecal Coliform Contributions Over the Span of 2001 Microbial Monitoring Study 25
Table 11. Numeric Targets for Fecal Coliforms for Tomales Bay and its Tributaries 28
Table 12. Tomales Bay Land Use Acreage by Subwatershed 32
Table13. Estimated Numbers of Livestock [a] and Manure Production inTomales Bay Watershed (Totals/Watershed/Day) 33
Table 14. Fresh Manure production and Characteristics 33
Table 15. List of pathogens of primary concern that can be shed in the feces of livestock and transmitted to humans through water 34
Table 16. Selected Pathogenic Human Enteric Viruses 38
Table 17. Permitted Sewage Treatment Systems in the Tomales Bay Watershed, which are Regulated Under Waste Discharge Requirements from the San Francisco Bay Regional Water Quality Control Board. 43
Table 18. Pathogen Source Assessment Summary 44
Table 19. Total Maximum Daily Loads for the Tomales Bay and its Tributaries 47
Table 20. Density-Based Pollutant Load Allocations for Different Categories of Nonpoint Source Pollution 48
Table 21. Public Participation for Tomales Bay Pathogen TMDL 53
Table 22. Implementation Goals 56
Table 23. Regional Board Actions 66
Table 24. Actions by Others 69

DEFINITION OF ACRONYMS AND ABBREVIATIONS

ABAG:	Association of Bay Area Governments
APA:	Administrative Procedures Act
Basin Plan:	San Francisco Bay Regional Water Quality Control Board Basin Plan
BMP:	Best Management Practices
CAMMPR:	California Management Measures for Polluted Runoff Report
CWA:	Clean Water Act
CWC:	California Water Code
CZARA:	Coastal Zone Act Reauthorization Amendments
DFG:	Department of Fish and Game
DHS:	Department of Health Services
EFAP:	Equine Facilities Assistance Program
FC:	Fecal Coliform
FDA:	Food and Drug Administration
HEV:	Human Enteric Viruses
LA:	Load Allocation
MCSTOPPP:	Marin County Stormwater Pollution Prevention Program
MOS:	Margin of Safety
MPN:	Most Probable Number
NSSP:	National Shellfish Sanitation Program
OAL:	Office of Administrative Law
OSDS:	Onsite Sewage Disposal System
RCD:	Resource Conservation District
REC I:	Water Contact Recreation Beneficial Use
REC II:	Non-contact Water Recreation Beneficial Use
RWQCB:	Regional Water Quality Control Board
SHEL:	Shellfish Harvesting Beneficial Use
SWRCB:	State Water Resources Control Board
TBAG:	Tomales Bay Agriculture Group
TBSTAC:	Tomales Bay Shellfish Technical Advisory Committee
TC:	Total Coliform
TMDL:	Total Maximum Daily Load
U.S. EPA:	United States Environmental Protection Agency
WDR:	Waste Discharge Requirements
WLA:	Waste Load Allocation
WQO:	Water Quality Objective
WQS:	Water Quality Standard

EXECUTIVE SUMMARY

Tomales Bay is listed as an impaired waterbody under the federal Clean Water Act, Section 303(d) for pathogens.

Problem Statement: The listing of Tomales Bay as impaired due to pathogens is based on:

- Exceedance of water quality standards for shellfish harvesting (SHEL), water contact recreation (REC-1), and noncontact water recreation (REC-2) beneficial uses;
- Listing of Tomales Bay as " threatened" under the state's Shellfish Protection Act;
- The prohibition on commercial shellfish harvesting during rainfall periods, regulated by Department of Health Services (DHS); and,
- An illness outbreak from the consumption of contaminated Bay shellfish.

Numeric Targets: The ultimate numeric targets (desired future conditions for the Bay and its tributaries) proposed for this Total Maximum Daily Load (TMDL) are as follows:

- The San Francisco Bay Regional Water Quality Control Board's (RWQCB) Basin Plan Water Quality Objectives (WQO) for shellfish growing waters, for the Bay (14 MPN/100 ML);
- RWQCB's Basin Plan WQO for water contact recreation, for all the major tributaries to Tomales Bay (200 MPN/100 ML); and,
- A zero discharge of human waste in order to protect the public from human pathogens, for the Bay and all its tributaries

In addition to the above numeric targets, interim targets based on percent fecal coliform concentration reductions in the Bay and the tributaries are proposed as follows for this TMDL:

- 30% reduction in water column fecal coliform concentrations by 2005; and,
- 75% reduction in water column fecal coliform concentrations by 2007.

Sources Assessment: Monitoring results form numerous studies on pathogen indicators in Tomales Bay, points towards a predominant group of actual and potential pathogen loading sources to the Bay. All of these sources fall under the nonpoint source category and they are:

- Agricultural Runoff (dairy farms, cattle/sheep grazing lands, horse facilities, etc.)
- Faulty Onsite Sewage Disposal Systems (OSDSs)
- Boat Discharges
- Urban Runoff (e.g., pet waste)
- Small Wastewater Treatment Facilities
- Wildlife

TMDLs: This report establishes density-based (number of microorganisms per unit volume) Total Maximum Daily Loads expressed in terms of fecal coliform concentrations. The table below lists the proposed TMDLs for the Tomales Bay and its tributaries. These TMDLs will be applicable year-round.

Total Maximum Daily Loads of Pathogen Indicators for the Bay and its Tributaries

WATERBODY	INDICATOR PARAMETER	TMDL	
		MEDIAN/ LOG MEAN [a]	MAXIMUM [b]
Tomales Bay	Fecal coliform	Median < 14 (MPN/100 ml)	43 MPN/100 ml
Major Tributaries: Walker Creek, Lagunitas Creek, Olema Creek	Fecal coliform	Log Mean < 200 (MPN/100 ml)	400 MPN/100 ml

a. Based on a minimum of no less than five samples equally spaced over a 30-day period.
b. No more than 10% of total samples during any 30-day period may exceed this number.

Load Allocations: The table below presents the density-based load allocations proposed for pathogens in Tomales Bay and its major tributaries. These load allocations will apply year-round to the different nonpoint source categories of pollution in the watershed.

Density-Based Pathogen indicator load allocations for different categories of Nonpoint source pollution

CATEGORICAL POLLUTANT SOUIRCES	LOAD ALLOCATIONS FECAL COLIFORM (MPN/ 100 ML)			
	For Discharges to The Bay		For Discharges to The Tributaries	
	Median [a]	Maximum [b]	Log Mean [a]	Maximum [b]
Onsite sewage disposal systems	0	0	0	0
Small wastewater treatment facilities	0	0	0	0
Boat discharge	0	0	N/A	N/A
Agricultural runoff	14	43	200	400
Urban runoff	14	43	200	400
Wildlife	Uncontrollable	Uncontrollable	Uncontrollable	Uncontrollable

a. Based on a minimum of no less than 5 samples equally spaced over a 30-day period.
b. No more than 10% of total samples during any 30-day period may exceed this number.

Linkage Analysis: The linkage analysis establishes the connection between pollutant load allocations and the protection of beneficial uses. The allocations we propose here protect the beneficial uses because 1) the numeric water quality objectives are the same as the load allocations for the given waterbodies and the TMDL targets (i.e., 14 MPN/100 ML for the Bay, and 200 MPN/100 ML for the tributaries), and 2) these numeric water quality objectives are protective of all beneficial uses.

Implementation Plan: The implementation plan describes existing regulatory programs and authorities that can assist with TMDL implementation. The implementation plan also identifies specific management measures that are necessary to achieve TMDL targets, a time schedule for implementing source control actions and, monitoring to determine compliance with the objectives.

In Tomales Bay, there are efforts underway within the watershed to reduce pathogen pollution. RWQCB staff hopes that these ongoing efforts will bring the Bay into compliance with water quality standards. The implementation of the final/approved TMDL Plan will take place in two phases. Phase I includes source assessment and plan development for most sources and is proposed to begin as soon as possible. We recommend that during Phase I the storm water runoff agency, recreational boaters, and equestrian and ranch facilities conduct source assessments and develop site-specific plans to reduce potential sources. Because dairy facilities, Marin County's on-site disposal systems (septic systems) program and small wastewater facilities have already completed the source assessment and plan development, we recommend that these source categories begin plan implementation in Phase I.

The goal of Phase II is to implement site-specific management measures for all of the pathogen contributing sources. We recommend this phase begin no later than January 2004 and run through 2007. Each potential source will need to document progress made toward fully implementing necessary source reduction and management measures. We recommend that an appropriate third party evaluate progress for each source type.

The implementation plan also includes interim targets of a 30% reduction in Bay pathogen concentrations by 2005 and 75% reduction in Bay pathogen concentrations by 2007. Throughout Phase I and Phase II, watershed monitoring will be needed to determine compliance with management measure implementation and identify the progress made toward interim targets. If necessary, RWQCB will use regulatory authorities and/or enforcement actions to ensure that reasonable progress is made towards meeting water quality targets.

1. INTRODUCTION

1.1 Introduction

We have prepared a Preliminary Project Report for the Total Maximum Daily Load (TMDL) for Pathogens in Tomales Bay. This report is a significant milestone in the TMDL development process and provides an opportunity for stakeholders to comment on the scientific basis of the TMDL and a preliminary implementation strategy. In this report we evaluate the degree of water quality impairment, and propose numeric targets that define a solution and a plan of actions to solve the water quality problem.

The next steps in developing a pathogen TMDL for Tomales Bay are:

- Distribute this preliminary report to stakeholders / interested parties;
- Hold meetings with various stakeholder groups to discuss implementation actions;
- Solicit feedback and input on key issues;
- Produce a final TMDL project report (June 2003);
- Technical peer review of the report;
- Put forward the final TMDL project report for RWQCB's consideration; and,
- Draft a Basin Plan Amendment for TMDL implementation.

2. BACKGROUND

2.1 Description of TMDL Process

The Tomales Bay estuary is a unique and highly valuable natural resource in the San Francisco Bay Region. Water quality standards are set and enforced by the State of California to protect its designated beneficial uses. When states and local communities identify a waterbody that has failed to meet water quality standards, a Total Maximum Daily Load (TMDL) must be developed to remedy the water quality problems. Tomales Bay and its tributaries have been identified as impaired for pathogens. The purpose of this TMDL is twofold: first, to assess the sources of pathogens which are causing water quality impairment in Tomales Bay, and second, to identify appropriate control measures that will lead to the attainment of the water quality standards set for the Bay.

Section 303(d) of the Clean Water Act (CWA) requires the California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB) to identify the Region's waters that do not comply with water quality standards (WQS); rank the impaired waterbodies by taking into consideration the severity of pollution and the uses made of such waters; and, establish TMDLs to ensure that impaired waters attain their beneficial uses. Lists of prioritized impaired water bodies, known as the "303(d)" lists, must be submitted to the U.S. Environmental Protection Agency (U.S. EPA) every two years.

A TMDL represents the total loading rate of a pollutant that a waterbody could receive and still meet the applicable water quality standards. The TMDL can be expressed as the total mass or quantity of a pollutant that can enter the water body within a unit of time. In most cases, a TMDL determines the allowable loading capacity for a constituent and divides it among the various contributors in the watershed as wasteload (for point source discharge) and load (for nonpoint source) allocations. TMDLs must also account for natural background sources and provide a margin of safety (implicit or explicit). A TMDL can be expressed in terms of mass per unit time, toxicity, density, concentration, or other appropriate measures. For this pathogen TMDL, we propose using a density-based (number of organisms per unit volume) measure of pathogen-indicator organisms.[1]

The U.S. EPA recommends using a phased approach to TMDL development and/or implementation for situations where data and information needed to determine the assimilative capacity of a waterbody and the necessary control measures (implementation plan) are limited (USEPA, 1991). The TMDL for pathogens in Tomales Bay is likely to be most effective if implemented in a phased manner. Section 9 of this report describes

[1] The direct detection and measurement of pathogens in ambient waters is not practical or feasible, due to high cost, time, equipment, the need for highly skilled laboratory personnel, and other considerations. A class of non-pathogenic indicator organisms (bacteria) called fecal coliforms is therefore commonly used to indicate the presence and assess the magnitude of fecally originated human pathogenic microorganisms in the environment. Fecal coliforms live and reproduce in the intestinal tracts of all warm-blooded animals (including humans) and are abundantly found in all warm-blooded animals' waste. The presence of fecal coliform in a water sample indicates the possible presence of fecally-originated pathogens. For more discussion, please refer to Section 2.1.

the preliminary implementation plan which includes potential pathogen control measures, the time frame for implementing these measures, and interim targets or milestones.

Section 303(d) of the CWA and section 130.0 et seq of the 40 Code of Federal Regulations (CFR), specify the components and requirements of a TMDL plan. In general, a TMDL plan must:

1. Develop a strategy to meet applicable Water Quality Standards: A TMDL must include a plan for the specific waters and pollutants that must be addressed to ensure that applicable water quality standards are attained.

2. Set quantifiable water quality goals or targets (numeric targets): A TMDL must establish specific goals and endpoints for the TMDL, which ensure attainment of applicable water quality standards.

3. Analyze/account for all sources of pollutants (source assessment): All significant pollutant sources should be described, including the magnitude and location of sources.

4. Identify pollution reduction goals (pollutant load allocations): A TMDL plan includes pollutant reduction targets for all point and nonpoint sources of pollution. TMDLs, load allocations, and wasteload allocations indicate maximum pollutant loads allowed.

5. Describe the linkage between water quality targets and pollutants of concern (linkage analysis): A TMDL must explain the relationship between the numeric targets and the pollutants of concern. That is, will the recommended pollutant load allocations lead to attainment of the target?

6. Develop margin of safety that considers uncertainties, seasonal variations, and critical conditions: A TMDL must consider any uncertainties regarding the ability of the plan to meet water quality standards. The plan must consider these issues in its recommended pollution reduction goals.

7. Include an appropriate level of public involvement in the TMDL process: This is usually achieved by publishing a public notice of the TMDL, circulating the TMDL for public comment, and holding public meetings in local communities.

8. Identify and implement alternative control measures to rectify impairment of the waterbody (implementation plan): A TMDL must recommend specific nonpoint source Best Management Practices (BMPs), point source controls, and other actions necessary to achieve the desired water quality endpoints.

9. Include a monitoring and review plan: A TMDL must include a plan to assess its implementation and effectiveness, and to provide for adjustment as needed.

In addition, a TMDL process should involve the public in both the development and implementation stages of the TMDL, as public participation is the key to a successful TMDL.

2.2 Regulatory Context

In the San Francisco Bay Region, the CWA is administered by RWQCB under its federally designated authority. The San Francisco Bay RWQCB is one of the nine regional boards in the State of California. The State Water Resources Control Board (SWRCB) establishes statewide policies and serves as the review and appeal body for the decisions of the regional boards. The SWRCB is made up of five members appointed by the governor.

RWQCB consists of nine governor-appointed members who serve four year terms. Scientific information is gathered and policy is developed for RWQCB by its civil service employees (staff). RWQCB has adopted a Water Quality Control Plan for the San Francisco Bay Region (Basin Plan) that contains a list of beneficial uses for waterbodies in the Region and the standards and implementation measures necessary to protect those beneficial uses.

Some measures that go beyond the scope of the current Basin Plan must first be adopted by RWQCB, using a Basin Plan amendment process, before they are implemented. Such measures include the TMDL that is the subject of this report. The process involves presenting proposed Basin Plan amendments to RWQCB in a publicly noticed hearing. RWQCB receives public comments, and at least sixty days later, staff present responses to comments and relevant revisions to the proposed amendment. RWQCB then votes on adoption, and if the amendment is adopted, it is sent to the SWRCB for approval. If SWRCB approves the amendment, it is sent to the Office of Administrative Law (OAL) to determine whether the amendment is consistent with the California Administrative Procedures Act (APA). State TMDL adoption is complete after OAL approval and State transmittal of the TMDL to the U.S. EPA for approval.

2.3 Waterbody Description

Tomales Bay is located in western Marin County, California, approximately 50 km (40 miles) northwest of San Francisco (Figure 1). The Bay has a surface area of approximately 28 square kilometers (11 square miles). The mouth of Tomales Bay is at the southern end of Bodega Bay, and its body extends in a southeasterly direction along the line of the San Andreas Fault. The Bay is about 12 miles in length with an average width of less than 1 mile. Tomales Bay is characterized by relatively shallow water, with the average depth being less than 20 feet. Hydrographic studies conducted from 1966-1970 by Smith, et al. (1971) indicate that the currents in the Bay are predominantly influenced by tidal cycles rather than wind-driven. They suggested that the Bay consists of three mixing regimes: 1) significant flushing in the lower-Bay from the mouth to approximately Hog Island near the Walker Creek Delta, 2) sluggish mixing in the mid-Bay (Pelican Point to Double Point), and, 3) even less water exchange in the portion of

the upper-Bay (south of Double Point). These studies were conducted in the summer and fall periods and therefore do not reflect the influence of increased inflow from runoff.

Figure 1. Tomales Bay, Marin County, California

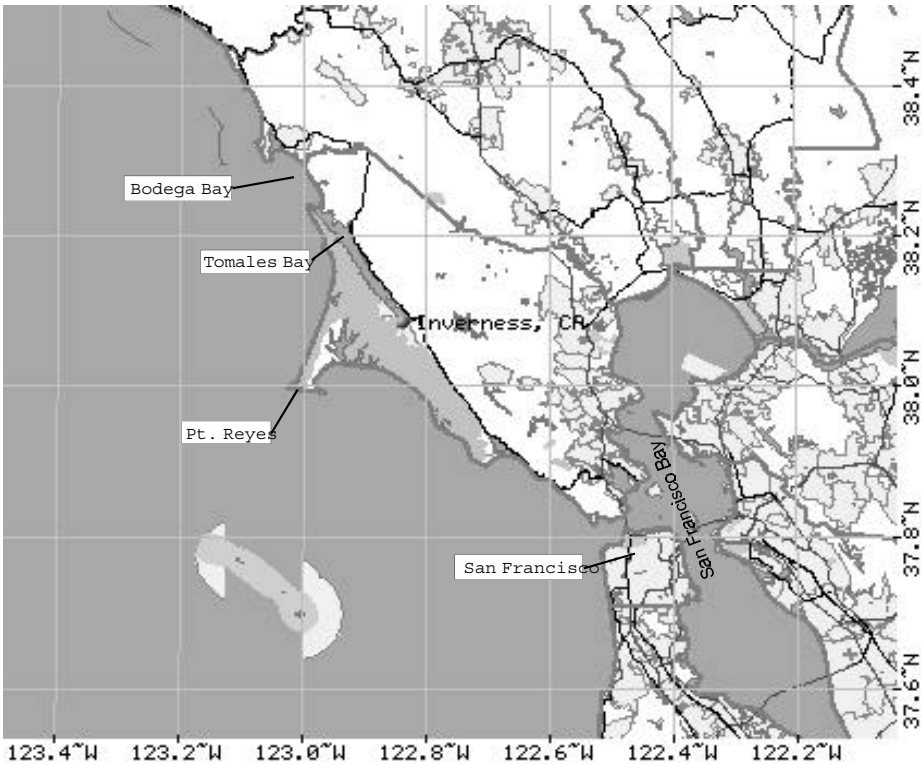


Figure 1. Location of Tomales Bay, Marin County, California (U.S. Census Tiger Map).

2.4 Watershed Description

The Tomales Bay watershed climate is consistent with the "Mediterranean" climate of the central coast of California, receiving intense rain during the winter months (November through March), with 85% of the annual rain usually falling during this period. Another 10% of the annual precipitation falls during October and April, with the remaining 5% during the other five months of the dry season. Average annual rainfall ranges from 26 inches per year in the northern and eastern part of the watershed to 39 inches per year in the south (Fischer et al., 1996).

The watershed area for Tomales Bay is approximately 561 km^2 (216 square miles) with four major drainage areas: (1) the immediate drainage from small tributaries along the west and east shores (73 km^2; 28 mi^2); (2) Lagunitas Creek (241 km^2; 93 mi^2) to the southeast; (3) Olema Creek (50 km^2; 19 mi^2), which flows into Lagunitas Creek close to the head of the Bay; and (4) Walker Creek (196 km^2; 76 mi^2) to the northeast (Table 1 and Figure 2) (Fischer et al. 1996).

Table 1. Tomales Bay Watershed Area Estimates, Including Reservoirs (Adapted from Fischer, 1996)

SUBWATERSHED	AREA (KM^2)	AREA (%)
Walker	196.35	35
Lagunitas	241.72	43
Olema	50.0	9
Remainder	72.93	13
TOTALS	**561**	**100%**

Figure 2. Tomales Bay Watershed

The U.S. Geological Survey maintains stream gauges on both Walker and Lagunitas creeks. These gauges measure only a portion of the runoff from their respective watersheds, as well as any water released from catchment reservoirs (Table 2). Fischer, et al. (1996) estimated that about two-thirds of the runoff into Tomales Bay comes through the Lagunitas-Olema Creek drainage even though this area only makes up about half of the watershed (Table 1 & 3). The Walker Creek drainage, which includes Chileno, Arroyo Sausal, Salmon, and Keyes Creeks, makes up about 35% of the Tomales Bay watershed area, but produces about 25% of the annual runoff into the Bay (Fischer, et al. 1996). The remainder of the flows into the Bay (approximately 10%) comes from the local Bay shore drainages, which make up 13% of the total watershed area. It is estimated that sediment runoff from the major creeks and tributaries into Tomales Bay may be as high as 48,600 tons/year. Approximately one third of the sediment is carried into the Bay from the Walker/Keyes Creek drainage.

Table 2. Area Estimates for the gauged Portions of the Tomales watershed, Including Release and Spill From Catchment Reservoirs and Unimpaired Flow from the Watershed Below the Reservoirs (Fischer, 1996)

WATERSHED	AREA (KM^2)	AREA (%)
Walker	78.54	14
Lagunitas	213.18	38
Remainder	269.28	48
TOTALS	**561**	**100%**

Table 3. Estimates of Watershed Contributions to Runoff into Tomales Bay (Fischer, 1996)

WATERSHED	% OF TOTAL
Walker	25
Lagunitas	66
Remainder	9
TOTALS	**100%**

Marin Municipal Water District (MMWD) maintains five water catchment reservoirs in the Lagunitas watershed (four on Lagunitas Creek and one on Nicasio Creek) with a total capacity of approximately 69,000 acre feet. MMWD also has a reservoir on a tributary to Walker Creek, with a capacity of 10,572 acre-feet.

2.5 Land Use

The Tomales Bay watershed is a major recreational area and is used for hiking, boating, camping, picnicking, clamming, fishing, and bird watching. The Bay also supports the commercial cultivation and harvesting of shellfish, including oysters, mussels, and clams. Herring and halibut are also harvested commercially from wild populations, and there is a sport fishery for halibut in the Bay.

The major land uses in the watershed are livestock grazing, dairy farming, equestrian, low-density residential, and parklands. Beef, sheep, and dairy farms have been an important part of the local economy since the mid-1800s, although the number of dairies has been declining since there has been an increase in competition from large Central Valley dairies. However, since some dairies have switched to raising beef cattle and others have increased the size of their dairy herds, it is unclear, at this time, how the total number of animals in the watershed may have changed.

There are nine small towns within the watershed, with limited commercial development and no industry. According to the 1990 census, the west side of Tomales Bay has a population of 1,392, with a total of 650 households. The east side of the Bay, from Dillon Beach to Point Reyes Station, has a population of 3,217, with 1,246 households. The population has probably increased since the last census due to some new residential development. All of the towns are served by onsite sewage disposal systems (OSDSs) except the town of Tomales, which is served by a centralized wastewater treatment facility. There are currently eight small wastewater treatment facilities within the watershed, and one facility that accepts septage waste.

The Regional Board prohibits direct discharge from treatment facilities into Tomales Bay or the creeks within the watershed (RWQCB Basin Plan, Table 4-1). A number of the wastewater treatment facilities have holding ponds and are permitted to discharge to irrigation fields during the dry season. A complete list and description of all small wastewater treatment facilities within the Tomales Bay watershed is provided in Table 17.

2.6 Aquaculture

There was at least a minor fishery for native oysters (*Ostera lurida*) from Tomales Bay as early as 1859 (Barrett, 1963). Although eastern oysters (*Crassostrea virginica*) were initially transplanted to Tomales Bay near Millerton Station in 1875, these efforts were not successful due to abundant production of the San Francisco Bay oyster grounds, which were closer to the major markets in San Francisco. Non-native oysters were again introduced into Tomales Bay around 1907 in response to increased pollution of San Francisco Bay and the resultant failure of its oyster industry. The Tomales Bay Oyster Company started operations near Hamlet, and the Consolidated Oyster Company began a short-lived operation at Blakes Landing.

The Tomales Bay Oyster Company was the first to introduce Pacific oysters (*Crassostrea gigas*) to Tomales Bay in 1929 following the earlier successful introduction of this species in Washington State. This species now constitutes the majority of oysters currently produced in Tomales Bay.

The vast majority of shellfish harvesting in Tomales Bay is from commercial shellfish growing areas. There are currently seven certified active commercial shellfish harvesters and one certified wet storage facility in Tomales Bay, with a combined aquaculture lease area of 483 acres (Figure 3 and Table 4). All active commercial growers in Tomales Bay

operate on eastern shoreline under leases granted by California Department of Fish and Game (DFG). An inactive grower, the Frank Spenger Company, used to operate on a Point Reyes National Seashore lease on the western shore.

Figure 3. General Location of Commercial Shellfish Growing Area Leases in Tomales Bay, California

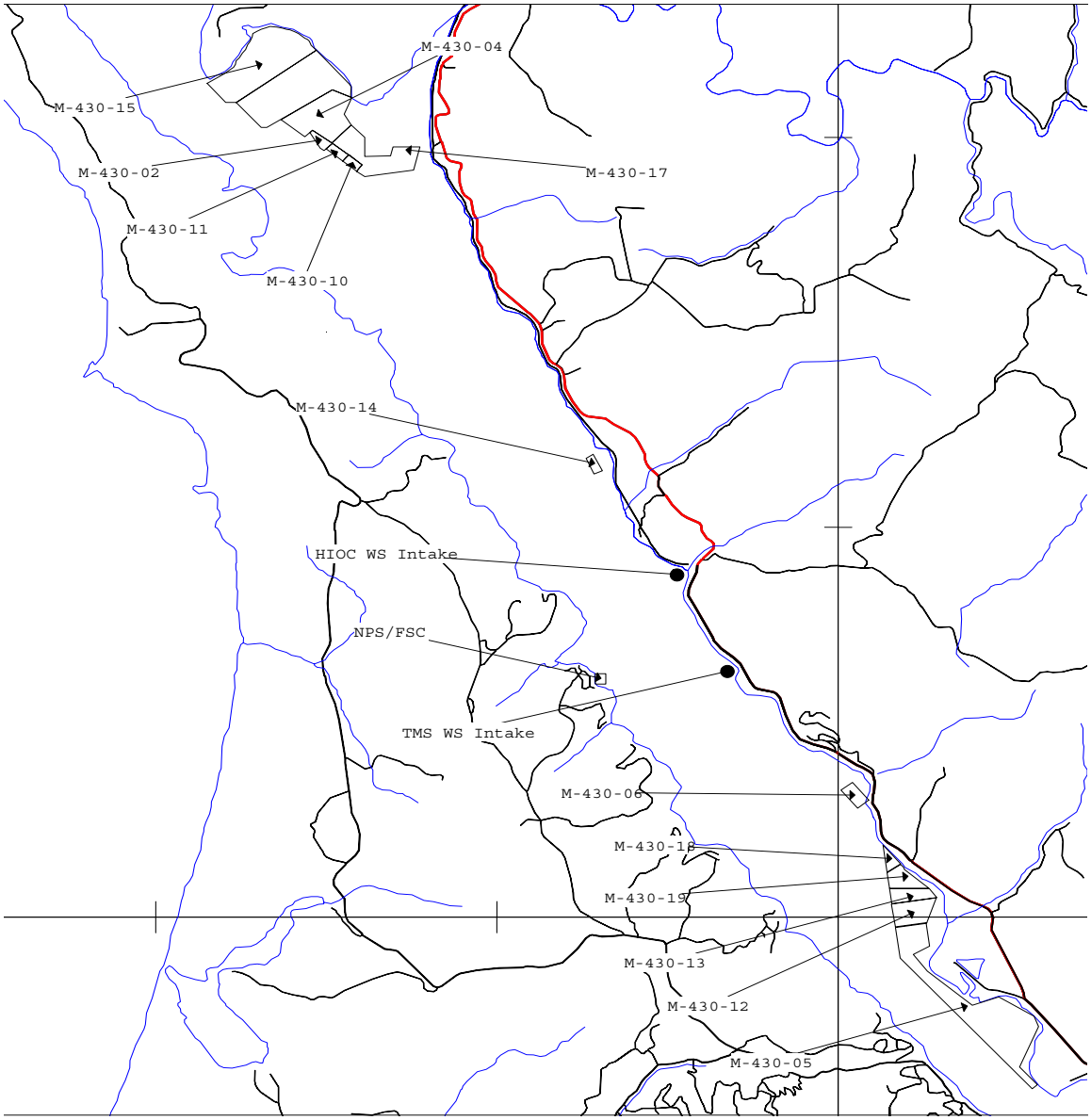


Figure 3. General location of commercial shellfish growing area leases in Tomales Ba

Table 4. Commercial Shellfish Growers and Wet Storage Operators in Tomales Bay.

COMPANY	REG. NO.	DFG LEASE NO.	NO. ACRES	PRODUCTS
Marin Oyster Company	00256	M-430-02	5	Pacific Oysters
Charles Friend Oyster Company	00256	M-430-04	62	Pacific Oysters
Bay Bottom Beds, Inc.	00256	M-430-04 M-430-04 M-430-19	25 62 25	Pacific Oysters, Manila Clams
Cove Mussel Company	00311	M-430-06	10	Bay Mussels, Pacific Oysters
Hog Island Oyster Company Inc.	00265 00364	M-430-10 M-430-11 M-430-15 M-430-12 Intake	5 5 98 25	Pacific Oysters, Manila Clams, Blue Mussels
Point Reyes Oyster Co.	00416	M-430-13 M-430-14 M-430-17	25 5 62	Pacific Oysters, European Oysters, Kumomoto Oysters,
Tomales Bay Shellfish Farms, Inc.	00330	M-430-05	156	Pacific Oysters, Bay Mussels, Manila Clams, European Flat Oysters

Commercial shellfish production in Tomales Bay is primarily devoted to Pacific oysters (*Crassostrea gigas*) and bay mussels (*Mytilus edulis and M. galloprovincialis*). In addition, there is a small amount of commercial production of Eastern oyster (*Crassostrea virginica*), European oysters (*Ostrea edulis*), Kumomoto oysters (*Crassostrea gigas kumomoto*), and Manila clams (*Tapes semidecussata*). There is a fairly large amount of recreational harvesting for horseneck clams north of the Walker Creek Delta during the spring and fall. There is also a small bed of cockles and clams used for recreational harvesting near Hamlet, just south of the Walker Creek Delta.

3. PROBLEM DEFINITION

In accordance with Section 303(d) of the CWA requirements, RWQCB developed a list of impaired waterbodies and pollutants in the Region. RWQCB recommended Tomales Bay as an impaired waterbody for pathogens, sediments, nutrients, and metals. The listing of Tomales Bay as impaired due to pathogens is based on:

- The exceedence of water quality standards for shellfish harvesting and water contact recreation,
- The listing of Tomales Bay as "threatened" under the State's Shellfish Protection Act in 1994,
- The prohibition on commercial shellfish harvesting during rainfall periods, regulated by the California Department of Health Services, and
- A 1997 illness outbreak from the consumption of contaminated Bay shellfish.

3.1 Fecal Coliforms as Indicators of Human Pathogens

More than 100 types of human pathogenic organisms occur in fecally-polluted water and continue to cause outbreaks of waterborne disease (Haveelar, 1993). Contaminated or improperly treated drinking water, fecally-polluted recreational waters, and shellfish harvested from waters contaminated by human sewage and/or animal wastes can be vectors of pathogenic disease.

The techniques that are currently available for direct monitoring of pathogens in the environment (i.e., natural waterbodies) 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[2] viruses often have limited sensitivity, are time consuming and expensive, and require highly skilled labor and sophisticated laboratory facilities (Snowdon and Cliver, 1989).

Due to these shortcomings, indicator organisms are commonly used to assess microbial water quality for both shellfish growing and recreational use waters. Several types of indicator bacteria colonize the intestinal tracts of warm-blooded animals and are routinely shed in their feces. These organisms are not necessarily pathogenic, but are abundant in wastes from warm-blooded animals and are easily detected in the environment. Historically, the detection of these indicator organisms indicates that the environment is contaminated with fecal waste and that pathogenic organisms may be present.

Two of the most commonly used indicators of human pathogenic organisms are total and fecal coliforms. Total coliform are comprised of four genera of bacteria that can exist on soil particles and plant surfaces as well as in fecal matter. Fecal coliforms are a subset of total coliform and are specific to wastes from warm-blooded animals, but not necessarily to humans. Although fecal coliform bacteria have historically been the indicator

[2] Viruses that replicate in the intestinal tract of humans are referred to as human enteric viruses (HEV).

organisms of choice, they do have some shortcomings. These organisms are not human-specific, and are inadequate to assess the health risk from human enteric viruses (which compared to other pathogenic organisms (i.e., bacteria, protozoan parasites) are believed to pose the greatest risk to human health).

Even though the scientific community is aware of the shortcomings of fecal coliform indicators, at the present time no perfect indicator organism exists. Moreover, the existing Basin Plan and the Department of Health Services water quality standards used to protect water quality and public health are all based on fecal coliform concentrations. For these reasons, the Tomales Bay Pathogen TMDL uses fecal coliforms to indicate and regulate pathogen presence.

3.2 Water Quality Standards

Under the CWA authority, RWQCB has established water quality standards for Tomales Bay which are comprised of: a) beneficial uses for the Bay, b) water quality objectives to protect those beneficial uses, and c) the Antidegradation Policy which requires the continued maintenance of existing high quality waters. RWQCB's Basin Plan contains a list of beneficial uses for each water body in the Region and the objectives and implementation measures necessary to protect those beneficial uses. The beneficial uses of Tomales Bay impaired due to high pathogen-indicators levels are shellfish harvesting, water contact recreation, and non-contact water recreation (Table 5). The purpose of this TMDL is to protect and restore these beneficial uses by reducing the levels of pathogens in Tomales Bay. The shellfish harvesting beneficial use is the most sensitive to elevated pathogen levels of all three of the beneficial uses of concern. The goal of this TMDL, therefore, is to protect all three beneficial uses by attaining water quality objectives protective of shellfish harvesting.

Table 5. Beneficial Uses of Tomales Bay Relevant to Pathogen TMDL

DESIGNATED BENEFICIAL USES OF TOMALES BAY	DESCRIPTION
Shellfish Harvesting (SHEL)	Uses of water that support habitats suitable for the collection of crustaceans and filter feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sport[3] purposes.
Water Contact Recreation (REC-I)	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-II)	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.

Numerical water quality objectives for fecal and total coliforms for each of the beneficial uses listed in Table 5 and are listed in the Basin Plan (Table 6).

[3] Since sport shellfish harvesting could take place at any spot within the Bay, the SHEL water quality standards must be met at the entire Bay and not just at the designated lease areas for commercial shellfish farming.

Table 6. Water Quality Objectives For Coliform Bacteria [a]

BENEFICIAL USE	FECAL COLIFORM (MPN[b]/100 ML)	TOTAL COLIFORM (MPN/100 ML)
Water Contact Recreation (REC I)	Log mean<200 90th percentile<400	Median< 240 No sample> 10,000
Shellfish Harvesting (SHEL)	Median<14 90th percentile <43	Median< 70 90th percentile< 230
Non-contact Water Recreation (REC II)	Mean<2000 90th percentile<4000	N/A

a. Based on a minimum of five consecutive samples equally spaced over a 30-day period.
b. Most Probable Number (MPN) is a statistical representation of the results of the standard coliform test.

3.3 Other Regulatory Authorities/Water Quality Standards

The California Department of Health Services (DHS) has separate authority and standards to regulate commercial shellfish growing areas that supersede those contained in Regional Basin Plans. In the San Francisco Bay Region, Basin Plan standards for fecal coliforms in shellfish-growing waters state that the concentration of fecal coliforms in the ambient water cannot exceed a median of 14 MPN/100 ML, or the 90th percentile cannot exceed 43 MPN/100 ML. Although DHS used a median value in the past, they now use a geometric mean of 14 MPN/100 ML. DHS standards follow criteria developed by the National Shellfish Sanitation Program (NSSP), which is administered by the U.S. Food and Drug Administration (FDA) (U.S.FDA, 1997). These standards allow for a median or a geometric mean to be used. The NSSP standards are based on acceptable levels of fecal coliforms in shellfish and shellfish growing waters. The NSSP fecal coliform standard for shellfish tissue is a market standard of 230 MPN/100 grams (U.S.FDA, 1995).

3.4 Rainfall Closure Rules

To ensure public safety, DHS has developed rainfall-based shellfish harvesting prohibition rules for different areas of the Bay. These rules are site specific and based on analysis of the influence of runoff events on tissue and water column fecal coliform concentrations (Table 7). As the volume of collected data has increased and the data analysis has become more refined, rainfall closure rules have also become more stringent. This has significantly impaired the economic viability of the commercial shellfishing industry. The latest and most stringent rules were issued in 1999.

Table 7. Summary of Closure Rules for Shellfish Growing Areas in Tomales Bay

AREA	AREA DESCRIPTION	24-HOUR RAINFALL THRESHOLD	CLOSURE LENGTH (DAYS)	SECONDARY RAINFALL THRESHOLD	CLOSURE LENGTH (DAYS)
A	Inner Bay excluding area of Lease M-430-05 south of Tomasini Point	0.4 inch	4	0.67 inch	5
B	Area of Lease M-430-05 south of Tomasini Point	0.50 inch	4	0.67 inch	5
C	Outer Bay excluding Lease M-430-15	0.50 inch	5	0.67 inch	6
D	Lease M-430-15 in outer Bay [a, b]	0.40 inch	6	0.67 inch	7

a. Lease M-430 shall be closed one additional day when the 10-day cumulative rainfall exceeds 2.0 inches.

b. Not including the portion of this lease that is subject to seasonal rainfall closure.

Source: Draft Twelve-Year Sanitary Survey Report; Shellfish Growing Area Classification for Tomales Bay (DHS, 2001).

Since the DHS's standards supersede those of RWQCB's Basin Plan, in regulating the commercial shellfish industry, and since the commercial shellfish growing industry is regulated by DHS based on fecal coliform standards, the various required endpoints (i.e., numeric targets, TMDL, load allocations) of this TMDL are based upon these fecal coliform standards as well.

3.5 Formation of Tomales Bay Shellfish Technical Advisory Committee

On October 10, 1993, California legislature passed a legislation that enacted the Shellfish Protection Act of 1993. This legislation is incorporated in the Porter Cologne Water Quality Control Act (California Water Code, Division 7, Chapter 24, Section 14950-14958). Under this law RWQCB is required to form a technical advisory committee for any commercial shellfish growing area determined to be threatened. One of the criteria for a "threatened" area is the number of days the area is closed to shellfish harvesting due to pollution threats. The Shellfish Protection Act states that a shellfish area shall be designated as threatened if it is closed to harvesting for more than thirty days in each of three consecutive calendar years. Based on the California Department of Health Services' (DHS) letter of January 5, 1994, notifying the RWQCB that Tomales Bay met the threatened designation, the RWQCB passed a resolution on January 19, 1994, authorizing formation of the Tomales Bay Shellfish Technical Advisory Committee

(TBSTAC). RWQCB staff organized the TBSTAC and held its first meeting on February 15, 1994. According to the Shellfish Act, the purpose of TBSTAC is to advise and assist RWQCB in developing an investigation and remediation strategy to reduce pollution affecting the shellfish growing areas.

3.6 Summary of Past Bacteriological Water Quality Studies

Shellfish growers under the authority of DHS conduct monthly water quality monitoring for fecal coliforms in Tomales Bay. In addition, several intensive studies have been conducted on bacteriological water quality in relation to shellfish harvesting over the past 28 years. These studies include:

- A shellfish and water quality study conducted in 1974 by the DHS (Sharpe, 1974),
- A shoreline and watershed water quality survey carried out in 1976-77 and 1977-78 by RWQCB (Jarvis et al., 1978),
- A sanitary survey conducted by the Department of Health and Human Services of FDA (Musselman, 1980),
- A pilot study conducted by DHS in the winter of 1994-95 to test sampling methods and locations for the 1995-96 study
- A SWRCB funded study conducted in 1995-96 by DHS and RWQCB, under the auspices of TBSTAC (TBSTAC et al., 2001), and
- A second SWRCB funded study conducted in 2001 by RWQCB and TBSTAC (RWQCB, 2001).

The results of these studies are briefly discussed below.

1974 Study – California Department of Health Services
In 1974 DHS designed a study (Sharpe, 1974) to determine the water quality of Tomales Bay and tributary streams during wet weather conditions and relate the results to the bacteriological quality of the shellfish grown in the Bay. The study also included a sanitary survey for potential pollutant sources, with a detailed description of the potential of contamination from land uses and recreational uses in and along Tomales Bay. DHS staff collected water samples at 17 Bay sampling stations, 19 shoreline stations and 49 tributary stream stations for 12 days in December, following a three-day rain event totaling 1.98 inches. They analyzed all samples for total and fecal coliforms. They also sampled the shellfish from six locations and analyzed them for coliforms and heavy metals.

Results from the Bay samples generally showed that the Bay waters did not exceed the median standard of 14 MPN/100 mL for shellfish harvesting waters but some stations did exceed the requirement that the 90th percentile of samples may not exceed 43 MPN/100mL. Shoreline samples showed elevated total and fecal coliform levels at numerous stations, which were attributed to the possibility of shoreline drainage, tributary streams entering the Bay, and possible failing septic systems. Shellfish samples were also elevated in most instances. In spite of fairly low runoff because of dry conditions in the watershed, results from tributary samples showed high total and fecal

coliform counts. The streams were considered the major source of pollutants to the Bay. The study concluded that the high coliform counts were due to contribution of wastes by upstream dairies and, in lower Keyes Creek, from raw sewage discharges from the town of Tomales. This study predates the adoption of the RWQCB requirements to improve handling of animal wastes on dairy farms and the construction of the Tomales sewage treatment plant.

1976-78 Study – Regional Water Quality Control Board
The San Francisco Bay RWQCB conducted a shoreline and tributary sampling survey during the winters of 1976-77 and 1977-78 (Jarvis et al., 1978), to evaluate the effectiveness of the RWQCB's recent requirements for dairy waste practices. The RWQCB adopted "Minimum Guidelines for Protection of Water Quality from Animal Wastes" in 1973 and required dairies to be in compliance with manure handling practices by September 1, 1976. Samples were taken from 20 stream stations and six shoreline stations (not every station was sampled during each survey nor during both years). Samples were analyzed for total and fecal coliforms, total organic carbon, and ammonia. Samples were only taken during the rainy season (from November through March in 1976-77 and November through January in 1977-78).

Results indicated improvement in stream conditions in areas where dairies had come into compliance with the minimum guidelines, although none of the shoreline or stream stations sampled met coliform objectives for water contact and non-contact recreation following periods of rainfall. The 1976-77 season had very light rainfall and the January 3, 1977, sampling event was the first major rain (approx. 2 inches in three days). The January 14, 1978 sampling event followed a 2.5 inch rain event in three days; however, there was significant rainfall in November and December, so that the runoff from the watershed was greater than the previous year's. There were much higher coliform levels along the shoreline in the 1977-78 season as compared with the previous year; this was attributed to greater freshwater inflows into the Bay during 1977-78. Stream stations showed decreases in coliform between 1976-77 and 1977-78 following implementation of the Minimum Guidelines. The report also concluded that sewering of the town of Tomales in June 1977 resulted in decreased levels of coliform in Keyes Creek below the town.

1980 Study – U.S. Food and Drug Administration
In 1980, USFDA, to determine the degree of pollution and recovery rate of the Bay during periods of rainfall, conducted a sanitary survey from February 24 through March 12. Samples were taken from 45 stations in the Bay and on tributary stations close to the Bay. A total of 393 samples were collected and analyzed for total and fecal coliforms, and fecal streptococci. Shellfish samples were taken from two sites in the Bay and analyzed for total and fecal coliforms.

The results of this study showed that the shellfish market standard for fecal coliform is exceeded in all Bay water quality stations during wet periods. The dry period samples met the standard, with the exception of stations at the head of the Bay and near the mouth of Walker Creek. Seven out of eight shellfish samples exceeded the market standard.

Tributary samples ranged from low fecal coliform densities during the dry periods to high densities during rainfall events. In order to quantify the numbers of bacteria entering the Bay, daily estimates of stream flow were made on major streams (Walker, Keyes, Lagunitas, Olema, and Bear Valley Creeks) and several eastshore tributaries to the Bay (Millerton Gulch, Tomasini Creek, Grand Canyon Creek, and Cypress Grove). It was determined that the fecal coliform densities in the streams during dry weather were equal to sewage from about 150 to 200 people. During wet weather, fecal coliform densities increased to the equivalent of sewage from 1,500 to 2,000 people or 500 to 700 cows. The highest loadings following rains revealed a bacterial equivalent of 40,000 to 50,000 people or 15,000 to 20,000 cows.

The 1980 study concluded that the portions of the Bay most seriously affected by pollution from rainfall and runoff were the head of the Bay (Millerton Point south) and the Walker Creek delta. Rural and livestock sources of nonpoint pollution were considered to be the most likely cause of high fecal coliform densities in the Bay.

1994-95 Pilot Study – Department of Health Services

The pilot study conducted by DHS in the winter of 1994-95 was a prelude to the study during 1995-96 (DHS, 1996). Both of these studies were initiated as a result of Tomales Bay being listed as "threatened" under the Shellfish Protection Act and the formation of the TBSTAC. This study was designed to evaluate indicator species, test sampling methods and laboratory analyses, and finalize site selection of watershed sampling stations for the 1995-96 study. A total of 352 samples were collected from 12 stations in the Bay and from 35 watershed stations on nine different sampling dates during both closed and open harvesting periods. Samples were analyzed for total and fecal coliforms, Enterococci, anaerobic bacterial indicators, and Methylene Blue-Active Substances (MBAS), which are common surfactants in detergent. A total of 26 shellfish samples were collected for total and fecal coliform analysis.

The results of this study show the impact of rainfall on the water quality of the tributaries entering Tomales Bay and on the water quality of the Bay itself following runoff events. The data supports the study's theory that the major source of fecal contamination to the Bay is rainfall-related runoff from the tributaries. Two seasonal patterns of fecal coliform densities were observed: 1) sites that showed declining fecal coliform densities throughout the winter, suggesting a nonrenewable source of coliforms and, 2) sites that exhibited high fecal coliform densities throughout the season, suggesting a renewable source. The results of this pilot study were used to determine what types of analyses would be used for the full-scale study during the 1995-96 winter season and which stations should be added or deleted from the sampling design.

1995-96 Study – TBSTAC, SWRCB, DHS, RWQCB

In the winter of 1995-96 RWQCB and DHS, under the auspices of TBSTAC and funded by SWRCB, conducted an intensive study of bacteriological and pathogen levels in the water of Tomales Bay and its watershed. They also measured the concentrations of fecal coliforms in oyster tissue. They collected samples before and after the wet season and throughout rainfall events, including the day the Bay would normally be opened for

shellfish harvesting (day X (i.e., 4 to 5 days after the rainfall event)). The study was conducted during the winter of 1995-1996, and consisted of 40 sampling stations throughout the Bay and watersheds. Samples were collected during two dry season periods and during four rainfall events. All samples were analyzed for four standard indicators of microbiological water quality: total coliform, fecal coliform, enterococcus, and *Escherichia coli* (*E. coli*). In addition, several sites were analyzed for coliphage and the anaerobic bacterium *Bacteriodes vulgatus*, indicators that were thought to be more specific for human fecal sources than the standard indicator organisms. A limited number of analyses were performed to detect the presence of pathogenic bacteria. *Salmonella typhirium* and *E. coli*:0157 were identified in separate watershed samples (See TBSTAC et al., for results).

Watershed Results

Bacterial densities usually exceeded the standards within the first one or two days of each rainfall event, then typically decreased to acceptable levels by the last day of sampling. Consistently high bacterial levels were detected during most of the study at sites within the Walker/Keyes/Chileno watershed and along the eastern shoreline watershed. Slightly lower concentrations of fecal coliforms were detected throughout the Lagunitas/Olema subwatershed. In contrast, bacterial levels at the western shoreline watershed stations were generally 10 to 100 times lower than those from all other subwatersheds.

Fecal coliform loadings were calculated to estimate the amount of fecal coliforms contributed by each subwatershed on a daily basis. The highest loadings estimated within the Walker/Keyes/Chileno Creek and the Lagunitas/Olema subwatersheds. The former region is primarily dairy and livestock grazing with some residential dwellings, while the latter contains a mix of agriculture, commercial, and residential uses. Within the Walker/Keyes/Chileno Creek watershed, the highest fecal coliform loadings estimated in the Chileno Creek subwatershed. Within the eastern shoreline watershed, the highest fecal coliform loadings generally estimated in the subwatersheds represented by stations Milepost 40.35, Milepost 34.95, Millerton Creek, Milepost 32.12, Grand Canyon Creek, and Tomasini Creek. Within the Lagunitas/Olema watershed, Lagunitas Creek contributed the largest share of the fecal load, followed by Olema Creek. The Bear Valley drainage contributed the lowest loadings for this subwatershed. Fecal coliform loadings from the western subwatershed were less than that contributed by the other subwatersheds.

Bay Results

Outer-bay (the area closer to the mouth of the Bay) sampling stations were adversely affected within the first two days following significant rainfall. Fecal coliform concentrations often remained elevated three days after a rainfall event and did not always return to acceptable levels by the day shellfish growing waters were reopened for harvest (day X). This indicates either a long residence time in the outer-bay or a prolonged source of contamination. The highest fecal coliform concentrations were observed at station 34, which is in the direct influence of the branch of Walker/Keyes Creek that flows around Preston Point. Fecal coliform levels at mid-bay stations were generally lower than either the outer or inner-bay regions, although all Bay stations

experienced elevated concentrations of fecal coliforms immediately following rainfall. Fecal coliform levels at the inner-bay monitoring stations were slightly greater than those of the mid-bay, and did not always return to acceptable levels by the day shellfish growing waters were reopened for harvest (day X). During rainfall event 3, both inner-bay monitoring stations showed an obvious spike of fecal coliform on day X that greatly exceeded the concentrations detected within the first three days of rainfall. A possible explanation for this sharp increase would be a pulse of contamination from the watershed or nearshore area.

Shellfish Results

The fecal coliform concentrations in oysters in the outer-bay typically reached extremely high levels following significant rainfall. These data suggest a pattern of increasing concentration throughout the winter, perhaps as a result of the continuous high fecal concentrations contributed by the watershed. In addition, lower water temperatures in winter may result in a reduced metabolic rate in the oysters, which in turn would lengthen the time necessary for satisfactory cleansing of contaminated shellfish. Consequently, oysters in the outer-bay do not always return to the National Shellfish Sanitation Program (NSSP) market standard by the time the outer-bay is reopened for harvesting.

Within the outer-bay stations, samples were collected from sites representing two different culture techniques: top-culture (i.e., floating bags) and bottom-culture (i.e., rack and bag). The top-culture station was significantly higher than the NSSP market standard during the first dry season sampling. It is likely that these elevated levels of fecal coliforms are the result of localized contamination, possibly from birds roosting and defecating on the floating bags.

Oysters from the mid-bay were found to exceed the NSSP standard following significant rainfall but generally returned to acceptable levels for fecal coliforms by day X. Oysters from the inner-bay typically exceed the NSSP market standard after significant rainfall, and the magnitude of contamination was generally equivalent to the observed levels in the outer-bay oysters.

As a result of this study and previous supporting data the rainfall closure requirements that DHS applies to harvesting shellfish in Tomales Bay are more stringent now (TBSTAC et al., 2001).

2000-01 Study – TBSTAC, RWQCB

In the winter of 2000/2001, RWQCB, in conjunction with the TBSTAC, designed and conducted a study with the joint purpose of implementing some of the TBSTAC recommendations from the 1995-96 study. The specific goals of the study were to: 1) verify the findings of previous studies regarding potential sources of fecal contamination to Tomales Bay, 2) collect fecal coliform data from some additional stations (points of interest) within the watershed, and, 3) characterize and assess the loadings of fecal coliforms to Tomales Bay.

Sampling Frequency

The study consisted of five sampling events. Two dry-weather sampling events were conducted, the first occurring prior to the wet season, and the second, following the wet season. Samples for each of the three wet season event were collected over a two-day period (with the exception of the first wet season sampling event which lasted only one day) that coincided with the first two days of a rainfall harvest closure (defined as 0.5 inch of rain within a 24-hour period).

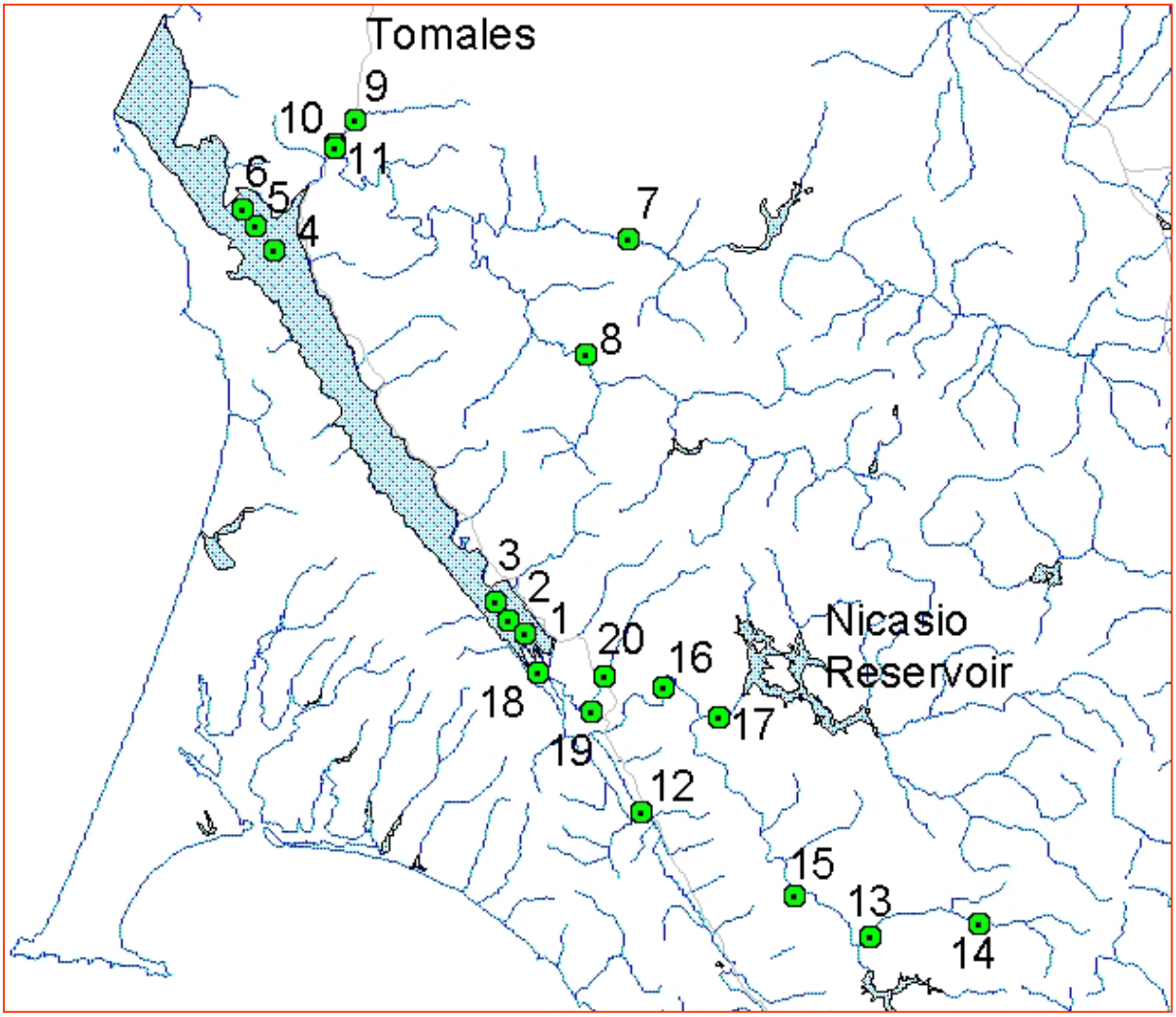
Sampling Stations

A total of 20 sampling stations were selected throughout the watershed and the Bay—three inner-Bay stations, three outer-Bay stations, and fourteen watershed stations (Table 8 & Figure 4). Station locations were selected on the basis of their i) proximity to potential sources of fecal contamination, ii) past history of contamination, iii) areas of regulatory compliance (i.e., shellfish beds), and iv) site accessibility.

Table 8. List of Sampling Sites for the 2001 Tomales Bay Bacterial Monitoring Study

STATION NUMBER	STATION NAME	BAY/ WATERSHED
1	Tomales Bay Oyster Co. Lease (TBOC), South	Bay
2	Tomales Bay Oyster Co. Lease (TBOC), Central	Bay
3	Tomales Bay Oyster Co. Lease (TBOC), North	Bay
4	Hog Island Oyster Co. Lease (HIOC), South	Bay
5	Hog Island Oyster Co. Lease (HIOC), Central	Bay
6	Hog Island Oyster Co. Lease (HIOC), North	Bay
7	Chileno Creek @ Gales Ranch	Watershed
8	Walker Creek @ Walker Creek Ranch	Watershed
9	Keyes Creek @ Tomales Village	Watershed
10	Keyes Creek @ Walker Creek Confluence	Watershed
11	Walker Creek @ High Way One Bridge	Watershed
12	Olema Creek @ Bear Valley Road	Watershed
13	San Geronimo Creek @ White Horse Bridge	Watershed
14	San Geronimo Creek @ Roy's Pool	Watershed
15	Lagunitas Creek @ Samuel P. Taylor Park	Watershed
16	Lagunitas Creek @ Gallagher Ranch	Watershed
17	Nicasio Creek @ Platform Bridge	Watershed
18	Giacomini Levee @ Giacomini Ranch	Watershed
19	Point Reyes Station @ 3rd Street	Watershed
20	Point Reyes Station @ Mesa Road	Watershed

Figure 4. Location of Sampling Stations for the 2001 Tomales Bay Bacterial Monitoring Study



During each sampling event, fecal coliform samples were collected and analyzed for each of the 20 stations. Bay stations were sampled three times daily, whereas the watershed stations were sampled only once in any given sampling day.

Flow/Discharge Measurements

Utilizing calibrated rating curves provided by the U.S. Geological Survey and the Point Reyes National Park Service, stream flow data in 15-minute increments were obtained for Lagunitas, Walker, and Olema Creeks from gauging stations. For the remaining streams for which no automated gauging station and/or accurate rating curves were available, manual discharge measurements were conducted.

Watershed Results

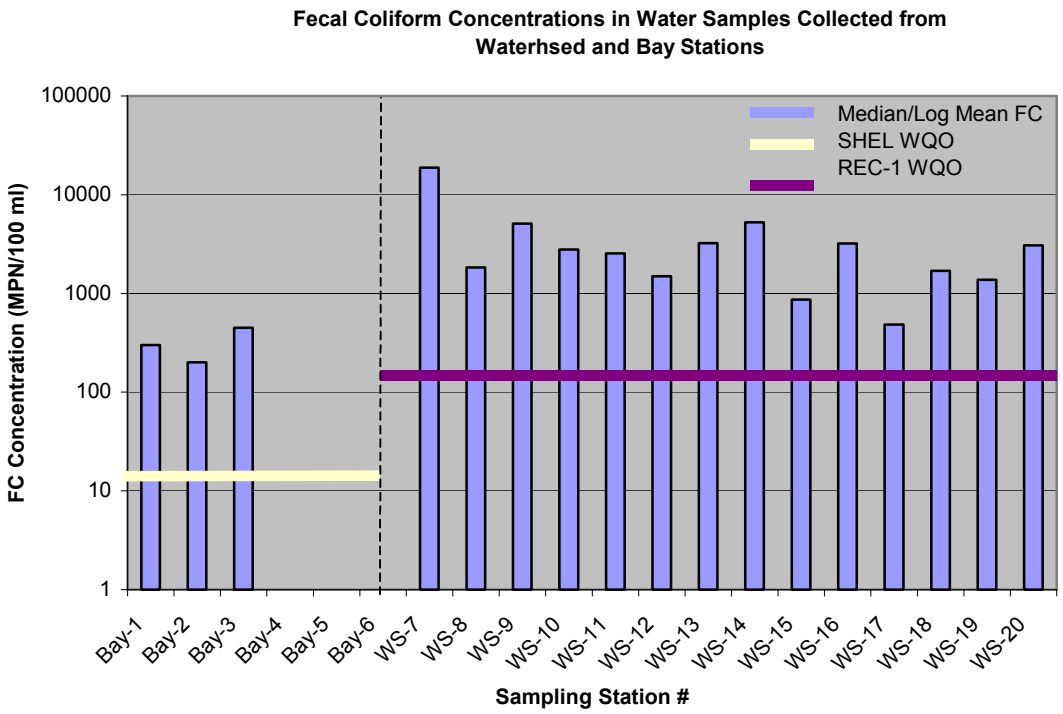
Throughout the three wet-weather sampling events, the fecal coliform levels for all watershed and Bay station samples significantly exceeded the designated water quality objectives for shellfish harvesting waters and in most cases for contact and non-contact water recreations (Table 9 & Figure 5). In general, fecal coliform levels increased during the second day of each wet-weather sampling event (with the exception of the first wet-weather sampling event which lasted only one day).

Table 9. Summary of 2001 Tomales Bay Bacterial Monitoring Results

Station	Station	Fecal Coliforms (MPN/100 ml)						
		1st Wet Event	2nd Wet Event		3rd Wet Event		Median	Log Mean
#	ID	Jan-11-01	Jan-25-01	Jan-26-01	Feb-9-01	Feb-10-01		
Bay-1	STBOC	750	300	4650	<200	<200	**300**	
Bay-2	CTBOC	200	200	1367	<200	<200	**200**	
Bay-3	NTBOC	450	450	1700	<200	200	**450**	
Bay-4	SHIOC	NS*	NS	NS	<200	NS	**NA**	
Bay-5	CHIOC	NS	NS	NS	<200	NS	**NA**	
Bay-6	NHIOC	NS	NS	NS	<200	NS	**NA**	
WS-7	CHG	126,667	11,667	32,000	800	63,333		**18,876**
WS-8	WCR	10,333	200	2,133	7,000	667		**1,831**
WS-9	KYT	9,000	1,770	7,000	6,667	4,667		**5,106**
WS-10	KYW	5,000	2,200	13,000	400	3,000		**2,798**
WS-11	WK1	3,033	500	94,333	NS	300		**2,560**
WS-12	OLC	1,000	2,100	3,033	2,550	450		**1,489**
WS-13	SGW	4,333	467	1,5667	3,667	3,100		**3,246**
WS-14	SGR	3,000	3,000	24,000	11,000	1,700		**5,263**
WS-15	LCS	2,200	200	7,000	200	800		**868**
WS-16	LCG	6,533	6,667	7,667	1,200	850		**3,210**
WS-17	NIC	400	400	700	<200	<200		**339**
WS-18	GIL	2,600	700	2,200	700	5,000		**1,696**
WS-19	PR3	4,100	1,900	333	NS	NS		**1,374**
WS-20	PRM	8,000	800	5,000	5,000	1,700		**3,068**

NS = Not Sampled
NA = Not Available

Figure 5. Summary of 2001 Tomales Bay Bacterial Monitoring Results



Bay Results

Due to the unavailability of a sampling boat, only one set of samples from Outer-Bay Stations Nos. 4-6 was collected during this study. For the remaining Inner-Bay sampling locations, fecal coliform levels did not change between Rainfall Event No. 1 and Rainfall Event No. 2-Day 1, but increased significantly on Rainfall Event No. 2-Day 2. Of the Inner-Bay station samples, over all of the sampling events, the highest fecal coliform levels were consistently detected at the Inner-Bay Station No. 1 (located south of the Tomales Bay Oyster Company (TBOC) lease area) which is closer to the inlet of Lagunitas and Olema Creeks than the other two Inner-Bay stations.

Overall Fecal Coliform Contributions

Table 10 contains the overall ranking of all subwatersheds according to the total number of fecal coliforms they each contributed over the span of the three rainfall sampling events. The lower Walker Creek subwatershed contributed the highest one-time and highest overall fecal coliform loadings. Lower and upper San Geronimo Creek subwatersheds rank as second and third largest contributors of fecal coliforms. The Keyes Creek and Olema Creek subwatersheds, recorded the lowest fecal coliform loadings (see RWQCB, 2001, for more details).

Table 10. Ranking of Tomales Bay's Subwatersheds Based on Their Overall Fecal Coliform Contributions Over the Span of 2001 Microbial Monitoring Study

SUBWATERSHED	FC/DAY 1/11/01	FC/DAY 1/25/01	FC/DAY 1/26/01	FC/DAY 2/9/01	FC/DAY 2/10/01	TOTAL FC/5DAYS
Lower-Walker Creek (station # 11)	$9.21x10^{13}$	$3.78x10^{12}$	$1.69x10^{15}$	N/A	$6.67x10^{12}$	**$1.79x10^{15}$**
Lower-San Geronimo (station # 13)	$9.40x10^{12}$	$4.86x10^{11}$	$1.69x10^{14}$	$7.20x10^{12}$	$4.15x10^{12}$	**$1.90x10^{14}$**
Upper-San Geronimo (station # 14)	$4.22x10^{12}$	$3.22x10^{12}$	$9.93x10^{13}$	$1.42x10^{13}$	$1.96x10^{12}$	**$1.23x10^{14}$**
Chileno Creek (station # 7)	$5.58x10^{13}$	$1.61x10^{12}$	$1.92x10^{13}$	$1.18x10^{11}$	$6.57x10^{12}$	**$8.33x10^{13}$**
Lower-Lagunitas creek (station # 16)	$9.36x10^{12}$	$9.55x10^{12}$	$5.40x10^{13}$	$9.04x10^{11}$	$7.95x10^{11}$	**$7.46x10^{13}$**
Upper-Lagunitas Creek (station # 15)	$2.74x10^{12}$	$1.71x10^{11}$	$4.72x10^{13}$	$2.28x10^{11}$	$9.68x10^{11}$	**$5.13x10^{13}$**
Upper-walker Creek (station # 8)	$7.80x10^{12}$	$8.12x10^{10}$	$3.04x10^{12}$	$3.81x10^{12}$	$3.63x10^{11}$	**$1.51x10^{13}$**
Olema Creek (station # 12)	$3.47x10^{11}$	$1.36x10^{12}$	$5.73x10^{12}$	$1.09x10^{12}$	$1.44x10^{11}$	**$8.67x10^{12}$**
Keyes Creek (station # 10)	N/A	$2.25x10^{11}$	$5.35x10^{12}$	N/A	N/A	**$5.57x10^{12}$**

Conclusions

The data from this study verifies previous findings, demonstrating that rainfall-induced runoff has a deleterious effect on the water quality of the Bay. During the rain events monitored in this study, fecal coliform levels increased in samples taken from tributaries in the Tomales Bay watershed, as well as in samples taken from shellfish growing waters within the Bay.

Throughout the three rainfall-sampling events, the fecal coliform concentrations for all Watershed and Bay station samples significantly exceeded the designated water quality objective of 14 MPN for Shellfish Harvesting Waters, and in most cases, even the much higher value set by the water quality objective for Non-Contact Water Recreation (mean < 2000 MPN).

The fecal coliform concentrations and loadings remained high during all rainfall events sampled in all watersheds. This suggests either the presence of a renewable source, or the introduction of new sources, of fecal coliform throughout portions of the watershed. Failing onsite sewage disposal systems, or runoff from animal pastures (containing manure) could be some of the potential new or renewable sources of fecal coliform.

The lower Walker Creek subwatershed contributed the highest one-time and highest overall fecal coliform loadings. Lower and upper San Geronimo Creek subwatersheds rank as second and third largest fecal coliform contributors. The Keyes Creek and Olema Creek subwatersheds had the lowest fecal coliform loadings.

Several past studies suggest that runoff from dairies and livestock grazed land are the primary source of fecal coliforms to Tomales Bay (DHS, 1974; U.S. FDA 1980; TBSTAC et al., 2001;). Results of the present study are consistent with past findings and are summarized as follows:

- The highest fecal coliform concentrations and/or loadings are observed in the Chileno and Walker Creek watersheds—watersheds whose land use consists primarily of grazing lands and dairies.

- High fecal coliform levels detected in the storm drains of the town of Point Reyes Station indicate that another likely source of fecal contamination to the Bay is residential runoff.

- While livestock and domestic animals provide significant loadings of fecal coliforms to the Bay, failing residential septic systems cannot be discounted as a loading source.

- Given that the predominant land use in the monitored segment of the San Geronimo Creek watershed is residential housing and horse farming, we conclude that the high fecal coliform concentrations/loadings observed there are most likely due to failing/substandard residential septic systems, urban runoff containing waste from pets, and runoff containing waste from the equestrian facilities.

3.7 Illness Outbreak

On May 13, 1998, DHS was notified of a food borne illness outbreak associated with the consumption of Tomales Bay oysters. DHS closed the Bay to shellfish harvesting and launched an investigation, which included several divisions at DHS, FDA, the Center for Disease Control and Prevention, and several local county health departments. This illness affected 171 people and was caused by a virus of human fecal origin. An investigation determined that the oysters causing the illness were harvested from the mid and outer-bay. DHS had collected water and shellfish samples on the earliest dates that the contaminated shellfish could have been harvested. This was after a rainfall closure and there was no additional rainfall after this time. Data showed that both water and shellfish met fecal coliform standards. After subsequent studies, DHS opened the mid and outer-bay leases to shellfish harvesting on August 4.

3.8 Problem Statement

To summarize, the following arguments form the basis for listing Tomales Bay as impaired due to pathogens under the CWA section 303(d):

1. Tomales Bay exceeds water quality objectives set by (a) RWQCB in the San Francisco Bay Water Quality Control Plan (Basin Plan); (b) DHS; and (c) FDA through National Shellfish Sanitation Program. Since DHS rainfall closure rules are based on fecal coliform concentrations in water and shellfish, the number of days Tomales Bay is closed for harvesting is a conservative estimate of the number of days fecal coliform concentrations exceed standards. Tomales Bay is closed to harvesting approximately 90 days per year, and therefore it is assumed that fecal coliform standards are exceeded for up to approximately 90 days per year.

2. Under the State's Porter Cologne Water Quality Control Act (California Water Code, Division 7, Chapter 24, Section 14950-14958), the Shellfish Protection Act, Tomales Bay is considered "threatened" due to the conditions listed under Paragraph No. 1.

3. DHS prohibits shellfish harvesting during periods of rainfall based on the results of bacteriological studies. As stated in Paragraph No. 1, the Bay is closed to harvesting approximately 90 days per year. Therefore, the Beneficial Use of Shellfish Harvesting is not currently being protected during the wet season.

4. A major human illness outbreak caused by the consumption of Tomales Bay oysters, contaminated with a pathogenic human virus, occurred during a dry weather period. This demonstrates that the beneficial uses of the Bay are not protected, even in the absence of wet weather conditions.

4. NUMERIC TARGETS

4.1 Proposed Numeric Targets

The numeric targets (desired future conditions for the Bay and its tributaries) proposed for this TMDL are as follows:

1. RWQCB's Basin Plan water quality objective (WQO) for shellfish growing waters for the Bay;
2. RWQCB's Basin Plan WQO for water contact recreation for all the major tributaries to Tomales Bay; and,
3. A zero discharge of human waste for the Bay and all its tributaries.

The first target is RWQCB's fecal coliform water quality objective that is contained in the Basin Plan (Table 11). The Basin Plan also lists a total coliform objective to protect the beneficial use of shellfish harvesting. Fecal coliforms are proposed as targets and not total coliforms because fecal coliforms are a better indicator of fecal contamination and their use as an indicator is consistent with how DHS regulates the shellfish growing industry.

Table 11. Numeric Targets for Fecal Coliforms for Tomales Bay and its Tributaries

MATRIX	FECAL COLIFORM
Bay Water (SHEL WQO) [b]	Median<14 (MPN[a]/100 ML) 90th percentile <43(MPN/100 ML)
Tributary Water (REC-I WQO) [b]	Log mean<200 (MPN/100 ML) 90th percentile<400(MPN/100 ML)
Shellfish Tissue	Median<230 (MPN/100 g) 95th percentile <700 (MPN/100 g)

a. Most Probable Number (MPN) is a statistical representation of the results of the standard coliform test
b. Based on a minimum of five consecutive samples equally spaced over a 30-day period.

Water contact recreation (REC-I) and non-contact recreation (REC-II) are two other beneficial uses of the Bay that have fecal and total coliform objectives which are designed to protect against the transmission of pathogens. The fecal coliform objectives to protect these uses (REC-I log mean <200MPN/100mL and 90%<400 MPN/100mL, REC-II mean<2000 MPN/100mL and 90%<4000 MPN/100mL) are much higher (i.e., allow a larger concentration of bacteria) than the objectives used to protect shellfish harvesting (Table 11). By requiring water quality in the entire Bay to meet the shellfish harvesting fecal coliform objective, the (less stringent) objectives assigned to the other beneficial uses in the Bay will also be met.

The second target is the Basin Plan's fecal coliform objective for water contact recreation. This target will be applied to the tributaries of the Bay (Table 12). Although this TMDL is aimed at addressing the pathogenic impairment of Tomales Bay,

considering that most if not all the tributaries to the Bay are also impaired due to pathogens, and also that the main sources of pathogens to the Bay are located within the watersheds of these tributaries, this target is proposed to fully protect the beneficial uses of Tomales Bay and its closely-associated tributaries.

The third target is zero discharge of human waste to the waters of Tomales Bay and its tributaries. This target is based on the knowledge that human waste is a significant source of pathogenic organisms, including viruses, and attainment of fecal coliform objectives by themselves does not necessarily protect human health. Fecal coliforms are bacterial indicators that have different characteristics than pathogens, particularly viruses, that cause disease in humans. Both animal and human waste contain microorganisms that can cause disease in humans. Although animal waste is associated with a variety of bacterial pathogens, human waste can contain both bacterial and viral pathogens and is the greatest concern to human health. Because it would be impossible to routinely monitor for all pathogenic organisms, and because viruses are particularly difficult to measure, indicator organisms are used to assess microbiological water quality.

The illness outbreak that occurred in 1998 is evidence that compliance with fecal coliform objectives does not sufficiently protect human health. Therefore, to protect human health from the transmission of viruses we propose a target of zero discharge of human waste into Tomales Bay or its tributaries. The Basin Plan prohibits discharge from sewage treatment systems into Tomales Bay and its tributaries based on a prohibition in the Basin Plan in Table 4 -1 which states: "It shall be prohibited to discharge any wastewater which has particular characteristics of concern to beneficial uses to Tomales Bay, Drakes Estero, Limantour Estero, Bolinas Lagoon, or Richardson Bay (between Sausalito Point and Peninsula Point)." This prohibition is applicable to discharge of human waste from recreational activities (boating, camping etc.) as well as septic systems. Septic systems that discharge to land and that are in accordance with accepted design standards (new systems) or performance standards (existing systems) and which are properly operated and maintained are acceptable.

All three of the above 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. These targets are proposed as the desired long-term conditions this TMDL is aiming to achieve.

4.2 Proposed Interim Targets

In addition to the above long-term targets, we propose establishing interim pathogen water quality targets for Tomales Bay to measure progress towards attaining the TMDL targets. We believe it is reasonable to strive for a 30% reduction in Bay pathogen concentrations by 2005 and a 75% reduction in Bay pathogen concentrations by 2007. In 2005 and 2007 we also propose evaluating water quality conditions, the percentage of water quality plans fully implemented, and the effectiveness of source control actions.

5. POLLUTANT SOURCE ASSESSMENT

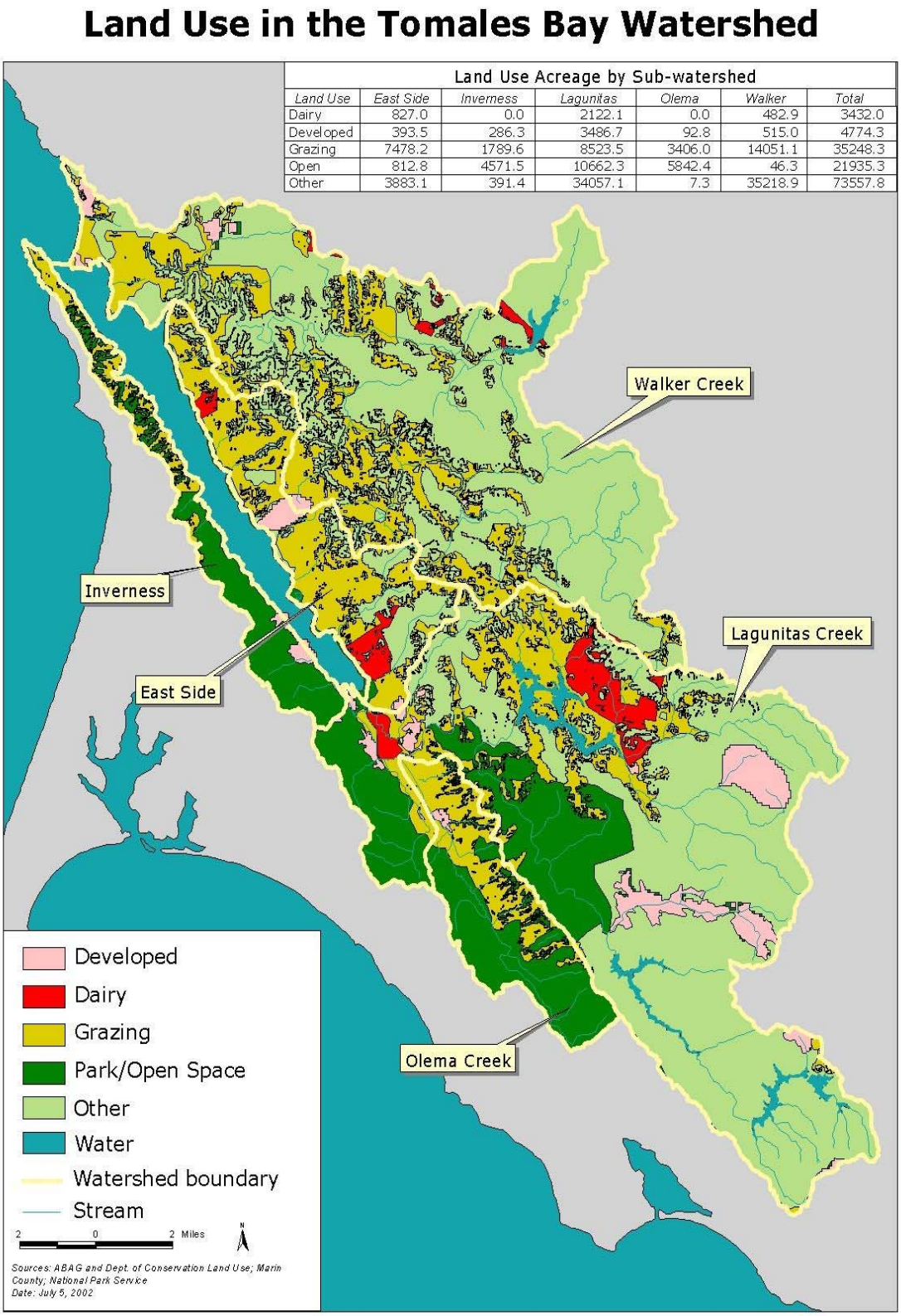
The numerous studies conducted on Tomales Bay pathogen indicators, point towards a predominant group of actual and potential pathogen loading sources to the Bay. These sources are:

- Agricultural runoff from grazing lands and confined animal facilities (i.e., cattle operations, dairies, sheep farms, equestrian facilities, etc.);
- Faulty on-site sewage disposal systems (residential and commercial);
- Boat discharges;
- Wildlife;
- Urban runoff; and,
- Small wastewater treatment facilities and sewage holding ponds.

5.1 Agricultural Runoff

Location:
Figure 6 shows the locations and distribution of various land uses within the greater Tomales Bay watershed based on data obtained from Association of Bay Area Governments (ABAG), Department of Conservation Land Use, County of Marin, and National Park Service.

Figure 6. Land Use in the Tomales Bay Watershed



Land Use Acreage by Sub-watershed

Land Use	East Side	Inverness	Lagunitas	Olema	Walker	Total
Dairy	827.0	0.0	2122.1	0.0	482.9	3432.0
Developed	393.5	286.3	3486.7	92.8	515.0	4774.3
Grazing	7478.2	1789.6	8523.5	3406.0	14051.1	35248.3
Open	812.8	4571.5	10662.3	5842.4	46.3	21935.3
Other	3883.1	391.4	34057.1	7.3	35218.9	73557.8

Table 12 summarizes the land use acreage for each subwatershed.

Table 12. Tomales Bay Land Use Acreage by Subwatershed

LAND USE	EASTERN SIDE	INVERNESS	LAGUNITAS	OLEMA	WALKER	TOTAL	% TOTAL
Dairy	827	0	2,122	0	483	3,432	**2.5%**
Grazing	7,478	1,789	8,524	3,406	14,051	35,283	**25.4%**
Developed	393	286	3,487	93	515	4,774	**3.4%**
Park/Open	813	4,571	10,662	5,842	46	21,935	**15.8%**
Other	3,883	391	34,057	7	35,219	73,558	**52.9%**

As illustrated on the map, the cattle grazing and dairy land uses are mainly located on the east and southern portion of the watershed and adjacent or very near the Bay and many of its tributaries.

Magnitude:
Dairy and grazing land uses account for almost 28% of the total acreage of Tomales Bay land use. Table 13 shows approximate numbers of livestock and an estimate of their associated manure production in different areas of the watershed based on data collected in 1990. The number of dairies has decreased since this time; however, it is possible that the remaining dairies as well as the existing cattle ranches, hold a greater number of animals than in past years. Attempts to obtain current numbers of dairy cows and beef cattle for each parcel (and/or the watershed), by contacting various agencies and/or organizations, have been unsuccessful. Therefore, the total number of animals per parcel and the magnitude of pathogen loadings from each individual parcel are not known at the present time.

Table13. Estimated Numbers of Livestock [a] and Manure Production inTomales Bay Watershed (Totals/Watershed/Day) [b]

DRAINAGE	DAIRY COWS/ HEIFERS	MANURE LBS/DAY	BEEF	MANURE LBS/DAY	SHEEP	MANURE LBS/DAY	TOTAL HEAD	TOTAL MANURE LBS/DAY
Chileno Creek	2,592	231,693	230	12,834	---	---	2,563	244,527
Keyes Creek	786	70,151	---	---	---	---	786	70,151
Walker Creek	1,182	105,553	540	30,132	1,000	7,200	2,722	142,885
Marshall to Pt. Reyes Station	3,847	343,553	550	30,690	---	---	4,397	374,243
Lagunitas/Nica-sio Reservoir	2,563	229,135	230	12,834	---	---	2,563	616,212
Totals	**10,970**	**980,084**	**1,320**	**86,490**	**1,000**	**7,200**	**13,031**	**1,448,018**

a. Approximate numbers based on rough estimate by the University of California Cooperative Extension
b. Table adapted from R. Bennett and S. Larson, *Preventing Animal Wastes from Degrading Water Quality: The Case for Tomales Bay, California, 1990.*

Table 14 lists the manure characteristics of different livestock in terms of pounds per day of total waste (feces and urine) produced by a typical animal.

Table 14. Fresh Manure production and Characteristics [a]

PARAMETER	DAIRY 1,400 LB	BEEF 800 LB	SHEEP 60 LB	HORSE 1,000 LB	DUCKS 3 LB
Total Manure (lb/day)	120.4	46.4	2.4	51	0.33
Urine (lb/day)	36.4	14.4	0.009	10	NA[b]
Total Nitrogen (lb/day)	0.63	0.27	0.025	0.30	0.005
Ammonia (lb/day)	0.11	0.07	NA	NA	NA
Fecal Coliform (# of colonies)[c]	10.1	10.4	12	0.042	0.24

a. Numbers are based on manure produced per 1,000 lb live animal unit per day. Data are adapted from the Agricultural Sanitation and Waste Management Committee, Manure Production and Characteristics, 1989. Numbers have been adjusted to confirm to the average sized animal, as noted under each animal type.
b. Data not available
c. Mean bacteria colonies per average animal mass multiplied by 10^{10}

Significance:
A variety of bacteria and protozoa found in livestock waste can be transmitted to humans. Some of the pathogens of primary concern that can be shed in the feces of livestock and transmitted to humans through water are listed in Table 15. Because Tomales Bay watershed is dominated by animal agriculture land use (grazing, livestock farming), and due to the proximity and hydrological accessibility of these land uses to the Bay and its tributaries, agricultural runoff carrying animal waste from grazing lands and/or confined animal facilities (beef, dairy, sheep, horse farms), is potentially a significant source of pathogen loading to Tomales Bay and its tributaries. As discussed in section 2, the 2001 monitoring study confirmed that the largest pathogen-indicators loads to the Bay are from watersheds whose primary land uses are livestock grazing and dairy farming (Walker and Chileno Creeks watersheds) (Table 10). Also, several studies have documented that livestock grazing results in an increase in fecal coliform counts over the background concentrations (Gary et al., 1983; Tiedeman, 1987).

Table 15. List of pathogens of primary concern that can be shed in the feces of livestock and transmitted to humans through water

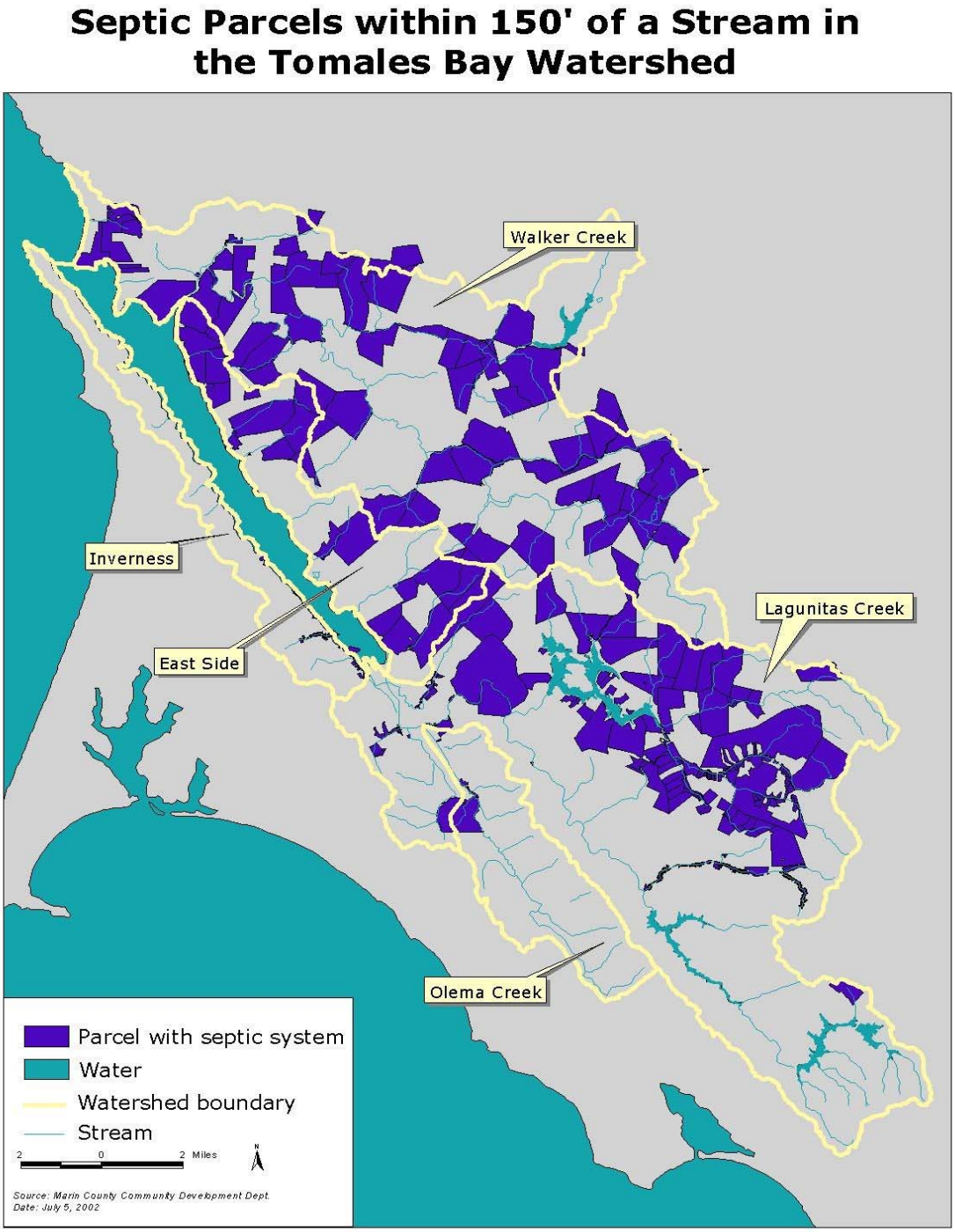
WATERBORNE PROTOZOA PATHOGENS OF PRIMARY CONCERN	SPECIAL CONCERNS
Cryptosporidium parvum	Low infectious dose; environmentally resistant oocysts
Giardia duodenalis	Low infectious dose; environmentally resistant cysts
WATERBORNE BACTERIAL PATHOGENS OF PRIMARY CONCERN	
Campylobacter spp.	Common in livestock and wild birds
Salmonella ssp.	Common in livestock feces
Pathogenic strains of E. coli	Can be highly infectious for humans
WATERBORNE VIRAL PATHOGENS OF PRIMARY CONCERN	Little scientific evidence that viruses shed in the feces of livestock pose a health threat to human in the United States. There is, however, growing concern regarding Hepatitis E virus from swine.

Source: Table adapted from "Microbial pathogen excreted by livestock and potentially transmitted to humans through water," (Atwill, 1995).

5.2 Faulty On-site Sewage Disposal Systems

Location:
The unincorporated areas around the Bay and its tributaries are served entirely by various types of on-site sewage disposal systems (OSDS) including septic tank and leach-field systems, holding tanks, and seepage pits. Figure 7 shows the location and distribution of land parcels with OSDSs within 150 feet of the Bay and/or a stream in the Tomales Bay watershed.

Figure 7. Septic Parcels Within 150 Feet of a Stream in Tomales Bay Watershed



Magnitude:
According to Marin County Community Development Department data, there are a total of 844 parcels within 150 feet of Tomales Bay and its tributaries that have OSDSs. In 1990, a Bay shoreline survey (35.5 miles) located 169 residences with OSDS, which could have an immediate impact on Bay water quality. Of the residents that responded to

either a written questionnaire or a door-to-door survey, 90 percent reported having septic systems with leach fields; the remainder reported either "not known" or having holding tanks. These systems are most likely to fail during times of heavy rainfall with resulting high groundwater. A number of seepage pits also exist within the watershed according to County files.

Tomales Bay eastern shoreline survey conducted by DHS in 2001 concluded that:

- Of the parcels surveyed, many of the residences are unsuitable for onsite sewage disposal.
- The majority of the parcels do not have sufficient land available to install an onsite sewage disposal system that meets the required sanitary setbacks and construction standards.
- Proper functioning onsite sewage disposal systems are unlikely at many residences due to site conditions.

Since then, DHS gathered more information on parcels with OSDSs in the watershed of Tomales Bay. They obtained this information through shoreline surveys, survey questionnaires, and file reviews.

- Of the 2,260 parcels in the study area, approximately 1,606 parcels have OSDSs.

- Along Tomales Bay shoreline 134 systems have extremely limited area available to properly operate an on-site sewage disposal system with a leach field. Most of these parcels offer limited space for structures. Many of these parcels are directly adjacent to the Bay or hanging over the Bay. In addition, many of the leach fields are paved over or used as parking areas.

- There are 533 parcels within 100 feet of surface water. This includes tributaries to the Bay and the shoreline of Tomales Bay. These parcels do not meet the minimum set back of 150 feet found in the Marin County regulations. A detailed analysis of flood area maps was not performed. However, 15 parcels are known to flood. This number could increase based on further analysis. The parcels that flooded are in the vicinity of Lagunitas Creek and Hwy 1. The 15 parcels flooded in January 1997. The septic systems on these properties will likely fail during flood events. There are 743 parcels located 100 to 500 feet from surface water. All of the 1,606 parcels with OSDSs, have poor soils for septic absorption fields as determined by USDA.

- DHS ranks the OSDS parcels into three categories as follows: The first rank (highest impact rank) is a group of 144 parcels with a scoring range of 55 - 110. The second rank (medium impact rank) is a group of 708 parcels with a scoring range of 15 -34. The third rank (low impact rank) is a group of 754 parcels with a score of 5.

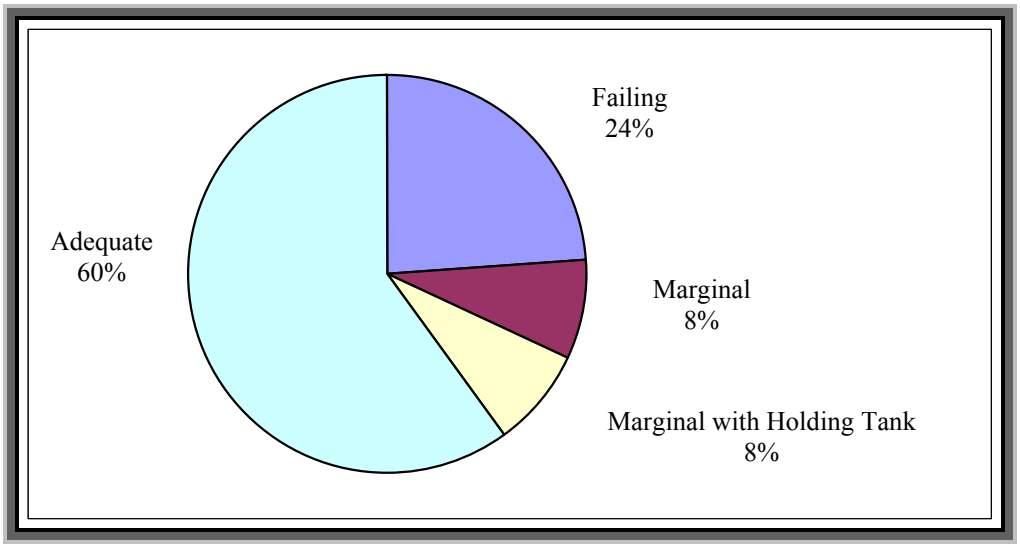
- The highest priority parcels are made up of a cumulative score of non-compliance, known septic system problem areas, incomplete file information, proximity to surface waters, limited space for functioning leach field or structure overhangs the Bay, area

known to flood, and poor soils. These parcels are directly adjacent to the Bay or within 100 feet of surface water. The medium priority sites are parcels that are within 500 feet of surface water and have poor soils. The lowest priority sites have only soil problems.

In a recent effort by the Marin County Community Development Agency (MCCDA), 37 OSDSs were confidentially inspected in the town of Marshall (on the eastern shoreline of Tomales Bay) to create a geographically representative sample from which to draw inferences on the remainder of the community. Of those inspected, 75% were adjacent to Tomales Bay and the remaining 25% were in the lower or upper uplands. This compares to 65% adjacent to Tomales Bay and 35 % in the uplands for Marshall as a whole. The lower uplands are those properties on the east side and within 150 feet of the Highway One. The upper uplands are those properties farther to the east.

The MCCDA rated the 37 systems as follows: 22 (60%) Adequate, 3 (8%) Marginal, 3 (8%) others Marginal because they used holding tanks, and 9 (24%) Failing (Figure 8).

Figure 8. Septic System Performance Rating for Town of Marshall



Significance:
Although both human and animal waste are associated with a variety of bacterial and protozoa pathogens, human waste can, in addition, contain viral pathogens which are of greatest concern to human health (Table 16).

Table 16. Selected Pathogenic Human Enteric Viruses

VIRUS GROUP	DISEASES
Enterovirus (i.e., Poliovirus)	Paralysis, aseptic meningitis
Reovirus	Respiratory disease, gastroenteritis
Adenovirus	Acute conjunctivitis, diarrhea, eye infection
Hepatitis A Virus	Infectious hepatitis
Rotavirus	Infantile gastroenteritis
Norwalk Agent	Gastroenteritis
Astrovirus	Gastroenteritis
Calcivirus	Gastroenteritis
Norwalk-like Viruses	Gastroenteritis

Source: Adapted from Gerba and Rose, 1990

Faulty onsite sewage disposal systems are one of the most significant sources of human pathogens in the watershed. Based on various surveys and inspections a significant percentage of all OSDSs in Tomales Bay watershed appear to be either failing or in marginal condition. Further, results from the 2001 microbial monitoring study of the Tomales Bay and its tributaries revealed that subwatersheds whose main land use are low-density residential and open space (San Geronimo) contributed the second largest loadings of pathogen-indicators to the Bay (Table 10).

Based on the information stated above, Faulty OSDSs are potentially a significant pathogen source to the Bay and its tributaries and pose a risk to public health.

5.3 Boat Discharges

Location:
There is one designated marina (at the Golden Hinde Inn Marina, Inverness), and 4 known live-aboard boats in the Bay (DHS, 2001). Small concentrations of moored boats are found at Lawson's Landing, Reynolds Cove, and the Marshall Boat Works. Live-aboards are not currently regulated in Tomales Bay and there are no controls over the mooring of boats that enter the Bay for short periods of time, primarily during the summer months.

Magnitude:
The Bay is estimated to support approximately 29 permanent boats (25 seasonal and 4 year-round) and a summer weekend recreational boating community of over 500 boats per weekend. In 2000, the California Department of Fish and Game reported that 38 permits for commercial fishing vessels were issued for the Pacific Herring (*Cluper harengus*) Fishery. Most of the fishing companies double up their fishing efforts, which

translates to only 22 fishing boats on Tomales Bay. The Department of Fish and Game currently has no plans to issue more permits for the Pacific Herring Fishery. Therefore, through attrition the number of permitees will only decrease over time.

The number of kayakers recreating on the Bay has increased in recent years. While the majority of kayakers head for the National Park land on the western shore, many begin their trips from the east shore, bringing them in proximity to several of the certified shellfish growing areas. The number of boats using the launching facilities at Miller Park has more than doubled since 1995. In 1995, 2,300 boats used the launch site; by October 2001, 6,000 boats had used the launch (DHS, 2001).

Significance:
With more than several thousands of boats using the Bay during each year, boaters could potentially be a significant source of human pathogens to the Bay. Currently, monitoring and enforcement of sewage disposal from boats and marinas is unclear. Further, there are presently no sewage pump-out facilities within the Bay, increasing the risk of Bay pollution from boats. More importantly, it is believed that many of the boats do not have "head" facilities on board or the individual boaters chose not to use their on-board heads because of potential leakage or odor problems. It is possible that illicit waste discharges from boats are contributing fecal contamination to the Bay. Since the wastes are of human origin, these potential discharges pose a significant threat to water quality and public health.

5.4 Wildlife

Location and Magnitude:
Migratory waterfowl are more numerous in the Bay during the winter months. Increased numbers of sea birds are also attracted to the Bay during the Pacific Herring spawns, which occur from December through February. Census data from the Audubon Canyon Ranch (Kelly, 1992) show that, on December 14, 1991, there were some 5,700 waterbirds, primarily bufflehead (*Bucephula albeola*), surf scoter (*Melanitta perspicillata*), and black Brandt (*Branta bernicla nigricans*), in the area between Pelican Point and Tom's Point. The maximum number of gulls observed was 7,400 in an area covering approximately 2.0 hectares of tidal flat between 0.0 and 1.0 feet above Mean Lower Low Water (Kelly et al 1994). In a study by Kelly et al. (1998) running from 1989 through 1996, the total numbers of shorebirds observed reached a maximum of 25,553 in early winter and 7,066 in late winter.

Tomales Bay has a large harbor seal population. Since the Marine Mammal Protection Act became effective in 1972, the population in Tomales Bay has increased noticeably. There are seal haul out sites near the mouth of Tomales Bay, as well as on the shoreline of Hog Island. The average number of seals hauled out in the Bay varies between 100 to 200 individuals. The National Park Service recently reports that the population of seals in Tomales Bay can range from 400 to 650 year round, with about 200 to 300 seals likely to be residents to the area. For 2001, the National Park Service reported that there were 611 seals in Tomales Bay during the peak-breeding season (May), including 130 pups.

In addition to the marine mammals and birds a variety of terrestrial wildlife such as deer, elks, birds, rodents, etc., that inhabit the watershed lands adjacent to the Bay and its tributaries may contribute pathogens to these waterbodies. No accurate information as to the magnitude and geographic dispersion of this waste source is available at this time.

Significance:
Because of the great variety of waterbirds, complex distribution and dispersal patterns, and fluctuating populations, it is very difficult to assess the impact of birds on water quality in the commercial shellfishing areas. Concentrations of birds on aquaculture structures can increase the potential for fecal contamination of the growing area and shellfish.

None of the known harbor seal haul out sites is in the vicinity of the commercial shellfish growing areas. However, as with the avian populations discussed above, marine mammals follow the herring runs into Tomales Bay, and may have a potential for intermittent impact on the water quality in some areas. In addition, as with the bird populations, some aquaculture structures attract large numbers of marine mammals, creating the potential for fecal contamination of growing area waters and shellfish.

Overall, due to the lack of information on the numbers and locations of various marine and/or terrestrial wildlife, and their possible pathogen contributions, it is difficult at this point to assess the significance of wildlife as a source of pathogens.

5.5 Residential Runoff

Location and magnitude:
There are nine small towns within the Tomales Bay watershed. Figure 6 illustrates the location of all developed areas within the watershed. Overall, developed areas (defined as all non-open-space urban lands) account for approximately 3.5% of all land use in the watershed. According to the 1990 census, the west side of Tomales Bay has a population of 1,392, with a total of 650 households. The east side of the Bay, from Dillon Beach to Point Reyes Station, has a population of 3,217, with 1,246 households. The population and the number of households have probably increased somewhat since the last census due to new development.

Significance:
Residential runoff may carry waste from pet or feral cats and dogs, as well as from leaky/failing OSDSs and, therefore, be a potential source of pathogens to the Bay and its tributaries. Results of the 2001 microbial monitoring study showed that the second highest loading of pathogen-indicators to the Bay was from the segment of the San Geronimo Valley subwatershed whose main land use is low density residential (Table 10). Also, residential runoff water samples collected from the storm drains in the town of Point Reyes Station, showed high levels of fecal coliforms (Table 9).

5.6 Small wastewater treatment facilities and sewage holding ponds

Location:
Figure 9 shows the location of all permitted small wastewater treatment plants and sewage holding ponds within the Tomales Bay watershed. Almost all of these facilities are located near bay tributary streams.

Magnitude:
There are eight small wastewater treatment facilities within the watershed, and one facility that accepts septage waste (Table 17). RWQCB prohibits direct discharge from treatment facilities into Tomales Bay or the creeks within the watershed. Four of the facilities have holding ponds and are permitted to discharge to irrigation fields during the dry season. The other five wastewater treatment facilities utilize leach fields for dispersing treated effluent.

Figure 9. Small Wastewater Treatment Facilities Within Tomales Bay Watershed

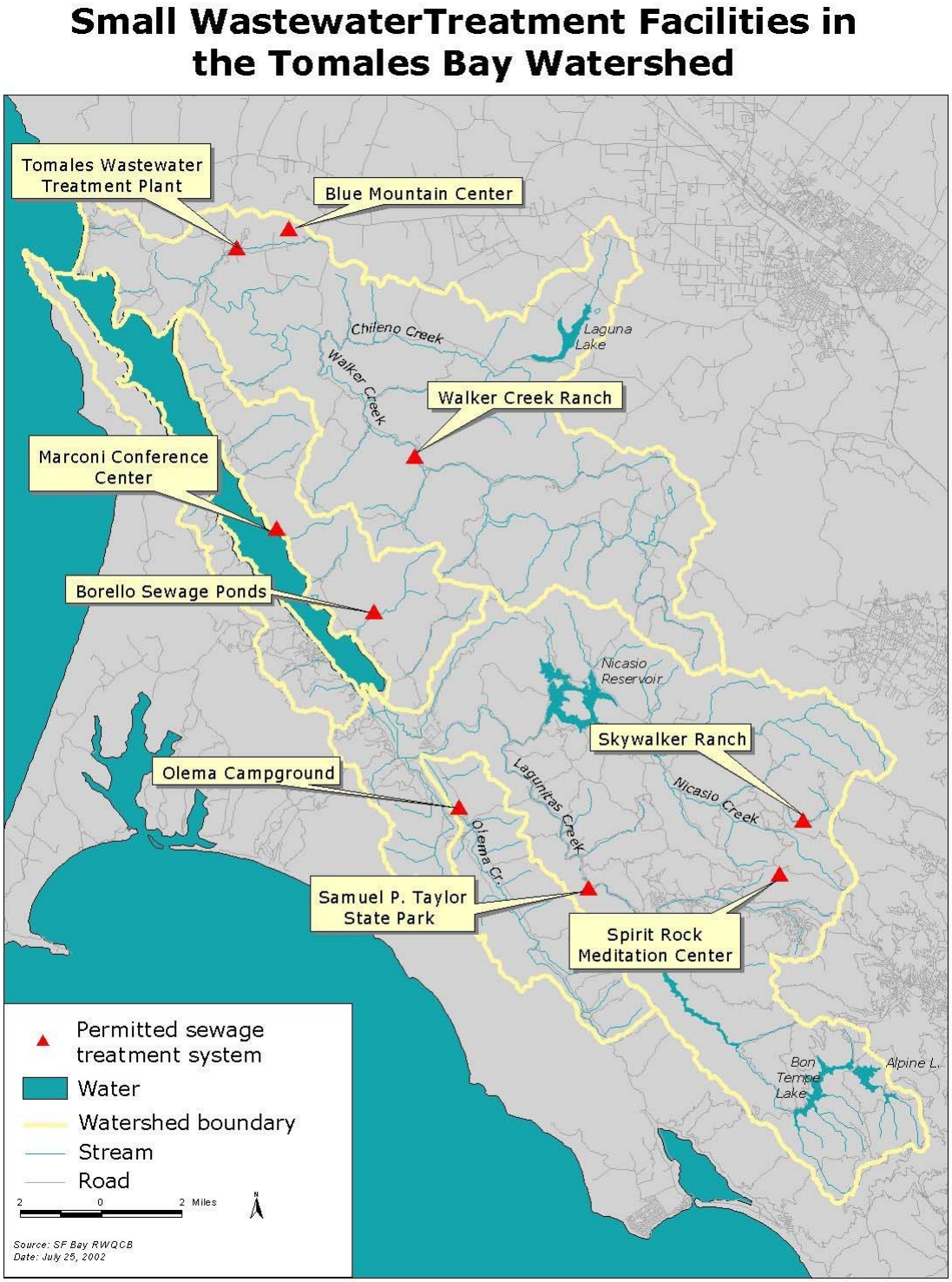


Table 17. Permitted Sewage Treatment Systems in the Tomales Bay Watershed, which are Regulated Under Waste Discharge Requirements from the San Francisco Bay Regional Water Quality Control Board.

NAME	LOCATION	WASTE (GPD[a])	WASTE SOURCE	TREATMENT TYPE	DISPOSAL	OPERATOR
Tomales Wastewater Treatment Plant	3 miles from Bay along Keyes Creek	38,000 (design) 11,000 (Avg-dry) 25,000 (Avg-wet)	Tomales (89 homes & school dist.)	Aerated storage ponds Chlorination	Spray Irrigation April to November	Tomales Village Community Services District
Marconi Conference Center	Highway 1 at Marconi Cove	25,000 (design) 13,500 (actual)	Conference facilities	Package plant secondary treatment (Chlorination)	Leaching trench w/backup irrigation	California State Parks
Borello Sewage Ponds	NE of Millerton Point above Millerton Creek	3400 (average)	Domestic and commercial septage	Holding ponds	Spray irrigation April-October	Owner operated
Skywalker Ranch	Lucas Valley Road, upper Nicasio Creek	8975 (maximum)	250 daytime users	Three septic tanks	Dual leachfields	Skywalker Ranch
Olema Campground	3.5 miles SW of Tomales Bay along Olema Creek	18,000 daily max	231 unit Campground	Septic tanks, holding tank, storage ponds Chlorination	Spray irrigation, April – October	Campground owner (manager)
Samuel P. Taylor Park	10 miles SE of Bay along Lagunitas Creek	80,000 (design) 45,000 (actual)	Campground, park	Digestor, primary clarifier, trickling filter	Leachfields, spray disposal if necessary	California State Parks
Blue Mountain	2 miles E of Tomales on Keyes Creek	4000 (actual)	50 residents, day use	Septic tanks, holding tank, 2 evaporation ponds	Discharge to leachfields	Blue Mountain Center
Spirit Rock	Sir Francis Drake Blvd. in Woodacre	9000 (design) 4875 (actual)	Residents, classes	2 Septic, one conventional, one sand filter	Leach fields	Insight Meditation Center
Walker Creek Ranch	11 miles from Bay, on Petaluma-Pt. Reyes Road	20,000 (design) 14,000 (actual)	100-220 overnighters, 230 day use	Package plant, activated sludge	Holding pond, pasture irrigation May – Sept.	Marin County Office of Education

a. GPD= Gallon Per Day

Significance:
In each case, accidental malfunctions, including the breaching of ponds, a break in a sewage line, or land application at times when the soil is saturated, could result in a discharge of untreated or partially treated effluent to the streams. All facilities have the potential to adversely impact water quality and impair beneficial uses if an accidental discharge occurred. For example, in 1996 a 1.02 million gallon sewage spill from the Town of Tomales wastewater treatment facility caused the closure of shellfish growing areas in the Walker Creek delta.

These facilities are permitted by Waste Discharge Requirements (WDRs) and regulated by RWQCB. All permits contain requirements for routine monitoring as well as performance standards to protect the water quality of the Bay for all beneficial uses including shellfish harvesting. Further, these permits require all wastewater treatment facilities to immediately notify RWQCB of any accidental waste discharge event. While these small wastewater treatment facilities have the potential to contaminate waters due to isolated and unexpected incidents such as a system malfunction or breaching of the holding ponds, under normal operating conditions, they are not considered to be a significant ongoing source of pathogens to the Bay.

5.7 Source Assessment Summary

Table 18 presents a summary of the pollutant source assessment, discussed in detail above. The summary lists the potential categorical sources of pathogens to the Tomales Bay watershed, describes what information is known and not known about each source, and states each source's significance level as a pathogen contributor.

Table 18. Pathogen Source Assessment Summary

POTENTIAL SOURCES	AVAILABLE INFORMATION	UNAVAILABLE INFORMATION	SIGNIFICANCE LEVEL
Agricultural Runoff (Cattle, Dairy, sheep farms, Equestrian facilities, etc.)	Parcel location, crude estimate of number of animals	Number of animals per parcel, animal movement within the parcel, proximity to creeks/waters, total loading	Significant
Onsite Sewage Disposal Systems	Parcel location, estimates of % failing systems in the watershed	Number of failing systems, proximity of systems to waters, condition of systems, total loading	Significant
Boat Discharge	Estimates of recreation, commercial, and live aboard boats in Bay	Potential discharge, total loading	Potentially significant

Residential Runoff	Location of developed areas, estimate of households in the watershed	Number of pets, runoff volume & coefficient, total loading	Unknown/May be significant
Wildlife	Estimates of marine mammals and shorebirds in the Bay	Estimates of numbers within watershed, total loading	Unknown
Small Wastewater Treatment Facilities	Location, Proximity to creeks/Bay, Discharge volume, Coliform concentration, Permit compliance status	--	Not significant as an ongoing source, Could be significant if accidental discharge occurs

6. TOTAL MAXIMUM DAILY LOAD AND LOAD ALLOCATIONS

6.1 General Approach

USEPA guidelines (USEPA, 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. Total Maximum Daily Loads are composed of the sum of individual wasteload allocations for point sources and load allocations for nonpoint sources for a given waterbody. 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 implicitly or explicitly, 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). For pathogen-indicators (i.e., fecal coliforms), however, it is the number of organisms in a given volume of water (i.e., their density), and not their mass or total number, which is significant with respect to public health and protection of beneficial uses. The density of fecal coliform 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 risk to the public health. USEPA guidance on the development of TMDLs recommends establishing a TMDL in this manner (density-based) for a pollutant that is not readily controllable on a mass basis. Therefore, this TMDL plan establishes density-based Total Maximum Daily Loads and pollutant load allocations, expressed in terms of fecal coliform concentrations.

6.2 Proposed Total Maximum Daily Loads

Table 19, below, lists the proposed TMDLs for Tomales Bay and its tributaries. These TMDLs will be applicable year-round. As shown, the TMDL established to ensure protection of water contact recreation use in the tributaries is the density-based REC-I water quality objective. This TMDL represents the total number of fecal coliform organisms that can be discharged from all sources, while not causing the water quality in the tributaries to exceed a five sample/month log mean fecal coliform density of 200 organisms/100 ml with no more than 10% of the samples exceeding 400 organisms/ 100 ml in a 30-day period.

Because shellfish harvesting is the most sensitive beneficial use of the Tomales Bay, the more stringent shellfish harvesting water quality objective, which again is expressed as the density of coliform organisms, is proposed as the TMDL for the Bay. This proposed TMDL requires that the water quality of the Bay be maintained to ensure a median of 14 MPN/100 ml of fecal coliform with no more than 10% of the samples in the Bay exceeding 43 MPN/100 ml.

Table 19. Total Maximum Daily Loads for the Tomales Bay and its Tributaries

WATERBODY	INDICATOR PARAMETER	TMDL	
		MEDIAN/ LOG MEAN [a]	MAXIMUM [b]
Tomales Bay	Fecal coliform	Median < 14 (MPN/100 ml)	43 MPN/100 ml
Major Tributaries: Walker Creek Lagunitas Creek Olema Creek	Fecal coliform	Log Mean < 200 (MPN/100 ml)	400 MPN/100 ml

a. Based on a minimum of no less than five samples equally spaced over a 30-day period.
b. No more than 10% of total samples during any 30-day period may exceed this number.

6.3 Proposed Load Allocations

As discussed above, unlike the mass-based load allocations established to meet mass-based TMDLs, 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 load allocation itself meets the density-based TMDL (Santa Ana Regional Water Quality Control Board, 1988).

Table 20 presents the density-based load allocations proposed for pathogens in Tomales Bay and its major tributaries. These load allocations will apply year-round to the different source categories of pollution in the watershed (i.e., agricultural and urban runoffs, OSDS's, Boat discharges, etc.). The attainment of these load allocations will ensure protection of the water quality and beneficial uses of the Bay and its major tributaries.

Table 20. Density-Based Pollutant Load Allocations for Different Categories of Nonpoint Source Pollution

CATEGORICAL POLLUTANT SOUIRCES	LOAD ALLOCATIONS FECAL COLIFORM (MPN/ 100 ML)			
	For Discharges to The Bay		For Discharges to The Tributaries	
	Median[a]	Maximum[b]	Log Mean[a]	Maximum[b]
Onsite sewage disposal systems	0	0	0	0
Small wastewater treatment facilities	0	0	0	0
Boat discharge	0	0	N/A	N/A
Agricultural runoff	14	43	200	400
Urban runoff	14	43	200	400
Wildlife	Uncontrollable	Uncontrollable	Uncontrollable	Uncontrollable

a. Based on a minimum of no less than five samples equally spaced over a 30-day period.
b. No more than 10% of total samples during any 30-day period may exceed this number.

The above sources 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 (e.g., Bay, tributary), 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 log mean of fecal coliform concentrations in stormwater runoff samples collected at a residential area's storm drain which discharges into a tributary, shall not exceed the allocated loads listed for the residential runoff source category discharging into tributaries (i.e., log mean of 200 MPN/100 ml).

The OSDSs, small wastewater treatment facilities, and boaters (the three potential sources of human waste to the Bay and its tributaries) are assigned a Load allocation of zero, for the following reasons:

1. As sources of human waste (as opposed to animal waste), they pose the greatest threat to the public health;
2. The numeric target of zero discharge of human waste proposed for this TMDL would, in effect, prohibit any discharge of human waste from these three sources, which is consistent with the existing RWQCB's Basin Plan's prohibition of any discharges from these sources;
3. When operated properly and lawfully, OSDSs, small wastewater treatment facilities and boats should not cause any human waste discharges; and,
4. Human waste discharges from these sources are fully controllable and preventable.

For these reasons, a zero load allocation for these sources is both feasible and warranted.

Once the TMDL is implemented, and all pathogen control measures are in place, if fecal coliform levels in the Bay and its tributaries remain high, investigation will need be made to determine whether the high levels of fecal coliforms originate from natural (wildlife) sources.

6.4 Margin of Safety

Total Maximum Daily Loads include a margin of safety to account for data uncertainty, growth, critical conditions, and lack of knowledge. Because the load allocations in this TMDL are based on the existing numeric water quality objectives, which are established as protective standards, the margin of safety is implicitly incorporated into the proposed TMDLs and load allocations. Therefore, no additional and/or explicit margin of safety is needed for this TMDL. Moreover, the implementation component of this TMDL will include a comprehensive monitoring and review plan, which will ensure the collection of data necessary for evaluating the adequacy and validity of this TMDL in protecting the water quality and beneficial uses of Tomales Bay and its tributaries (see Section 9, Implementation Plan).

6.5 Seasonal Variation

The largest discharges of fecal coliform bacteria, and the great majority of the violations of the pathogen-indicator objectives in the Bay, are associated with rainfall, particularly during the winter season. During the winter rainfall season, commercial shellfish are harvested, except when the mandatory closure rules are enforced. Use of the Bay for water contact recreation activities (and possibly sport shellfish harvesting) is reduced during the winter season but not necessarily eliminated. Fecal coliform and associated pathogen discharges in winter season stormwater runoff are believed to originate mainly from animal agriculture land usages (TBSTAC, 2001). Control of wintertime fecal coliform and pathogen concentrations is expected to be very challenging.

Recreational use of the Bay and its major tributaries are most prevalent during the summertime, when water quality objectives for REC-I and REC-II as well as for SHEL are exceeded less often than during the winter season. The Bay and its tributaries, however, remain impaired by pathogens, though in varying degrees, during all seasons (SWAMP, 2001; RWQCB, 2001), and the beneficial uses are not consistently protected during any season. No seasonal variations to the above-listed TMDLs and load allocations, therefore, are proposed.

6.6 Critical Conditions

The three most critical conditions that could cause an increase in pathogen densities in the Tomales Bay watershed are:

1. An increase in the number of agriculture livestock;
2. An increase in the size and/or density of developed areas; and,
3. Unusually high rainfall and runoff levels.

An increase in the number of agriculture livestock could result in the generation and disposal of additional animal waste within the watershed. This condition could result in increased pathogen loadings to the Bay and its tributaries. Similarly, an increase in the magnitude of developed areas and/or the population within the watershed could result in the production of additional human and pet waste, which may result in the increased loading of pathogens from these sources, to the Bay. Lastly, as discussed above, since rainfall-driven runoff is the biggest source of pathogen and bacterial indicator contributions in the watershed, an unusually high or sustained rainfall event may cause increased pathogen loadings to both the Bay and its tributaries.

7. LINKAGE ANALYSIS

7.1 Linkage between Water Quality Targets and Pollutant Sources

The objective of linkage analysis is to define a connection between the pollutant load allocations and the protection of beneficial uses (USEPA, 2001). For this TMDL, the linkage is already established, because:

- There is a one-to-one relationship between the pollutant load allocations and the numeric water quality objectives for the given waterbodies (the numeric water quality objectives and the pollutant load allocations are the same); and,
- The numeric water quality objectives, contained in RWQCB's Basin Plan, are believed to be protective of all the beneficial uses of the Bay.

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

7.2 Water Quality Modeling

On behalf of RWQCB, University of California at Berkeley scientists are developing a hydrodynamic model of Tomales Bay. The model will allow better understanding of the hydrodynamic processes of the Bay and its tributaries. It will provide a tool for evaluating whether the proposed pollutant load allocations for the Bay tributaries are fully protective of the beneficial uses within the Bay. For example, the model will enable RWQCB to ascertain whether a fecal coliform load allocation of 200 MPN/100 ml at some point near the mouth of the tributaries will ensure a median[4] fecal coliform density of 14 MPN/100ml or lower within the Bay.

Development of the model began in April 2002. It is anticipated that more refined simulations of fecal coliform fate and transport inside the Bay will be available by the summer of 2003.

[4] As calculated based on a minimum of five consecutive samples equally spaced over a 30-day period.

8. PUBLIC PARTICIPATION

Public participation is a requirement of the TMDL process and is vital to TMDL's success. Release of this Preliminary TMDL and Implementation Plan is an opportunity for the public to provide input to the Regional Board on the TMDL. The TMDL will not be considered final until the Regional Board has incorporated the TMDL into its Basin Plan.

8.1 Formal Process for Public Participation

The final TMDL Project plan will be presented to the Regional Board for review and adoption in the Summer of 2003. At this time, the TMDL will have a public hearing process for the promulgation of the TMDL and subsequent adoption into the Basin Plan. This process will allow the public to formally comment on the TMDL.

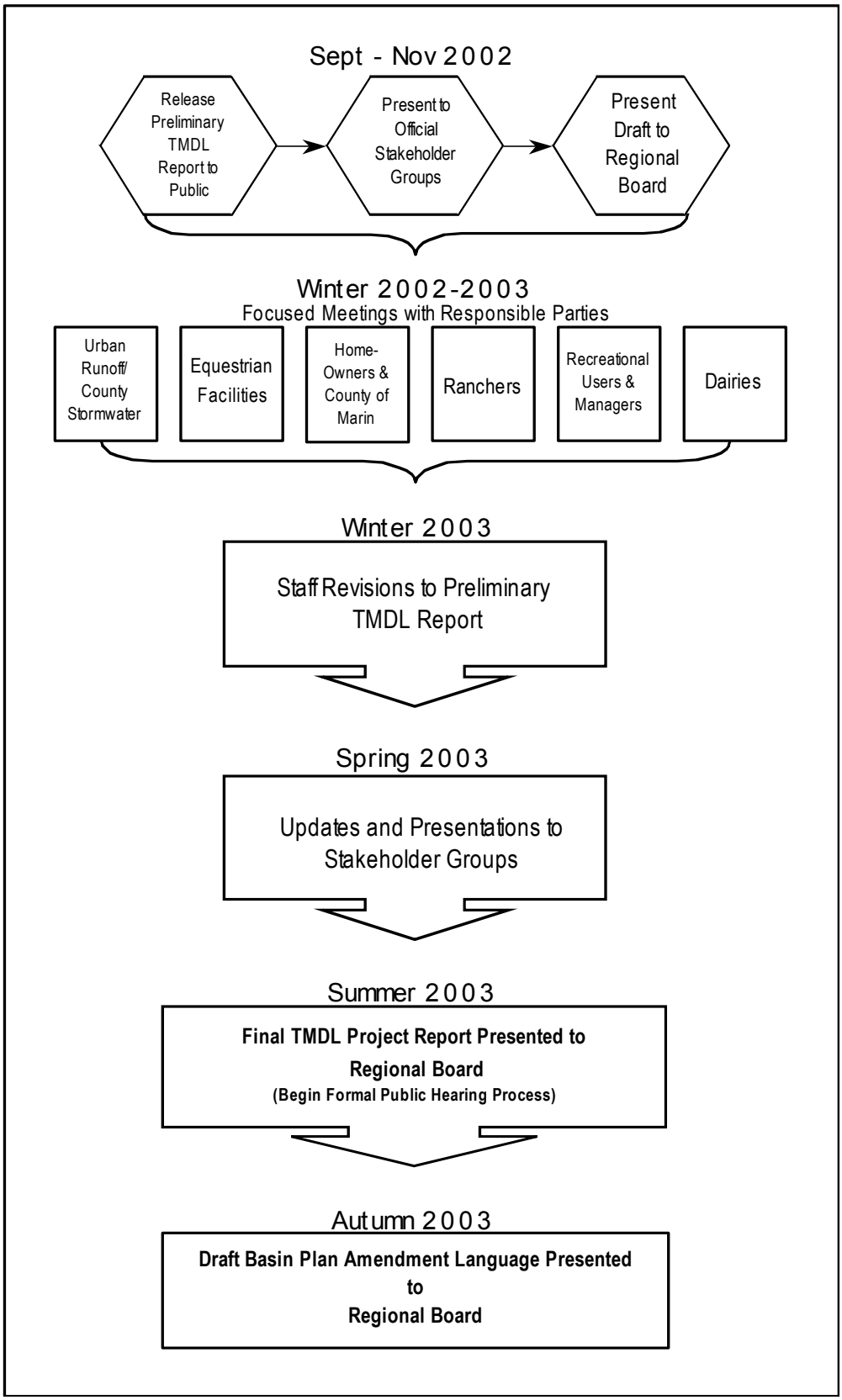
8.2 Informal Process for Public Participation

The Regional Board staff will continue to work with the designated stakeholder groups for this TMDL: the Tomales Bay Shellfish Technical Advisory Committee (TBSTAC), and the Tomales Bay Watershed Council. These groups hold bimonthly and monthly meetings, respectively, which are open to the public. Local stakeholders and regulatory agencies are active participants in both forums. Also, the monitoring subcommittee of the TBSTAC serves a technical advisory role in the development of the TMDL. Updates on the TMDL are provided to these stakeholder groups on a regular basis.

The RWQCB staff will hold meetings with each of the responsible parties identified in Chapter 9. These workgroups will meet to discuss the Implementation Plan and develop focused comments and recommendations on how best to meet the proposed water quality targets for Tomales Bay pathogens.

The proposed timeline and process for public participation and outreach is provided below in Table 21.

Table 21. Public Participation for Tomales Bay Pathogen TMDL



9. IMPLEMENTATION PLAN

9.1 Overview of Proposed TMDL Implementation Plan

As discussed in Section 1, TMDL Plans are an approach for addressing cumulative impacts of both point and nonpoint sources that are causing water quality impairments. One of the required elements of a final TMDL is an Implementation Plan. The Implementation Plan describes existing regulatory controls and cites relevant sections of the California Water Code (CWC) establishing RWQCB's authority to enforce the provisions set forth in the Implementation Plan. The Implementation Plan must include:

1. A description of the nature of the actions necessary to achieve water quality objectives, including recommendations for appropriate action by any entity, public or private;

2. A time schedule for the actions to be taken; and,

3. A description of the monitoring and surveillance to be undertaken to determine compliance with the objectives.

While Section 13242 of the California Water Code (CWC) requires that an Implementation Plan be incorporated into the Basin Plan upon RWQCB adoption of the final TMDL project report, an implementation plan is not a required element of this preliminary TMDL project report. Nonetheless, RWQCB is putting forth a draft implementation plan in the hopes that it will initiate consideration of the possible types of measures and actions needed to attain targets.

The overall intent of this implementation plan is to restore and protect beneficial uses of the Bay and its major tributaries by reducing pathogen loadings into these water bodies. The potential significant sources of pathogens to Tomales Bay include discharges from: dairy facilities, equestrian facilities, ranching facilities, faulty OSDSs, recreational and commercial boaters, and runoff from residential and commercial areas[5]. RWQCB 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 propose interim targets to allow for the additional time that may be needed to overcome some of these obstacles.

9.2 Summary of Implementation Plan Phases and Actions

There are many efforts aimed at improving water quality that are currently underway in the Tomales watershed. However, it is anticipated that in order to meet TMDL targets, RWQCB and stakeholders will need to implement additional efforts beyond those already

[5] Wildlife could be a source of pathogens as well but is believed to be not a significant and/or controllable source, and therefore is not discussed in this section.

underway. This preliminary implementation plan describes potential source reduction measures, the phasing for implementing these measures, and interim targets or milestones. This approach is summarized in Table 22, below.

The implementation plan acknowledges the recent progress made by each source type towards pathogen reduction and seeks to build upon these successful efforts in a phased manner. Phase I includes source assessment and plan development and is proposed to begin as soon as possible. Because ranches, equestrian facilities, residential runoff, and boaters are at an earlier implementation stage, we recommend that these source categories develop site-specific management plans detailing how they will reduce pathogen pollution from their facility to acceptable levels. We recommend that these management plans be completed by 2004 and that pollution prevention steps should begin as soon as possible. Dairies, on-site sewage disposal (septic) systems owners and small wastewater treatment facilities have already completed a management plan for their source-type. The TMDL proposes that these source categories continue with BMP implementation and improve their performance where needed.

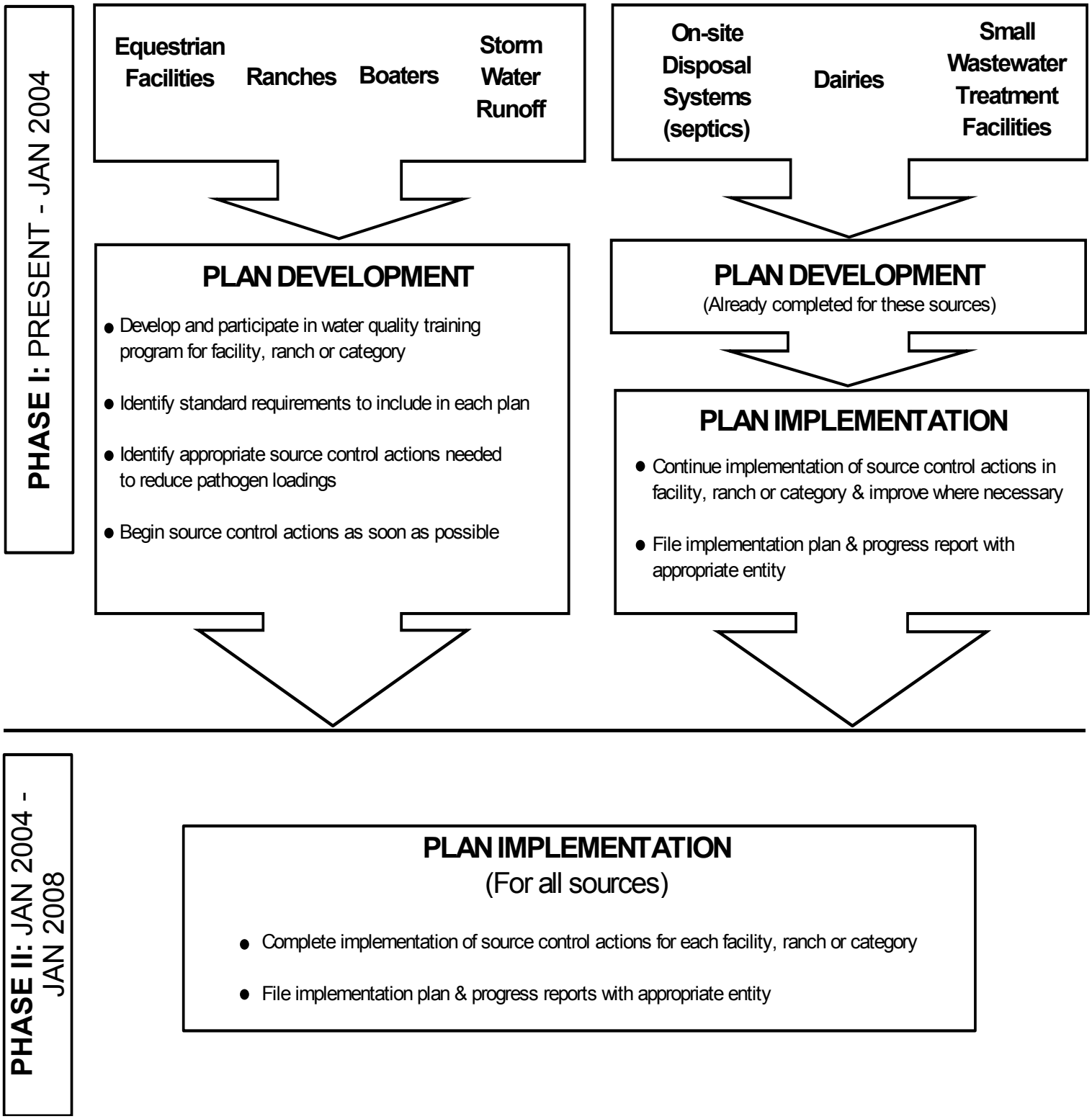
The goal of Phase II is to implement site-specific management measures for all of the pathogen contributing sources. This phase is proposed to begin no later than January 2004 and run through 2007. It is anticipated that each potential source will provide documentation on the progress made toward implementation of management measures. RWQCB recommends that an appropriate third party with expertise in implementation measures evaluate these reports for each source type.

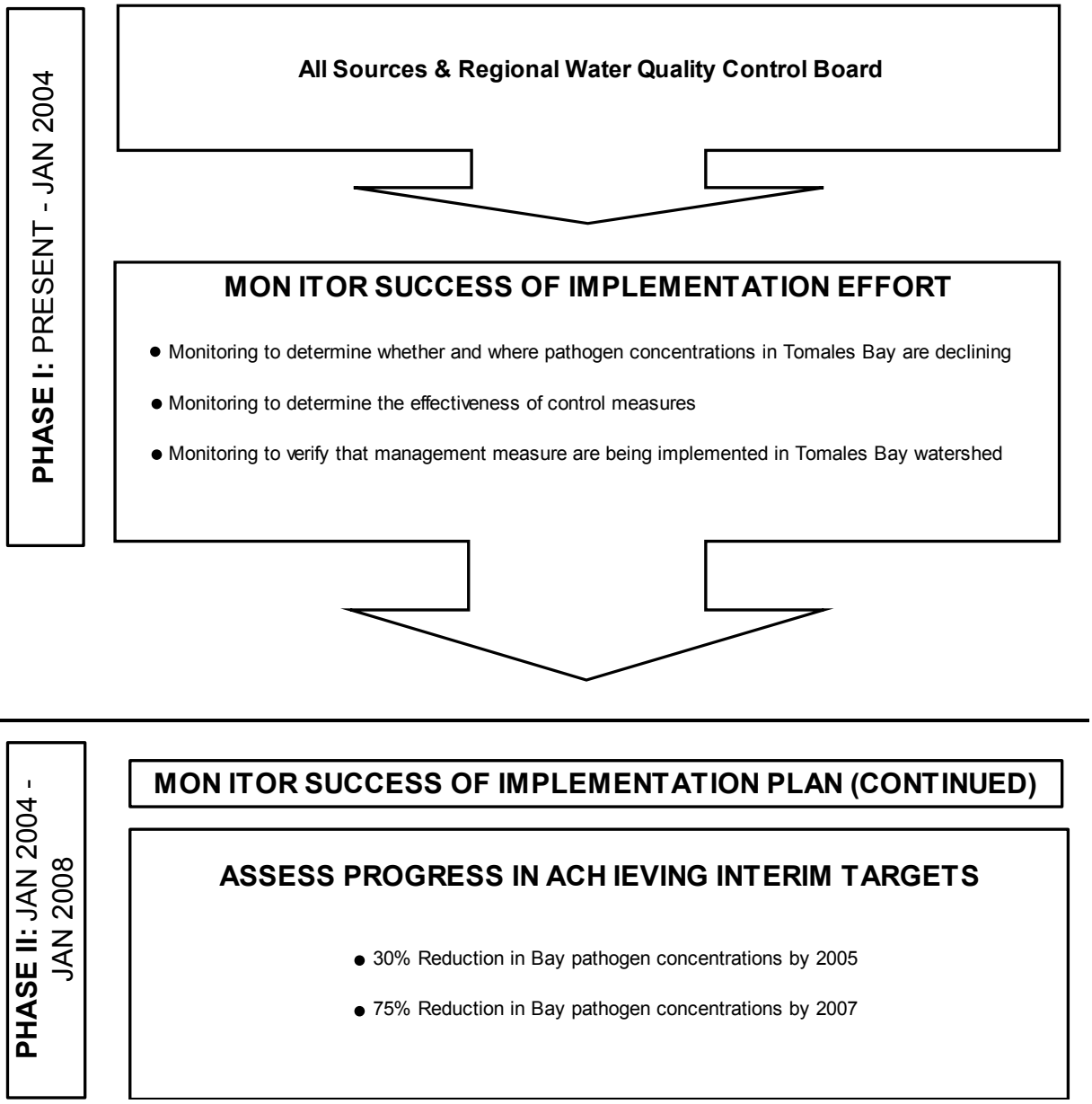
The implementation plan also recommends interim targets of a 30% reduction in pathogen concentrations by 2005 and 75% reduction in pathogen concentrations by 2007. Throughout Phase I and Phase II, RWQCB and stakeholders in the watershed will need to monitor compliance with management measure implementation and identify the progress made toward interim targets. It is anticipated that RWQCB will use regulatory measures and/or enforcement actions as needed throughout the implementation process to ensure that reasonable progress is made towards meeting water quality targets.

If reasonable progress is not made toward meeting the interim targets and/or implementation measures are not being implemented, RWQCB staff recommends increasing use of regulatory control measures. If implementation measures are being implemented and water quality targets are still not being met, then RWQCB staff recommends a reassessment of the pathogen contributions and/or TMDL targets.

This implementation plan describes RWQCB's regulatory authority (Section 9.3) as well as other plans and policies in the Tomales Bay watershed that affect pathogen-source management activities (Section 9.4). A description of the implementation actions and monitoring components for Phase I and Phase II are provided in Sections 9.8 and 9.11, respectively.

Table 22. Implementation Goals




PHASE I: PRESENT - JAN 2004
All Sources & Regional Water Quality Control Board
MON ITOR SUCCESS OF IMPLEMENTATION EFFORT
● Monitoring to determine whether and where pathogen concentrations in Tomales Bay are declining
● Monitoring to determine the effectiveness of control measures
● Monitoring to verify that management measure are being implemented in Tomales Bay watershed
PHASE II: JAN 2004 - JAN 2008
MON ITOR SUCCESS OF IMPLEMENTATION PLAN (CONTINUED)
ASSESS PROGRESS IN ACH IEVING INTERIM TARGETS
● 30% Reduction in Bay pathogen concentrations by 2005
● 75% Reduction in Bay pathogen concentrations by 2007

9.3 Legal Authorities and Requirements

The RWQCB has the responsibility and authority for regional water quality control and planning, per the state's Porter-Cologne Water Quality Control Act. The RWQCB 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* (hereafter referred to as the State NPS Management Plan). The State's Porter Cologne Water Quality Control Act gives RWQCB authority to issue Waste Discharge Requirements (WDRs) for point and nonpoint sources of contamination.

9.4 California Nonpoint Source Program

California's Nonpoint Source (NPS) Pollution Control Program has been in effect since 1988 (WMI Chapter, 2001). The Nonpoint Source 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 Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA). The lead state agencies for the NPS Program are the SWRCB, the nine RWQCBs and the California Coastal Commission. Its 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."

Implementation of the Nonpoint Source (NPS) Program is particularly amenable to a watershed-based approach, which acknowledges existing water body impairments from nonpoint sources. The NPS Program puts forth long-term goals, as well as short-term objectives to address these impairments. A key element of the Program is the "Three-Tiered Approach," through which self-determined implementation is favored, but more stringent regulatory authorities are utilized when necessary to achieve implementation. The three-tiered approach consists of implementation of self-determined best management practices (Tier 1), regulatory-encouraged best management practices (Tier 2) and effluent requirements and enforcement (Tier 3). The RWQCB is not required to sequentially move throughout these tiers and, depending upon water quality impacts and problem severity, may move directly to enforcement actions specified in Tier 3. The RWQCB may also implement a combination of water quality control mechanisms from each of the tiers or other remedies, as provided in the CWC.

9.5 Plans & Policies in the Tomales Bay Watershed

Below is a description of the current regulations, policies, and plans for each of the categorical pathogen sources in Tomales Bay. The Tomales Bay pathogen sources of concern include:

- Animal waste from grazing/rangeland;
- Animal waste from confined animal facilities (dairy and equestrian facilities);
- Faulty Onsite Sewage Disposal Systems (OSDSs);
- Boat discharges;
- On-site Sewage Treatment Facilities and,
- Runoff from towns or developed areas.

Grazing/Rangeland

SWRCB and California Coastal Commission have identified management measures to be used to address nonpoint source pollution from grazing activities. According to the California NPS Plan, ranches should be participating in the Range Management Advisory Committee. The NPS Plan also concludes that ranches should complete rangeland Water Quality Management Plans for their respective ranches. All of the ranches on lands leased from the Department of Interior and the majority of the ranches in private ownership have completed a ranch plan.

Confined Animals (Dairy and Equestrian Facilities)

Minimum design and management standards for the protection of water quality from confined animal operations are promulgated in Title 23, California Code of Regulations, Chapter 15, Article 6. These regulations prohibit the discharge of facility wash water, animal wastes, and stormwater runoff from animal confinement areas into waters of the State. They also specify minimum design and waste management standards for the:

- Collection of all wastewaters;
- Retention of water within manured areas during a 25-year, 24-hour storm;
- Use of paving or impermeable soils in manure storage areas; and
- Application of manures and wastewaters on land at reasonable rates

The RWQCB has the authority to enforce these regulations through Waste Discharge Requirements (WDRs). Facilities such as dairies, horse boarding stables, and sheep farms are typical of animal confinement operations within the watershed. The RWQCB typically waives WDRs for dairies (Resolution No 83-3) where proper waste control facilities are in place and management practices conform with the California Code of Regulations: Title 23, Article 3, Chapter 15 (Discharge of Waste to Land). A waiver does not prohibit RWQCB from taking enforcement action. Types of enforcement actions may include: the issuance of a Clean-up and Abatement Order; or, in cases where dairy practices have resulted in or threaten to cause a condition of pollution or nuisance in surface waters, an assessment of monetary penalties through the issuance of an Administrative Civil Liability; or, referral to the California Attorney General's office.

In 1990, the State Board established a Dairy Waste Task Force to look at the dairy industry statewide and develop standards for dairy regulation. The main emphases have been on developing better communication and guidance materials for the industry; developing a dairy survey form to help the RWQCB determine if a dairy qualifies for a waiver from WDRs; determining the number and location of dairies; developing more uniform WDRs; and preparing an outreach program aimed at the dairy industry, local

government, and the public. The State Board members directed staff to continue the following activities:

- Work with the dairy industry through the local dairy waste committees, county farm bureaus, Resource Conservation Districts (RCDs), and other local/state agencies in obtaining cooperative correction of dairy waste problems.

- Recommend adoption of WDRs in those cases where water quality objectives for waters within an agricultural watershed are consistently exceeded, or where corrective action is unsuccessful in eliminating either the short or long-term water quality problems or threats.

- Monitor compliance with animal waste guidelines and WDR waiver.

Onsite Sewage Disposal Systems

The San Francisco Bay Basin Plan specifically addresses water quality issues related to on-site wastewater treatment and disposal systems. In 1978, RWQCB 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 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 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 RWQCB has delegated authority for the regulation of individual OSDS in Marin County to the County Health Officer, through Resolution 84-12, which waives Waste Discharge Requirements for individual systems. Under a county ordinance approved by the Board of Supervisors in August 1984, the Marin County Environmental Health Department has responsibility for overseeing individual onsite sewage disposal systems.

This includes the responsibility for siting and design, installation and repair standards, and monitoring and inspection programs.

Recreational Boaters

Jurisdictions over boating and recreational uses in Tomales Bay are complex and overlap in many areas. Most of the waters and submerged lands of Tomales Bay are managed by three trustee agencies: California Department of Fish and Game; US Department of Interior (National Park Service); and US Department of Commerce (Gulf of the Farallones National Marine Sanctuary).

As part of the Gulf of the Farallones, Tomales Bay is designated as a no-discharge zone and discharges of untreated sewage into the Bay are prohibited. The US Coast Guard and the State of California Boating laws also regulate discharges of untreated sewage into navigable waters.

These regulations require use of a Coast Guard approved Marine Sanitation Device (MSD) on all boats with installed toilets (33 U.S.C. III 1322). An MSD is any equipment for installation onboard a vessel, other than a toilet, which is designed to receive, retain, treat or discharge sewage and any process to treat such sewage. It has been recommended by the Department of Health Services that all boats in Tomales Bay be equipped with some type of MSD; including a portable toilet or a bucket with a tight fitting lid to contain the waste until it can be disposed of properly.

Ongoing local, state and national park efforts specifically related to human waste disposal from boating and recreational activities in the Bay have focused on distribution of educational materials identifying the location of sanitary facilities along the shoreline and informing the public about proper sanitary disposal methods. The park managers have also focused on providing adequate sanitary facilities that are commensurate with the amount of recreational use.

The Gulf of the Farallones convened an Interagency Mooring Committee to evaluate current day-use and live-aboard mooring practices and develop guidelines and recommendations for establishing future moorings. The National Park Service recently instituted a ban on personal watercraft (e.g. jet skis) throughout Tomales Bay and has established a permit program for overnight camping along Tomales Bay. These agencies are continuing to work on development of a recreational management plan for Tomales Bay.

Small Wastewater Facilities

Pursuant to Section 13260 of the California Water Code, any person discharging waste or proposing to discharge waste that could affect water quality (other than to a community sewer system) must file a Report of Waste Discharge (ROWD) with RWQCB. The CWC further provides that RWQCB may prescribe requirements for the discharge through issuance of Waste Discharge Requirements (WDRs). These WDRs typically include a prohibition on the discharge into waters of the State, monitoring requirements, treatment requirements, and a categorization of the WDR according to its threat to water

quality and its complexity. As described in Figure 9 (Chapter 4), there are a number of small wastewater facilities in the Tomales Bay watershed that are regulated by WDRs.

Storm water Management Program

The RWQCB 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 storm water permit requires that the entities responsible for the system develop and implement comprehensive control programs. Phase I of the storm water conveyance program runs from 1990 – March 9, 2003 and includes requirements for construction sites greater than five acres, industrial storm water discharges, and large and medium municipalities.

Phase II begins on March 10, 2003 and addresses storm water runoff from construction sites greater than one acre and small municipalities. The runoff from land uses within the Tomales Bay watershed will be addressed in Phase II. Marin County's Stormwater Pollution Prevention Program (MCSTOPPP) is responsible for implementing Phase II requirements in the Tomales Bay watershed.

Phase II Municipal program requirements include the following elements:

- Develop, implement, and enforce a storm water 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 storm water impacts, public involvement, illicit discharge detection and elimination, construction site storm water runoff control, post construction storm water management in new development and redevelopment and pollution prevention/good housekeeping for municipal operations;
- Evaluation and assessment of measures; and
- Monitoring and reporting.

9.6 Cooperating Stakeholders

A number of active stakeholder groups, government entities and non-governmental organizations can play an important role in reducing pathogen loadings and attaining water quality targets. These stakeholders are described below:

County of Marin

- *Marin County Stormwater Pollution Prevention Program (MCSTOPPP)*: Marin County administers and manages the countywide stormwater program. MCSTOPPP is the Department that administers the stormwater program for the County. MCSTOPP is also working with the Marin Resource Conservation District on improving waste management of equestrian facilities.

- *Environmental Health Services*: The RWQCB has delegated responsibility for overseeing individual onsite sewage disposal systems including siting and design,

installation and repair standards, and enforcement, monitoring and inspection programs to the County of Marin. The Environmental Health Services is the Department that administers the onsite sewage disposal system program for the County.

Shellfish Technical Advisory Committee

The Shellfish Protection Act of 1993 applies to all commercial shellfish growing areas determined to be threated and required the formation of the Tomales Bay Shellfish Technical Advisory Committee (TBSTAC). The TBSTAC convened in 1994, with the main goal of developing a strategy to eliminate pathogen impairment of the Bay, such that the beneficial use of shellfish harvesting is protected.

UC Cooperative Extension/Tomales Bay Agricultural Group

The Tomales Bay Agricultural Group (TBAG) is a private organization comprised of dairy farmers and cattle ranchers within the Tomales Bay watershed that was formed in 1999 to provide direction and support on water quality management for animal agricultural producers. UC Cooperative Extension is a department within the University of California system that addresses specific research questions. TBAG is working with UC Cooperative Extension on a grant to assess impacts of dairy practices on water quality.

Marin Resource Conservation District (RCD)

Resource Conservation Districts are non-regulatory, special districts established by Division 9 of the California Public Resources Code. Volunteer boards of directors provide local leadership in directing conservation services to meet the needs of residents and landowners. RCDs assist landowners by providing technical advice and conservation education, supporting locally led watershed-planning efforts, protecting waterways and groundwater from pollution, and encouraging habitat restoration projects. Additionally, the Marin County and Southern Sonoma Resource Conservation Districts (RCDs) have a cooperative, voluntary program in which a farmer agrees to use the land within its capabilities, develop a conservation plan, and apply conservation practices to meet objectives and technical standards of the RCDs. The Marin RCD is managing several grants related to ensuring source control and implementation of Best Management Practices on dairy and ranchlands. The RCD is also working with the Council of Bay Area RCDs, MCSTOPPP, and the Marin Horse Council to provide manuals and technical assistance to equestrian facilities on manure management. Specific projects include an Equine Facilities Assistance Program, a manure facility site assessment and production of a manual, *Horse keeping: A guide to land management and water quality.* The RCD has also worked with ranchers to prepare the Walker Creek Enhancement Plan, which targeted reduction of erosion and sedimentation in Walker Creek.

Government Agencies

Federal and state agency jurisdictions over Tomales Bay are complex, interconnected and overlap in many areas. Most resources are managed by three trustee agencies: California Department of Fish and Game; Department of the Interior (Point Reyes National Seashore); and US Department of Commerce (Gulf of Farallones National Marine

Sanctuary). The Point Reyes National Seashore is one of the largest landowners in the Tomales Bay watershed.

Most water quality issues are managed by two state agencies: RWQCB and California Department of Health Services.

Tomales Bay Watershed Council (TBWC)
The Tomales Bay Watershed Council is a non-governmental organization that uses a community-wide consensus approach to address water quality and resource concerns in the Tomales Bay watershed. TBWC is currently developing a watershed plan for Tomales Bay.

9.7 Watershed-Wide Implementation According to Source of Pollution

This section describes potential management measures for the Tomales Bay watershed. Load reductions and implementation of pollution control measures are necessary throughout the watershed to achieve water quality goals in Tomales Bay.

As discussed above in Section 4 and illustrated in Figure 6 (Tomales Bay land use map), the potential pathogen sources are distributed throughout the Tomales Bay watershed. In this document, implementation measures are organized by source category rather than by sub-watershed. If a given sub-watershed has a predominant land use type or a predominant source of pathogens, then the management measures for that particular source may be emphasized for that geographic area. The RWQCB staff is evaluating how best to work with stakeholders to identify these sub-watershed areas and management practices.

9.8 Implementation Actions to Reduce Pathogens

To determine the appropriate level and type of source control and regulatory actions necessary to achieve water quality objectives, RWQCB 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.

This TMDL is likely to be most effective if implemented in a phased manner. Implementation actions will need to be “trackable” and will include both voluntary, or self-determined efforts, and those required under existing or anticipated regulatory

requirements. We propose to use an interim target of 30% reduction in concentration by 2005 and 75% reduction in concentration by 2007 to determine if progress is being made.

The TMDL includes actions to be carried out by RWQCB and also includes actions that each facility or source-type will need to conduct. Active participation from local entities and third parties within the watershed will also be essential for attainment of water quality standards. To ensure that actions assigned to the RCD, UCCE, and government agencies (including County of Marin, National Park Service, Gulf of Farallones Sanctuary, CDFG, and DHS) are implemented, RWQCB will rely on inter-agency coordination, grant funding, and research and monitoring.

The specific activities to facilitate interagency and third party participation need to be clearly defined. Options for clarifying the role that third parties can play range from: identifying these third parties' responsibilities in official RWQCB documents including WDRs, requiring "reports" from these third parties, developing Memorandum of Understandings between RWQCB and third parties, and continuing the ongoing, informal collaboration and discussions between the stakeholders and RWQCB staff.

With the exception of those facilities already operating under Waste Discharge Requirements, implementation actions assigned to private landowners, boaters, and non-governmental organizations are voluntary at this time. As already mentioned, regulatory control measures for all potential pollution sources may become necessary if water quality standards are not met by December 2008 or if reasonable progress is not being made toward achieving interim targets. Such regulatory control measures may include enforcement actions on existing permitted facilities and implementing Waste Discharge Requirements for activities that are not currently permitted (i.e., equestrian and ranch facilities and boats).

Many implementation activities are already underway in the watershed. The RWQCB staff strongly supports these activities and recommends that these efforts be continued.

Table 23 and 24 summarize the recommended implementation actions to be performed by both RWQCB and other parties.

Table 23. Regional Board Actions

Area of Focus	Status or Phase	Action
FUNDING	Completed	1. Awarded $750,000 to Marin RCD under the State Proposition 13 fund to assist dairies and ranches in the Tomales Bay watershed to reduce pathogens and nutrients.
	Completed	2. Awarded $600,000 to Council of Bay Area Resource Conservation Districts under 319 Grant to Equine Facilities Assistance Program (EFAP) and Manure Management Program.
	Completed	3. Awarded $800,000 to Marin County under the State Proposition 13 fund to repair failed OSDS along east shore of Tomales Bay and provide technical assistance to homeowners in the watershed.
	Completed	4. Award Proposition 13 grant to UC Cooperative Extension to conduct study of pathogen sources in coastal estuaries.
	All Phases	5. Encourage grant funding for activities likely to reduce pathogen loadings, promote best management practices, or otherwise further the goals of this implementation plan.
COORDINATION	Phase I	6. Work with stakeholders in the watershed to clearly define the role they can play in assisting with implementation of the TMDL. Options to consider include developing Memorandum of Understandings between RWQCB and third parties and continuing ongoing, informal collaboration and discussions between third parties, stakeholders and RWQCB staff.
	Phase I	7. Work with stakeholders in the watershed to identify guidelines and criteria for water quality protection plans.
	All Phases	8. Assist RCD/UCCE with conducting technical assistance and outreach to animal waste facilities.

Area of Focus	Status or Phase	Action
	All Phases	9. Promote the implementation of best management practices within Tomales Bay watershed.
	All Phases	10. Assist National Park Service, Gulf of Farallones and recreational community in providing education and outreach and in developing water quality protection and management plan for reducing human waste from recreational users in Tomales Bay.
	All Phases	11. Provide technical assistance and guidance to MCSTOPPP storm water program to incorporate necessary requirements into general permit to reduce pathogen loadings within Tomales Bay watershed.
	All Phases	12. Work with California Department of Health Services to evaluate and update as needed the rainfall model used to determine closures for shellfish lease areas.
	All Phases	13. Work with Environmental Health Services to develop an inventory of OSDS' and provide ongoing evaluation of how OSDS are functioning.
	All Phases	14. Promote establishment of management program for OSDS.
RESEARCH & MONITORING	All Phases	15. Promote the development and adoption of evaluation methods (e.g. fate and transport models) for determining how pathogens are distributed and transported in the environment.
	All Phases	16. Promote studies to evaluate the effectiveness of source control measures.
	All Phases	17. Encourage pilot demonstration projects to evaluate methods for reducing pathogen discharges.

Area of Focus	Status or Phase	Action
	Phase I	18. In coordination with responsible parties and interested third parties in the watershed, develop monitoring program to measure progress toward meeting interim targets, attainment of water quality standards and, compliance with TMDL implementation plan.
	Phase I	19. Coordinate implementation of monitoring program (i.e. funding options and mechanisms).
PROACTIVE REGULATION	All Phases	20. Conduct regular inspections on all WDR facilities and identify facilities with greatest risk to water quality.
	Phase I	21. Update all WDRs that are more than five (5) years old.
	Phase II	22. Assess progress in achieving interim targets and implement regulatory measures, as appropriate.
	All Phases	23. Enforce conditions of waivers related to pathogen reduction including dairy compliance with Animal Waste Guidelines and EHS and homeowner compliance with OSDS regulations.
	All Phases	24. Implement, as necessary, WDRs related to pathogen reduction including equestrian facilities, ranching facilities and boating operations.
	All Phases	25. Require appropriate third party with expertise to review and comment on source assessment, plan development and plan implementation for each source type.

Table 24. Actions by Others

Organization	Status or Phase	Action
Marin County, EHS	Completed	1. Provide education to homeowners on managing septic systems – Homeowner Manual mailed to all homeowners in watershed describing how to improve management and maintenance of their system.
	Completed	2. Identify areas of greatest water quality concern from septic system failure - GIS Risk Assessment conducted which identified septic parcels and rated their risk to public health including proximity to impaired waters, drinking wells, shellfish beds, and swimming areas
	Ongoing	3. Offer incentives to homeowners to measure how their systems are performing (i.e. free, voluntary inspection program offered to homeowners along Tomales Bay shoreline).
	Phase I	4. Inventory and document performance of individual OSDSs in the watershed. Priority should be given to systems within 100 feet of stream or Bay.
	Phase II	5. Notify and/or report progress on inventory and OSDS repair to appropriate entity.
	Phase II	6. Ensure compliance with County's repair standards for all systems within 100 feet of stream or Bay that did not pass routine inspection.
	Phase II	7. Complete inventory of systems and assess overall performance within watershed. Identify appropriate enforcement or follow-up actions as needed.
MCSTOPPP	Ongoing	8. Provide equestrian facilities and ranchers with educational materials and assist with water quality plan development to reduce waste from these land uses.
	Phase I	9. Provide educational information and technical assistance to residential areas to help promote pathogen reduction.

Organization	Status or Phase	Action
	Phase I	10. Identify Municipal Program Requirements for NPDES storm water program for residential areas in Tomales Bay watershed (including Pt. Reyes Station, Inverness, Marshall, etc.).
	Phase II	11. Notify and/or report progress on source assessment, plan development and plan implementation to RWQCB.
	Phase II	12. Implement storm water management plans, public education and outreach, discharge detection and elimination program(s) in Tomales Bay watershed.
RCD/UCCE		
	Ongoing	13. Provide education and technical assistance to equestrian facilities, dairy facilities and ranches so that they can develop appropriate plans for reducing waste.
	Ongoing	14. Assist with monitoring and assessment of dairy, equestrian, and ranchland waste practices. Progress to date includes formation of Tomales Bay Agricultural Group and two years of monitoring and assessment on 11 facilities throughout the watershed.
	All phases	15. Identify and promote pilot demonstration projects in dairy, equestrian and ranching facilities.
	Ongoing	16. Provide technical assistance and training programs to identify and implement site-specific best management practices for dairy, equestrian, and ranching facilities.
National Park Service, Gulf of Farallones, boaters & Recreational users	Ongoing	17. Inform public about importance of proper human waste disposal. Continue such efforts as signs posted at local, State and National Parks.
	Ongoing	18. Initiate planning process identifying recreational use guidelines in Tomales Bay. Progress to date includes the *Guidelines for Protection and Use of Tomales Bay* (August 2001); A planning document that recommended development of a long-range comprehensive plan for dealing with community waste.

Organization	Status or Phase	Action
	Ongoing	19. Provide adequate and aesthetically designed sanitary facilities for recreational users at appropriate locations in Tomales Bay watershed.
	Phase I	20. Develop comprehensive management plan for Tomales Bay identifying necessary restroom facilities and educational materials for anticipated recreational users in Tomales Bay.
	Phase I	21. Develop human waste capacity standards for each boat type (non-motorized, recreational, commercial, liveaboards).
		22. Recommend permitting procedures for moorings, anchor-outs, and liveaboards.
	Phase II	23. Notify and/or report progress on source assessment, plan development and plan implementation to appropriate entity.
	Phase II	24. Establish program to ensure that Tomales Bay boats have sufficient capacity to accommodate and properly dispose of human waste.
	Phase II	25. Enforcement actions, as needed, on boats not demonstrating sufficient capacity for accommodating human waste.
Dairy Operators	Ongoing	26. Participate in Sonoma-Marin Animal Resource Committee. The Committee supports dairy operators in their efforts to solve waste control problems and locate technical and financial assistance. The committee serves as a vehicle through which the RWQCB and California Department of Fish and Game can disseminate information on water quality regulations and requirements.
	Phase I	27. Participate in a training program that identifies water quality concerns and site-specific best management practices for reducing such water quality impacts (e.g. Dairy Quality Assurance Program Training).
	Phase I	28. Implement best management practices to reduce pathogen loading to watershed.

Organization	Status or Phase	Action
	Phase I	29. Ensure that facility is in full compliance with animal waste guidelines.
TBSTAC	Ongoing	30. Support ongoing research and technical assistance currently being performed by the UC Cooperative Extension and Tomales Bay Agricultural Group (TBAG) and implementation of best management practices at these facilities.
	Ongoing	31. Support community-based management measures (such as the East Shore Planning Group) and regular evaluation of OSDSs.
	Ongoing	32. Assist with expanding restroom facilities for recreational users (e.g. siting & design of boater pump-out facility at Miller Park).
	All Phases	33. Review monitoring information on water quality and implementation of management measures.
Ranchers	Ongoing	34. Participate in RCD's and other programs to ensure that land is used within its capabilities.
	Phase I	35. Participate in Ranch Management training program.
	Phase I	36. Develop and begin implementation of a ranch conservation plan (e.g. Ranch Management Plan).
	Phase II	37. Notify and/or submit documentation of plan development and plan implementation to appropriate entity.
	Phase II	38. Fully implement best management practices and apply conservation measures on land to meet water quality objectives (e.g. riparian planting, riparian fencing & crossings, etc).
Equestrian Facilities	Ongoing	39. Participate in RCD and MCSTOPPP program to improve horse facilities and manure management.
	Ongoing	40. Work with RCD and County to identify equestrian facilities in watershed and steps needed to implement an Equestrian Ranch training program in the watershed.

Organization	Status or Phase	Action
	Phase I	41. Participate in Equestrian Ranch training program.
	Phase I	42. Identify site-specific source control measures and conservation practices on each equestrian facility. Develop and begin implementing an Equestrian Ranch Plan.
	Phase II	43. Notify and/or submit documentation on pathogen source assessment, plan development and plan implementation to appropriate entity.
	Phase II	44. Fully implement identified source control measures in Equestrian Ranch Plan to meet water quality objectives (e.g. move stables away from creeks, riparian fencing & crossings, etc).

9.9 Future Plans and Policies

There are a number of plans and policies that are anticipated, but not yet completed. Two recently passed State Bills, Assembly Bill (AB) 885 and Senate Bill (SB) 390, will affect RWQCB and local counties' management of OSDS. AB 885 requires the SWRCB to adopt specified regulations or standards for the permitting and operation of prescribed onsite sewage treatment systems by January 1, 2004. SB 390 requires that all waivers issued pursuant to Section 13269 be reviewed by January 1, 2003.

The Tomales Bay Watershed Council is developing a Watershed Management Plan to address water quality and resource concerns within the Tomales Bay watershed. They have identified specific actions related to improvement of water quality. This Plan should be finalized in Spring of 2003. These future items identified will be incorporated into the Implementation Plan, as appropriate, upon their completion.

9.10 Evaluation of Regulatory Measures

The RWQCB will periodically evaluate the effectiveness of the TMDL implementation plan in achieving water quality targets. We recommend establishing interim targets of 30% reduction in pathogen concentration to Tomales Bay by 2005 and 75% reduction by 2007. The proposed monitoring plan is discussed below.

If RWQCB determines that load and concentration reductions are being achieved as management measures are effectively 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 the control measures are not effective; whether high fecal coliform level is due to uncontrollable (wildlife) sources; and/or, is unattainable.

If self-determined measures are not implemented and as a result interim targets are not achieved and/or load and concentration reductions are not achieved by 2008, RWQCB may adopt more stringent regulatory measures. These more stringent management measures may include (but not be limited to) a moratorium on building permits for homes with OSDSs, enforcement actions against equestrian, dairy, sheep, and ranch facilities, limits on boats in Bay not meeting human waste requirement, limits on development in areas not complying with the storm water management plan, and a prohibition of boaters in Tomales Bay.

9.11 Monitoring Program

The primary measure of success for implementation of this TMDL is attainment of the water quality targets for Tomales Bay and its major tributaries (see Section 5.2). Other measures of success, including attainment of trackable implementation actions will also be considered.

To measure the success of load reduction, RWQCB staff will collaborate with existing stakeholders in the watershed to monitor selected water quality testing stations within the watershed and the Bay. Some of the proposed stations to monitor on a monthly basis from November – March (including three storm events per year) are:

- Walker Creek at Highway 1 Bridge
- Chileno Creek at Gale's Ranch
- Lagunitas Creek at Gallagher Ranch
- Lagunitas Creek at Green Bridge, Point Reyes Station
- Olema Creek at Bear Valley Road Bridge
- San Geronimo Creek at Inkwells, Sir Francis Drake
- Several stations within the Bay (from inner-Bay to Outer-Bay)

Each source and/or subwatershed will have the opportunity to demonstrate that water quality objectives (TMDLs) are being met for their sector/watershed.

In coordination with responsible parties and interested third parties in the watershed such as the TBSTAC, Tomales Bay Watershed Council, DHS, UC Cooperative Extension, and Marin RCD, RWQCB will identify appropriate ambient monitoring stations to determine compliance with TMDL implementation. The ambient monitoring stations and sampling frequency will be chosen so that it accurately reflects the effectiveness of different land use practices in meeting the proposed TMDLs and the potential threat to water quality.

9.12 Conclusion

The measure of success for implementation of this TMDL is attainment of the fecal coliform numeric water quality objectives for SHEL (within the Bay) and REC-1 (within Major tributaries). This preliminary implementation plan relies on existing efforts within the watershed and offers a broad-based plan for pathogen-reduction that promotes the development of water quality management plans and the implementation of Best Management Practices. If by 2008, RWQCB finds that beneficial uses are still impaired despite the implementation of best management practices and source control measures, RWQCB will consider the need to revise the implementation actions and/or reevaluate the water quality targets.

10. REFERENCES

Atwill, E.R. 1995. Microbial pathogens excreted by livestock and potentially transmitted to humans through water. Veterinary Medicine Teaching and Research Center, School of Veterinary Medicine, University of California, Davis.

Barrett, E.M. 1963. The California Oyster Industry. Fish Bulletin 123, California Department of Fish and game. pp 103.

California Coastal Commission and California State Water Resources Control Board, Plan for California's Nonpoint Source Pollution Control Program. January 2000

California Department of Health Services. August 1996. Identification of Sources of Bacterial Indicators of Water Quality of Tomales Bay Shellfish Beds, Pilot Monitoring Program, Winter 1994-95, California Department of Health Services, Environmental Microbial Diseases Laboratory,

California Department of Health Services. December 2001. Draft Twelve-Year Sanitary Survey Report, Shellfish Growing Area Classifications for Tomales Bay, California.

California Regional Water Quality Control Board, San Francisco Region. June 30, 2001.

California Regional Water Quality Control Board; San Francisco Bay Region. June 21, 1995. Water Quality Control Plan.

California Regional Water Quality Control Board; San Francisco Bay Region. 2001. Surface Water Ambient Monitoring Program (SWAMP) results.

California Regional Water Quality Control Board; Santa Anna Region. November 24, 1998. Total Maximum Daily Load for fecal coliform bacteria in Newport Bay, California.

Council of Bay Area Resource Conservation Districts, Horse Keeping: A Guide to Land Management for Clean Water. 2001

Council of Bay Area Resource Conservation Districts, Improved Resource Management at Equine Facilities, Final Report. October 30, 2000

County of Marin, Environmental Health Services, Septic Technical Advisory Committee Recommendations, Final Report. December 2001

Fischer, D.T.; Smith, S.V.; Churchill, R.R. 1996. Simulation of a century of runoff across the Tomales watershed, Marin County, California. J Hydrol. 186. pp 253-73.

Gary, G.F. et al. Cattle grazing impact in Colorado Front range stream. 1983. J. Soil and Water Cons. Vol 38, No. 2. pp 124-128.

Gerba, C.P.; Rose, J.B. 1990. Viruses in source and drinking water. In G.A. McFeters (ed.) Drinking Water Microbiology. Springer-Verlag, New York. pp 380-396.

Havelaar A.H. 1993. Bacteriophages as Models of Human Enteric Viruses in the Environment. J ASM News, Vol. 59, No. 12, pp 614-619.

Jarvis, F.; Nokay, C.; Ammann, M.; Yee, M.; Williams, S. Tomales Bay and Watershed Water Quality Survey during 1976-77 and 1977-78, San Francisco Bay Regional Water Quality Control Board, November 1978.

Kelly, J. Unpublished data for 1992 census of winter water bird species. Audubon Canyon Ranch, Cypress Grove Preserve, Marshall, CA.

Kelly, J. et al. 1994. The use of aquaculture areas by wintering shorebirds at Walker Creek Delta, Tomales Bay, California.

Kelly, J; Tappen, S, 1998. Distribution, Abundance, and Implications for Conservation of Winter Waterbirds on Tomales Bay, Western Birds 29:103-120.

Musselman, J.F. Sanitary Survey of Shellfish Waters, Tomales Bay, California, February-March 1980, Department of Health and Human Services, Public Health Service, Food and Drug Administration, Shellfish Sanitation Branch, Davisville, RI, October 1980.

Progress report: Total Maximum Daily Load for pathogens in Tomales Bay, California. Sharpe, C.A., Tomales Bay Shellfish and Water Quality Survey, California State Department of Health, Water Sanitation Section, December 1974.

Smith, E.H.; Johnson, R.G.; and Obrebski, S., Final Report, Environmental Study of Tomales Bay, Volume 2, 1966-1970, Physical, Chemical, Microbiological and Hydrographic Characteristics, Pacific Marine Station Research Report #9, U.S. Environmental Protection Agency, Water Quality Office, Project #18050DFP, August 1971.

Snowdon, J.C.; Cliver, D.O. 1989. Coliphages as Indicators of Human Enteric Viruses in Groundwater. Critical Reviews in Environmental Control, Vol. 19, No. 3. pp 231-249.

Tideman, et al. 1987. Responses of fecal coliform in streamwater to four grazing strategies. J. Range management, Vol. 40. pp 322-329.

Tomales Bay Shellfish Technical Advisory Committee, Tomales Bay Shellfish Technical Advisory Committee, Final Report. 2001

Tomales Bay Shellfish Technical Advisory Committee. Investigation of Nonpoint Pollution Sources Impacting Shellfish Growing Areas in Tomales Bay. Prepared by the State Water Resources Control Board, California Dept. of Health Services and the

California Regional Water Quality Control Board, San Francisco Bay Region. Final report. February 2001.

U.S. Food and Drug Administration. 1995. Harvesting, Handling and Shipping Shellfish, Section B. National Shellfish Sanitation Program Manual: Part 2.

U.S. Food and Drug Administration. 1997. Guide for the Control of Molluscan Shellfish. Model Ordinance. National Shellfish and Sanitation Program.

United States Environmental Protection Agency. 1991. Guidance for Water-Quality-based Decisions: The TMDL Process. USEPA, Washington D.C.

US Department of the Interior, Point Reyes National Seashore, Guidelines for Protection and Use of Tomales Bay. August 2001.