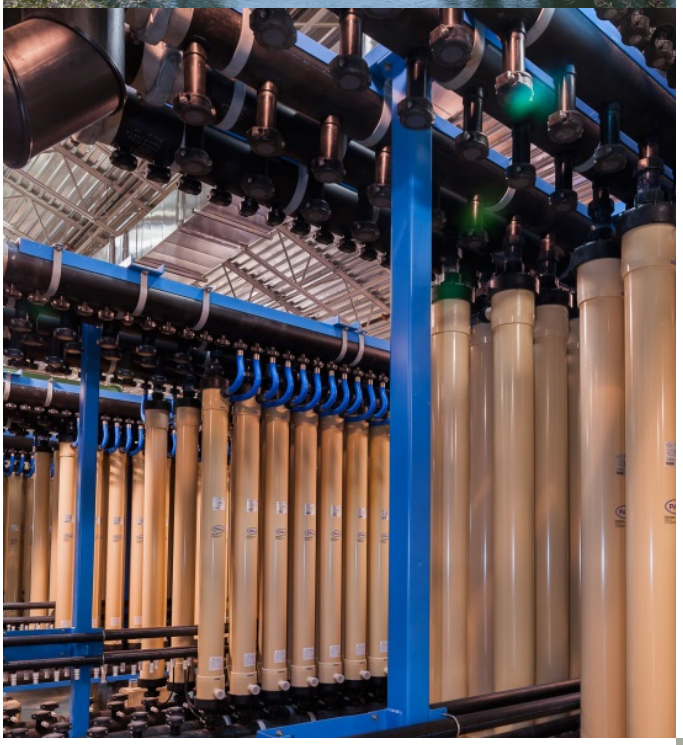

LOWER MOKELUMNE RIVER WATERSHED SANITARY SURVEY

Prepared for the City of Lodi's Surface Water Treatment Facility

Lodi, CA

October 2, 2015

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Table of Contents

Executive Summary 1
Background 1
City of Lodi Water Supply System 1
Contributing Watersheds 1
Significant Potential Contaminant Sources and Source Water Quality Recommendations 2
Invasive Species 3
1 Introduction 5
1.1 Background 5
1.2 Objectives 6
1.3 Conduct of the Study 6
1.4 Report Content and Organization 7
2 Watershed Study Area and Water Supply System 9
2.1 Watershed Sanitary Survey Study Area Description 9
2.1.1 Watershed Hydrology 9
2.1.2 Geology and Ecology 13
2.1.3 Land Use 14
2.1.4 River Use 15
2.2 Upper Mokelumne River Watershed Summary 16
2.2.1 Upper Mokelumne River Watershed Description 16
2.2.2 Summary of the 2011 Upper Mokelumne River Watershed Sanitary Survey 20
2.3 Water Supply System for the Lower Mokelumne River Watershed 21
2.3.1 Surface Water Treatment Facility Description 21
2.3.2 Description of Technology 25
2.3.3 Emergency Response Plans 26
2.3.4 Water Quality Complaints 28
3 Potential Contaminant Sources 29
3.1 Wastewater 29
3.1.1 Water Quality Concerns 29
3.2 Septic Tanks 31
3.2.1 Water Quality Concerns 31
3.2.2 Watershed Management 31
3.3 Reclaimed Water 32

3.3.1 Water Quality Concerns 33
3.3.2 Watershed Management 33
3.4 Urban and Industrial Runoff 33
3.4.1 Water Quality Concerns 33
3.4.2 Watershed Management 33
3.5 Agriculture 36
3.5.1 Water Quality Concerns 37
3.5.2 Watershed Management 37
3.6 Grazing Animals & Confined Animal Facilities 38
3.6.1 Water Quality Concerns 39
3.6.2 Watershed Management 39
3.7 Wild Animals 41
3.7.1 Water Quality Concerns 41
3.7.2 Watershed Management 42
3.8 Mine Runoff 42
3.8.1 Water Quality Concerns 43
3.8.2 Watershed Management 43
3.9 Recreation 44
3.9.1 Water Quality Concern 45
3.10 Solid and Hazardous Waste Disposal Facilities 48
3.10.1 Water Quality Concern 49
3.10.2 Watershed Management 49
3.11 Unauthorized Activity 50
3.11.1 Water Quality Concerns 50
3.11.2 Watershed Management 51
3.12 Hazardous Materials Spills and Traffic Accidents 54
3.12.1 Water Quality Concerns 54
3.12.2 Watershed Management 54
3.13 Geologic Hazards 55
3.13.1 Water Quality Concerns 55
3.13.2 Watershed Management 55
3.14 Fires 56
3.14.1 Water Quality Concerns 57
3.14.2 Watershed Management 57

3.15 Invasive Species ... 58
3.15.1 Water Quality Concerns ... 61
3.15.2 Watershed Management ... 61
3.16 Anticipated Growth within the Watershed ... 62
3.17 Watershed Protection Regulatory Update ... 62
3.17.1 Clean Water Act Section 303(d) List and TMDL Development ... 63
3.17.2 Watershed Management Initiative ... 64
3.17.3 Regulation of Point Sources of Potential Contaminants ... 64
3.17.4 Regulation of Non-Point Sources of Potential Contaminants ... 65
3.18 Summary of Potential Contaminant Sources ... 66
4 Water Quality ... 69
4.1 Regulatory Overview ... 69
4.1.1 Federal Regulations ... 69
4.1.2 State Regulations ... 72
4.2 Constituents of Concern to Water Purveyors ... 73
4.2.1 Microbiological Water Quality ... 73
4.2.2 Disinfectants and Disinfection By-Products ... 75
4.2.3 Chemical Contaminants ... 76
4.2.4 Emerging Contaminants ... 76
4.3 Mokelumne River Flow Data ... 79
4.4 Review of Water Quality Data ... 82
4.4.1 Description of Sample Locations ... 83
4.4.2 Summaries of Water Quality Data ... 87
4.4.3 Analysis of Raw Water Constituents ... 95
4.4.4 Summaries of Water Quality Data ... 110
4.5 Summary of Raw Water Quality ... 115
5 Conclusions ... 117
Urban Runoff and Industrial Runoff ... 117
Agriculture ... 117
Grazing Animals & Concentrated Animal Facilities ... 117
Wild Animals ... 118
Mine Runoff ... 118
Recreational Use ... 119
Unauthorized Activity ... 119

Invasive Species 119
Completion of Recommendations from 2010 Watershed Sanitary Survey 120
6 Recommendations 121
7 References 123
8 Limitations 127

List of Tables

Table 2.1. Average Monthly Precipitation in Lodi, California, 2010 - 2015 13
Table 2.2. Populations in the Lower Mokelumne River Waterhsed 15
Table 2.3. Potential contaminant Sources in the Upper Mokelumne River Watershed 20
Table 2.4. SWTF Membrane System Design Criteria 25
Table 2.5 Number of Water Quality Complaints by Constituent, 2012-2015 28
Table 3.1. List of Facilities with NPDES Permits to Discharge to Mokelumne River 31
Table 3.2. Samples in Exceedence of Local Health Standards 42
Table 3.3. Solid Waste Facilities in the Watershed 49
Table 3.4. Summary of Spills that Entered Surface Water in the Watershed, 2011 - 2015 55
Table 3.5. Summary of Fires in the Watershed and in Amador and Calaveras Counties, 2011 – 2015 56
Table 3.6. Summary of Contaminant Sources and their Potential to Impact Drinking Water Quality ... 66
Table 4.1. Summary of Federal Water Quality Regulations 70
Table 4.2. Summary of California Water Quality Regulations 72
Table 4.3. California SWTR Reduction Requirements for Giardia and Viruses 74
Table 4.4. US EPA LT2ESTWR Bin Assignment for Cryptosoridium Reduction Requirements 75
Table 4.5. US EPA Stage 1 and 2 D/DBP Rules Disinfectants and Disinfection By-product Limits 76
Table 4.6. US EPA UCMR 3 Monitoring List 78
Table 4.7. Water Sampling Overview 83
Table 4.8. Summary of Water Quality Data at the WID Intake, 2010 - 2014 87
Table 4.9. Summary of Storm Drain Detective Data 89
Table 4.10. Annual Organic, inorganic, and Metals Data, WID Intake 2013-2014 90
Table 4.11. Average E. coli Concentrations by Year 101
Table 4.12. Average Cryptosporidium and Giardia Concentrations in Raw Water, 2007, 2010, 2010-2012 104
Table 4.13. Summary of Water Quality Data at the WID Intake, 2010 - 2014 110

Table 4.14. Summary of Storm Drain Detective Data 113
Table 4.15. Summary of Water Quality Data 115
Table 5.1. Updated of 2010 Watershed Sanitary Survey Recommendations 120

List of Figures

Figure 2.1. Lower Mokelumne River Watershed 10
Figure 2.2. Daily Discharge from the WID Canal, 2007 - 2014 12
Figure 2.3. Upper Mokelumne River Watershed 18
Figure 2.4. Camanche and Pardee Reservoir 19
Figure 2.5. Location of SWTF and Pump Station 22
Figure 2.6. Location of SWTF Functions 23
Figure 2.7. Flow Schematic of the City's Surface Water Treatment Facility 24
Figure 3.1. Sanitary Sewer Overflows in the Watershed, 2010 - 2015 31
Figure 3.2. Location of the Clements Rock Plant 44
Figure 3.3. Quagga and Zebra Mussel Sightings in California, 2007 – 2014 60
Figure 4.1. Mokelumne River Flows Below Camanche Dam, 2011-2014 80
Figure 4.2. Flows Below the Woodbridge Dam, January 2011 - September 2014 81
Figure 4.3. Flows in the WID Canal, February 2014 - September 2014 81
Figure 4.4. Total Monthly Precipitation in Lodi, California, 2010 – 2015 82
Figure 4.5. Location of Public Works Department Sampling Sites 84
Figure 4.6. Map of Storm Drain Detective Sampling Sites 85
Figure 4.7. Raw Water Temperatures at WID Intake, 2010 – 2012 95
Figure 4.8. Raw Water Alkalinity at WID Intake, 2011 – 2014 96
Figure 4.9. Raw and Finished Water Turbidity Fluctuations at WID Intake, 2010-2014 97
Figure 4.10. Precipitation and Turbidity Below WID Dam, 2007-2015 98
Figure 4.11. Total Coliform Counts at WID Intake, by Year, 2010 – 2014 99
Figure 4.12. Monthly Average Total Coliform and Precipitation at WID Intake, 2013 - 2014 100
Figure 4.13. Seasonal E. Coli Counts and Water Temperature at the WID Intake, 2010-2012 102
Figure 4.14. Monthly Precipitation and E. Coli Averages at the WID Intake, 2010-2014 103
Figure 4.15. Total Coliform and E. coli Counts, 2013 – 2014 104
Figure 4.16. Total Dissolved Solids Concentrations at Storm Drain Sites, 2007 - 2015 105
Figure 4.17. Total Organic Carbon at WID Intake, 2010-2014 106

Figure 4.18. Finished and Raw Water Total Organic Carbon Monthly Averages, 2013-2014 107
Figure 4.19. Dissolved Oxygen Concentrations at Storm Drain Sites, 2007 - 2014 108

List of Photos

Photo 3.1. Vineyards near Lodi 37
Photo 3.2. Location of Cattle Grazing Entry to Mokelumne River 40
Photo 3.3. Geese near Lodi Lake 41
Photo 3.4. Swimming Beach Closed at Lodi Lake 46
Photo 3.5. Motorized Vehicle Exits Lodi Lake Using the Boat Ramp 47
Photo 3.6. Homeless Encampment under CA-99 Bridge 50
Photo 3.7. Trash at the CA-99 Homeless Camp 52
Photo 3.8. Closed RV Dump Station Near Lodi Lake 53

List of Appendices

A HDR Field Survey Information
B NPDES Discharge Permits
C 2012 Watershed Owner's Manual
D 2010 Lodi General Plan (Excerpt)
E The Mokelumne Current
F The Basin Plan
G National and Statewide Maximum Contaminant Levels
H Complete Data Sets
I Standard Operating Procedure #011

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List of Acronyms

AF	Acre-feet
ACH	Aluminum chlorohydrate
BMP	Best management practice
BTEX	Benzene, toluene, ethylbenzene, xylene
CAF	Confined animal facility
CalRecycle	CA Department of Resource, Recycle, and Recovery
CAP	Cryptosporidium Action Plan
CDFG	CA Department of Fish and Game
CDFW	CA Department of Fish and Wildlife
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
cfs	Cubic feet per second
CIP	Cleaning-in-place
City	City of Lodi
CCL	Contaminant Candidate List
CCR	CA Title 22 Code of Regulations
CIP	Cleaning-in-place
CM	Control measure
County	San Joaquin County
CVRWQCB	Central Valley Regional Water Quality
D/DBP	Disinfectants/ Disinfection Byproducts
DLR	Detection Limit for Reporting
DOC	Dissolved organic carbon
DPB	Disinfection byproduct
EBMUD	East Bay Municipal Utility District
EFM	Enhanced flux membrane
EPA	Environmental Protection Agency
HAA	Haloacetic acid
hp	Horsepower
HVAC	Heating, ventilation, and air conditioning
ICR	Information collection rule
IT	Integrity test
LRAA	Local running annual average
LMRWSPC	Lower Mokelumne River Watershed Stewardship Plan Committee
LPRD	Lodi Parks and Recreation Department
LT1ESWTR	Long Term 1 Enhanced Surface Water Treatment Rule
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
LWWTF	Lockeford Wastewater Treatment Facility
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
mgd	Million gallons per day
mg/L	Milligram per liter

µg/L	Micrograms per liter
µS/cm	MicroSiemens per centimeter
mL	Milliliter
MPN/100mL	Most probable number per 100 milliliters
MRDL	Maximum residual disinfection levels
MS4	Municipal separate storm sewer system
MTBE	Methyl tert-butyl ether
MTL	Moore-Twining Laboratory
NDMA	N-Nitrosodimethylamine
ng/L	Nanograms per liter
NL	Notification level
NOM	Natural organic matter
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	Nephelometric turbidity unit
OEHHA	Office of Environmental Health & Hazard Assessment
OWTS	Onsite Wastewater Treatment System
PHG	Public health goal
PWD	Public works department
PWS	Public water system
RTCR	Revised total coliform rule
SCADA	Supervisory control and data acquisition
SDD	Storm drains detectives
SDWA	Safe drinking water act
SJCEH	San Joaquin County Environmental Health
SJCOES	San Joaquin County Office of Emergency Services
SJCP	San Joaquin County Parks
SJCRCD	San Joaquin County Resource Conservation District
SSO	Sanitary sewer overflow
SVOC	Semi-volatile organic compound
SWIS	Solid Waste Information System
SWRCB	State Water Resources Control Board
SWTF	Surface Water Treatment Facility
SWTR	Surface Water Treatment Rule
TDS	Total dissolved solids
THM	Trihalomenthane
TMDL	Total maximum daily load
TOC	Total organic carbon
TON	Threshold odor number
UCANR	University of California Department of Agriculture and Natural Resources
UCMR	Unregulated contaminant monitoring rule
UMRWA	Upper Mokelumne River Water Authority
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture

USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Department of the Interior Fish and Wildlife Services
USGS	U.S. Geological Survey
VOCs	Volatile organic compounds
WID	Woodbridge Irrigation District
WWTF	Wastewater treatment facility

Executive Summary

This report presents the findings of a watershed sanitary survey conducted on the Lower Mokelumne River for the City of Lodi's (City's) Surface Water Treatment Facility (SWTF). The SWTF is part of a conjunctive use program that integrates surface water and groundwater supplies to serve the City.

Background

The California Surface Water Treatment Rule (SWTR) requires that all domestic water suppliers using surface water conduct a watershed sanitary survey of their watersheds, and to update that survey every five years thereafter. The survey is required to evaluate potential contaminant sources within the watershed that may impact drinking water quality. The City of Lodi completed its initial Watershed Sanitary Survey for the Lower Mokelumne River Watershed in July 2010. The City's surface water supply source continues to be the Mokelumne River.

City of Lodi Water Supply System

On November 26, 2012, the City of Lodi initiated the treatment of surface water at its SWTF and its distribution to customers in Lodi. The plant's current rated capacity is 10 MGD. The water supply source is the Mokelumne River, which flows from tributaries in the Sierra Nevada Mountains to the Sacramento-San Joaquin River Delta. Generally, the Upper Mokelumne River is the segment of the Mokelumne from the original tributaries in the Sierra Nevada Mountains to the Camanche Dam in the foothills, and the Lower Mokelumne River is the segment of the Mokelumne River from the Camanche Dam to its convergence with the San Joaquin River. The SWTF diverts water just upstream of the Woodbridge Irrigation District (WID) Dam in Lodi at the WID Canal. Under an agreement between WID and the City of Lodi in 2003, portions of the flows from the 431,000 acre-foot Camanche Reservoir are allotted to WID and the City of Lodi. The WID Dam impounds the most of the year, creating Lodi Lake just upstream and allowing water to flow in the WID Canal.

Contributing Watersheds

The surface water supply source is the Lower Mokelumne River and the approximately 80 square mile watershed that drains into the river. The Camanche Reservoir, which is at the base of the Upper Mokelumne River Watershed, is the primary source of water for the Lower Mokelumne River. The surface water quality in the Camanche Reservoir is considered to be excellent. Recent watershed sanitary surveys prepared for the Upper Mokelumne River Watershed are summarized in Section 2. The other significant tributary to the Lower Mokelumne River in the watershed is Murphy Creek, which flows into the Mokelumne River just downstream of the Camanche Dam.

Land use in the watershed is primarily agricultural. The City of Lodi is the only incorporated city in the watershed, and has significant urban and industrial land use, with a population of more than 60,000. There are six unincorporated towns and communities in the watershed, with populations ranging from approximately 300-4,000.

Significant Potential Contaminant Sources and Source Water Quality Recommendations

The 29.6 mile segment of the Lower Mokelumne River is managed by East Bay Municipal Utilities District (EBMUD), San Joaquin County, and the City of Lodi. Several municipal, state, and federal agencies are responsible for maintaining water quality and controlling potential contaminant sources. Significant contaminant sources identified in this sanitary survey update include urban and industrial runoff, agriculture, wildlife, grazing, mine runoff, and recreation.

The City of Lodi has significant urban and industrial land use. Due to its population, it is regulated for stormwater runoff under Phase II of the National Pollutant Discharge Elimination Service (NPDES). The City created a Storm Water Management Plan to cater the NPDES regulations to the City. Included in the plan are goals to engage in public outreach and education, control construction site runoff, and detect illicit discharge.

Agriculture is the predominant land use in the watershed. Agriculture can contribute excess nutrients, pesticides, herbicides, and sediment into the water if improper management practices are used. In water sampling and testing conducted in 2013 and 2014, the data does not suggest that pesticides and herbicides are significantly impacting water quality.

Wildlife is present throughout the watershed. Animals can contribute to erosion and to microbial contamination in the water. Total coliform and E. coli bacteria data collected from 2010-2014 suggest that wildlife may have a significant impact on the water quality at the SWTF intake. The population of geese in Lodi Lake may have a particular impact because their feces can directly enter the water supply just upstream of the intake.

There are several pastures, farms, and ranches in the watershed that raise farm animals, primarily cattle. If grazing animals enter or come near to surface water, they can contribute to erosion and to bacterial contamination of the surface water. There are two identified locations where cattle are known to encroach on the Mokelumne River in the watershed while grazing. In addition to total coliform and E. coli, primary indicators include Giardia, Cryptosporidium, and turbidity. Cryptosporidium levels in the Mokelumne River at the WID Canal are low, which places water at the SWTF intake to be classified in highest water quality bin for Cryptosporidium treatment. There is no current benchmark for Giardia in surface waters.

There are many abandoned mines in the Upper Mokelumne River Watershed. Metal loads from these mines can drift downstream into the Lower Mokelumne River, contributing to contamination downstream. The Clean Water Action Section 303(d) lists 29 miles of the Lower Mokelumne River as impaired for copper and zinc. Historically, acid leakage from the Penn Mine contributed high loads of copper and zinc to the river; since 1999, the mine has been sealed, preventing acid from leaking. All metals, excluding iron, have concentrations in the raw water below their maximum contaminant limits (MCLs), including copper and zinc. The metals can be further removed through pre-oxidation at the SWTF.

Recreation is permitted along the Mokelumne River and in Lodi Lake. Popular activities include kayaking, rafting, swimming, hiking, camping, and fishing. Boating is also permitted at Lodi Lake

at low speeds. Recreation can also contribute to coliform and E. coli counts in the water. The high levels of bacterial content in the watershed have led to consistent beach closures in Lodi Lake during the summer months. Gasoline from boating has not appeared to significantly impact water quality, as volatile organic compounds (VOCs) such as benzene were found in concentrations lower than their detection limit. The SWTF should continue to monitor VOC concentrations in the surface water when a second boat launch is constructed in December 2015.

Invasive Species

To date, no invasive mussel species have been found in the Mokelumne River or the Camanche Reservoir. However, the potential for these species to become introduced remains a concern. EBMUD owns and operates the Camanche Reservoir, and has proactive inspection and education programs to prevent invasive mussel species from entering the water. Mussel prevention programs are currently limited at Lodi Lake. However, because boating is popular, the City of Lodi should consider initiating a mussel prevention program similar to EBMUD's program.

Recommendations

The following recommendations are the result of the Lower Mokelumne River Watershed Sanitary Survey:

1. Continue to monitor turbidity levels and concentrations of total organic carbon (TOC), pathogens, and pesticides along the Mokelumne River.
2. Increase understanding of potential sources of bacterial and other contamination by monitoring water quality at the WID intake, Lodi Lake beach, and at a point near cattle grazing activities, as well as after annual lake refilling activities.
3. Perform annual sampling for pesticides and herbicides during periods of application in the watershed.
4. Continue to use the Storm Drain Detective program to monitor for activities that may impact water quality.
5. Collaborate with the Lodi Parks Department on development of a comprehensive invasive species program including mussel prevention focused on education and stewardship.
6. Increase awareness of potential water quality impacts in the vicinity of homeless encampments by working with the City's homeless task force, Caltrans, and other agencies.
7. Collaborate with the Lodi Parks Department to mitigate the goose problem at Lodi Lake.
8. Follow LT2ESWTR monitoring plan and complete monthly sampling of Cryptosporidium and related constituents over a two year period at the WID Intake beginning October 2015.

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1 Introduction

This 2015 Watershed Sanitary Survey of the Lower Mokelumne River Watershed is prepared for the City to fulfill the requirement to conduct a survey every five years, per the Surface Water Treatment Rule. Water quality analysis is focused primarily on the Lower Mokelumne River (Hydro Unit 531.200).

1.1 Background

Source water protection is the first and foremost barrier required for inclusion in a well-developed protection and treatment plan for public drinking water supplies. A comprehensive source water protection program can prevent contaminants from entering the public water supply, reduce treatment costs, and increase public confidence in the quality, reliability, and safety of drinking water supplies. Developing and implementing source protection includes an assessment of potential sources of contamination in the watershed.

The California Department of Public Health submitted 1996 Amendments to the Safe Drinking Water Act's (SDWA) Surface Water Treatment Rule (SWTR), requiring watershed sanitary surveys and watershed management plans for surface water supplies qualifying for filtration avoidance. The State of California Title 22, Code of Regulations (CCR), Article 7, Section 64665, requires all water suppliers to conduct a sanitary survey of their watersheds at least once every five years. The purpose of the SWTR is to provide the general public a level of protection by identifying surface water contaminants and their potential sources within the watershed. Constituents of interest include turbidity, bacteria, viruses, metals, organics, and inorganics that may impact drinking water quality. The City operates a SWTF that provides drinking water to its residents, and is therefore required to conduct a watershed sanitary survey.

In 2010, HDR Engineering, Inc. (HDR) conducted the City's first watershed sanitary survey for its proposed SWTF. The 10 MGD SWTF has been in operation since November 26, 2012, providing the City a secure, reliable supplemental supply of water to meet future water supply needs while reducing its dependence on groundwater. To achieve this goal, the City contracted with WID in May 2003 to purchase 6,000 acre-feet (AF) per year of WID's pre-1914 Mokelumne River water entitlement for a period of 40 years (City of Lodi and WID, 2003). In 2014, the SWTF provided 1,437 MGD of treated water to the water supply system.

The water supply watershed for the SWTF covers an area of approximately 80 square miles in San Joaquin County. The watershed's primary hydrologic feature is the Lower Mokelumne River, which flows 29.6 miles from the base of the Camanche Dam to the WID Dam in Lodi. The surrounding landscape in the watershed includes several parks and recreational areas, urban and industrial land, and agricultural land. The 2015 Watershed Sanitary Survey assesses how land use and its corresponding activity impact the water quality at the SWTF's intake at the WID Dam.

1.2 Objectives

The objectives of this Watershed Sanitary Survey are to:

- Meet the SWTR requirements for a watershed sanitary survey;
- Evaluate potential contaminant sources within the Lower Mokelumne River Watershed that may impact the quality of the source water;
- Consider contaminant source management in the watershed;
- Analyze water quality data available at the intake;
- Compare trends in contaminant sources and water quality data to the survey conducted in 2010; and
- Recommend controls and management practices to protect drinking water quality within the watershed.

1.3 Conduct of the Study

HDR conducted the 2015 Watershed Sanitary Survey for the City's SWTF. The literature survey consisted of reports, maps, and public agency documents from government agencies, laboratories, and other stakeholders in the watershed.

The scope for the City of Lodi's Watershed Sanitary Survey is limited to Lower Mokelumne River Watershed between Camanche Dam and the WID Dam. Relevant findings from the EBMUD 2011 Watershed Sanitary Survey for the Upper Mokelumne River are briefly summarized in this report to provide water quality data and potential contaminant sources upstream of the Lower Mokelumne River. Results from the City's 2010 Watershed Sanitary Survey are also included in this report to compare water quality and source information over time.

Water quality data sources used in this report include:

- Water quality sampling conducted by the City Public Works Department (PWD) at the WID Intake in 2006-2007 and 2010-2014;
- Storm Drain Detective (SDD) water quality sampling, conducted by students and volunteers at several storm drain sites located along the Mokelumne River in 2007-2015;
- Laboratory test results sampled by the City and conducted by Moore-Twining Labs (MTL) for samples collected at the WID Intake in Jan 2013 and 2014;
- University of California Agriculture & Natural Resources (UCANR) precipitation data from 2007-2015 for the City of Lodi; and
- United States Geological Survey (USGS) streamflow data at the WID Intake.

On June 23, 2015, HDR staff conducted a field survey of the watershed along the Mokelumne River. The field survey started at the SWTF and proceeded approximately 10 miles toward the Camanche Dam. See Appendix A for the route and stops taken during the field survey. Observed watershed characteristics from this field study supplement the analysis provided in this report.

1.4 Report Content and Organization

The content and organization of this Watershed Sanitary Survey is consistent with the format recommended in the California Code of Regulations, Title 22, Chapter 1, Section 64665. The report is organized according to the following sections:

Section 1	Introduction	Identification of the study's objectives and conduct.
Section 2	Watershed Study Area and Water Supply System	Discussion of the watershed's land use, geography, hydrology, land ownership, and the City of Lodi water supply system.
Section 3	Potential Contaminant Sources	Description of all significant sources of contamination in the watershed and their management.
Section 4	Water Quality	Assessment of existing water quality data at the SWTF intake and in the Lower Mokelumne River.
Section 5	Conclusions	Summary of information and key findings from the sanitary survey.
Section 6	Recommendations	Recommendations of best management practices to the City of Lodi.

A complete list of references used in the preparation of this Watershed Sanitary Survey is included at the end of this report.

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2 Watershed Study Area and Water Supply System

The primary focus of this section is to define and describe the study area for the Watershed Sanitary Survey. The Upper Mokelumne Watershed Sanitary Survey, conducted by EBMUD in 2011, is summarized with special attention to water quality data and potential source contaminants. The Lower Mokelumne River water supply system and the City of Lodi's Surface Water Treatment Facility are also described.

2.1 Watershed Sanitary Survey Study Area Description

The Lower Mokelumne River Watershed is the study area of interest for this Watershed Sanitary Survey. The watershed encompasses 82.3 square miles across three counties in Central California in the following proportions:

- San Joaquin County, 96.4% (79.36 square miles)
- Amador County, 2.4% (1.96 square miles)
- Sacramento County, 1.2% (1.08 square miles)

Generally, the Mokelumne River is broken up into two sections. The Upper Mokelumne River is fed by an extensive network of tributaries in the Sierra Nevada Mountains and flows through the Pardee Reservoir to the Camanche Reservoir. The Lower Mokelumne River exits the Camanche Reservoir at the Camanche Dam, and is a primary tributary to the San Joaquin River, which ultimately feeds into the Sacramento-San Joaquin River Delta.

The Lower Mokelumne River is the primary hydrologic feature of the watershed in this sanitary survey. The 29.6-mile stretch of the Lower Mokelumne River from the Camanche Dam to the WID Dam in Lodi is the section of the river in the Lower Mokelumne River Watershed that is considered in this Watershed Sanitary Survey.

2.1.1 Watershed Hydrology

The primary source of flow for the Lower Mokelumne River is the Camanche Dam. Downstream of the Camanche Dam, major tributaries to the Lower Mokelumne River include Murphy Creek and Jahant Slough. Murphy Creek traverses Amador and San Joaquin counties entering the Mokelumne River below Camanche Dam. Jahant Slough is located 5.5 miles northwest of Lodi and empties into the Mokelumne River below Woodbridge, and therefore, is not considered in this sanitary survey. Figure 2-1 shows a map of the Lower Mokelumne River Watershed that is included in this Watershed Sanitary Survey.

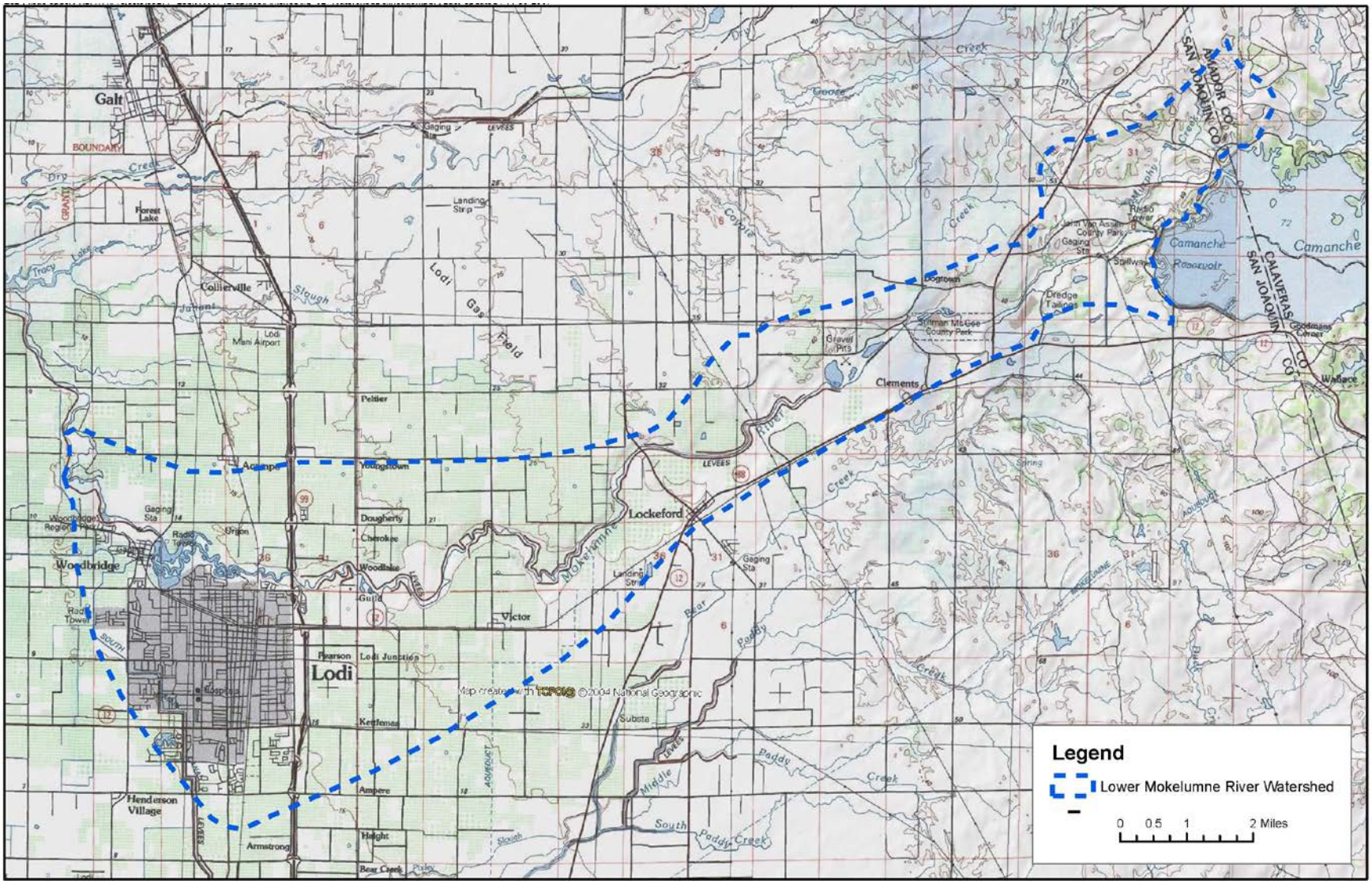

Figure 2-1. Lower Mokelumne River Watershed

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EBMUD operates the Camanche Dam and regulates the flows entering the Lower Mokelumne River. Controlled releases from Camanche Dam provide sustained flows in the river throughout the year, ranging from approximately 120 to 3,200 MGD. Under the 2003 Agreement between WID and the City of Lodi, the diversion of WID water from the Mokelumne River is permitted from March 1 through October 15. In April 2009, WID and EBMUD signed a supplementary agreement allowing the City of Lodi to utilize the water year-round. From March 1 through October 15, the City will receive 5,000 AF; and from October 16 through the end of February, the City will receive 1,000 AF. This will be accomplished by EBMUD releasing additional water during the winter months from Camanche Reservoir and increasing flow in the Lower Mokelumne River.

USGS maintains flow records for the Lower Mokelumne River at Station No. 11325000, located at the WID Canal. The gage, operating since 1926, is at the end of a steel footbridge, on the right bank, 300 feet downstream of the point of diversion from Lodi Lake. Figure 2-2 shows discharge from the WID Canal in 2007-2014.

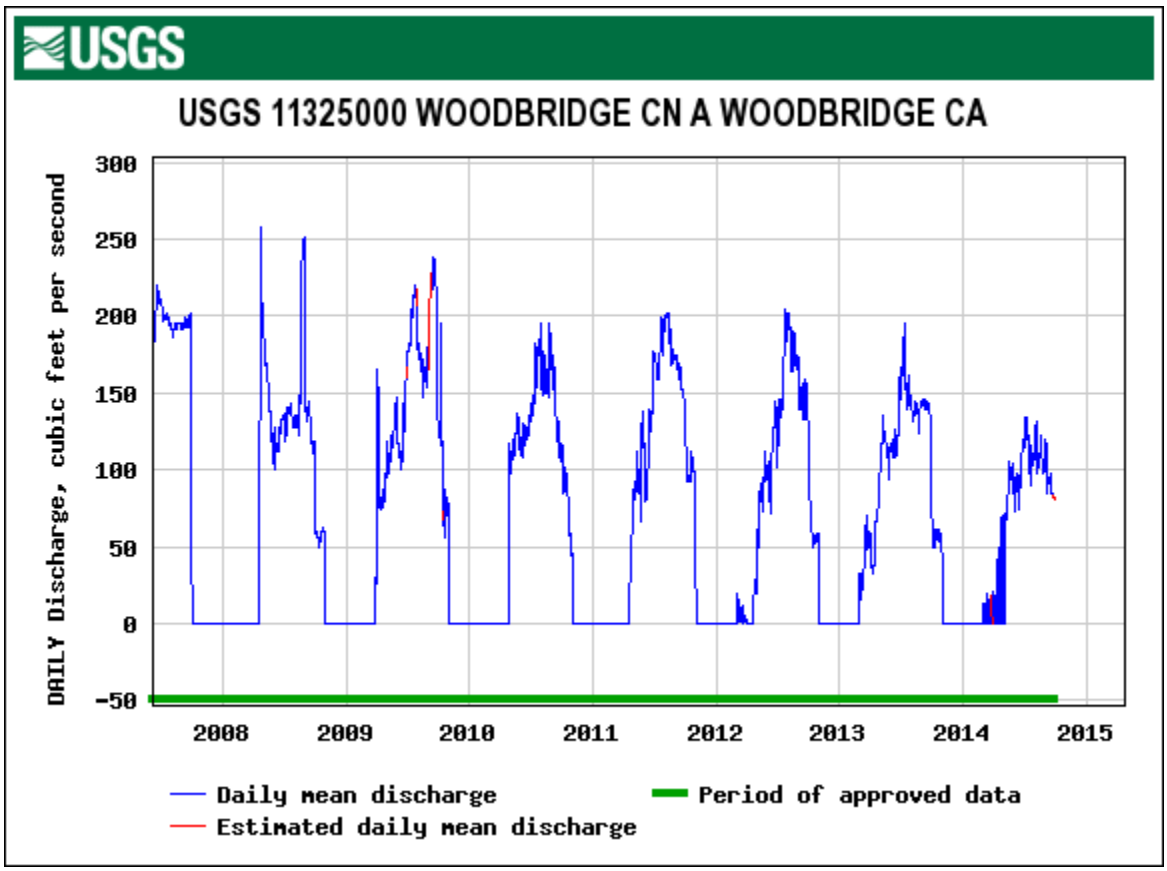

Figure 2-2. Daily Discharge from the WID Canal, 2007 - 2014

Historically, there were no recorded flows through the canal from October to March. Lodi Lake and the canal were emptied and dry during this time of the year. However, since operation of the SWTF started, WID now plans to maintain flows into the canal for approximately 11 months

per year. WID will use four to six weeks per year in the month of February to clean, maintain, and repair the canal and its related infrastructure, including the fish screens at the inlet.

The climate in the watershed is characterized by hot, dry summers and mild, wet winters. Nearly all precipitation in the watershed falls as rain. The average maximum summer temperature is about 93 DegF and the average minimum winter temperature is 37 DegF. Precipitation occurs primarily between November and April when 88 percent of the average rainfall is received. Annual rainfall averages typically range from 10 to 18 inches in the region. Monthly precipitation data from 2010-2015 is summarized in Table 2.1. The watershed has experienced unusually low precipitation in recent years due to the statewide drought in California.

Table 2.1. Average Monthly Precipitation in Lodi, California, 2010 - 2015

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Avg. Prec. (in)	1.63	2.55	2.37	1.34	0.31	0.23	0	0	0.19	0.89	2.48	3.96	15.96

University of California Agriculture & Natural Resources, 2015

2.1.2 Geology and Ecology

The Lower Mokelumne River begins below Camanche Dam where the elevation is 92 feet above sea level and extends westward to the Sacramento-San Joaquin Delta, which is at sea level. Average channel gradients range from 0.10 percent in the upper five miles below Camanche Dam, to 0.02 percent near the Mokelumne Rivers confluence with the Cosumnes River. At the WID Dam, the elevation is 38 feet above sea level (Merz and Setka, 2004).

The Lower Mokelumne River flows through floodplains and alluvial fan-deposit soils of the Valdez-Columbia and Hanford-Greenfield associations, which are both sandy-loams with good to poor drainage characteristics. Tailings from abandoned gravel mining operations are frequent along the upper third of the Lower Mokelumne River. Although many of the tailings are isolated from the river by berms and levees, several large pit are now incorporated into the main river channel (Merz and Setka, 2004).

Prominent rock outcrops associated with the Mehrten Formation are found along the Lower Mokelumne River. The Mehrten formation consists of Andesitic conglomerates, sandstone, and breccias near Camanche Dam and mostly alluvium, levee and channel deposits downstream into the Delta. The alluvium is mostly Pleistocene and stems from volcanic, granitic, sedimentary, and metamorphic rock sources. The surface geology of the areas consists of one geologic belt, the Victor alluvial plain that extends westward from near Camanche Dam. Deposits in the Victor alluvial plain consist of unconsolidated sands, silts, and gravels of the Victor formation and recent alluvium. These sediments exhibit a relatively high permeability. The Victor alluvial plain comprises most of the heavily cultivated and irrigated land in the area. Channel substrates in the Lower Mokelumne River range from large gravels and cobbles in the upper six miles below Camanche Dam to sand, mud, sandstone, and highly compacted alluvium further downstream (Wheaton, 2008).

The Camanche Dam is located at the base of the foothills of the Sierra Nevada Mountains. The watershed is primarily located in the Sierra Nevada foothills and the flat, grassy plains in the Central Valley. Riparian vegetation is found along both banks of the Lower Mokelumne River corridor. Overstory species are tall and include cottonwoods (*Populus fremontii*), valley oaks (*Quercus lobata*), and black walnuts (*Juglans hindsii*) in a mixed stand. Box elder (*Acer negundo* var. *californicum*), willow (*Salix* sp.), alder (*Alnus rhombifolia*), and Oregon ash (*Fraxinus latifolia*) are present in a second canopy layer. Grape (*Vitus californica*) and blackberry vines (*Rubus* sp.) drape the overstory. Groundcover species include horsetails (*Equisetum laveigatum*), nightshade (*Solanum* sp.), and lambs quarters (*Cenopodium album*) (Wheaton, 2008).

Wildlife, like livestock, has the potential to move nutrients closer to waterbodies, pass along microorganisms, and increase erosion. Mammalian wildlife along the Mokelumne River includes black-tailed deer (*Odocoileus hemionus columbianus*) that use riparian woodlands for cover. Common furbearer species are also found in this area including skunk, raccoon, long-tailed weasel (*Mustela frenata*), badger, opossum (*Didelphis* sp.), beaver (*Castor canadensis*), river otter (*Lontra canadensis*), muskrat (*Ondatra zibethicus*), mink (*Neovison vison*), gray fox (*Urocyon cinereoargenteus*), and black-tailed jackrabbit (*Lepus californicus*). Bobcat (*Lynx rufus*) and coyote (*Canis latrans*) potentially occur in the area, and various small rodents are also present.

At least 35 fish species occur in the Lower Mokelumne River including prickly sculpin (*Cottus asper*), Sacramento sucker (*Catostomus occidentalis*, and two anadromous salmonids, steelhead (*Oncorhynchus mykiss*) and fall-run Chinook salmon (*Oncorhynchus tshawytscha*). Both salmonid populations are supplemented by fish reared in the Mokelumne River Hatchery or imported from the Feather River and Nimbus hatcheries (American River). Abundant nonnative fish species include western mosquitofish (*Gambusia affinis*), golden shiner (*Notemigonus crysoleucas*), and spotted bass (*Micropterus punctulatus*) (Merz and Setka, 2004).

2.1.3 Land Use

The Lower Mokelumne River flows through a mix of agricultural, recreational, urbanized, and industrial land. The City of Lodi is the only incorporated city in the watershed. Other communities and unincorporated rural areas in the watershed include Acampo, Clements, Dogtown, Lockeford, Victor, and Woodbridge. Their populations are listed in Table 2.2.

The primary highways that run through the watershed are CA-12, CA-99, and CA-88. CA-99 is a major freeway that travels north-south through the watershed and features a bridge that crosses the Lower Mokelumne River. CA-12 lies on the southwest outskirts of the watershed. CA-88 parallels several miles of the Mokelumne River.

Table 2.2. Populations in the Lower Mokelumne River Waterhsed

City or Town	2010 Census
Acampo	341
Clements	892
Dogtown	2,506
Lockeford	3,233
Lodi	62,134
Victor	293
Woodbridge	3,984

Population data compiled by 2010 U.S. Census Bureau

Lodi is located at the western edge of the watershed at the intersection of CA-12 and CA-99. Being the most populous and only incorporated city in the watershed, most of the developed urban and industrial land in the watershed lies in Lodi. From 2010-2013, Lodi experienced a 1.9 percent population increase (U.S. Census Bureau). Within the city limits, about 50 percent of the land is residential, 21 percent commercial or industrial, and 1 percent is agriculture (Lodi General Plan, 2010). Most of the open land that does exist in the city limits lies along the Lower Mokelumne River. The eastern edge beyond CA-99 is the predominant industrial zone, which expands to the edge of the Lower Mokelumne River. Lodi has several parks, a golf course, a transit center, and several schools. Woodbridge lies on the northwest edge of Lodi, and is a predominantly residential community.

The other unincorporated towns are predominantly rural agricultural communities. Acampo is north of Lodi across the Mokelumne River. Clements, Dogtown, and Lockeford lie close to the river along CA-88, east of Lodi. Victor lies on CA-12 and is also adjacent to the river. Of the rural communities, Lockeford has a relatively prominent downtown area with several businesses.

Agriculture predominates watershed land usage outside the Lodi city limits and other town centers. The Lower Mokelumne River Watershed Stewardship Planning Committee (LMRWSPC) estimates agricultural land use is approximately broken down in the following proportions: 51 percent vineyard, 31 percent dairy/grazing, 9 percent orchard, 8 percent annual cropland, and 1 percent idle (LMRWSPC, 2002).

2.1.4 River Use

The Mokelumne River is a water source for drinking water and irrigation by water districts and agencies. The WID Canal diverges water from the Mokelumne River about one-quarter mile upstream of the WID Dam. This diverted water supplies irrigation for agriculture in the surrounding farmlands as well as drinking water for the City's SWTF. In the watershed, jurisdiction over the Lower Mokelumne River is split between several entities including the City of Lodi, San Joaquin County, and EBMUD.

Historically, the Mokelumne River's water quality was highly impacted by mining activity following the discovery of gold in 1848 and copper in 1861 in the foothills. Gold mining in the Mokelumne River watershed peaked in 1854, and declined steadily thereafter. Copper was

mined heavily from 1899-1919. Mine effluent discharged into the river eliminated all downstream aquatic life in 1943 and 1944. 29 miles of the Lower Mokelumne River, from Camanche Reservoir toward the Sacramento-San Joaquin Delta have been identified as a Water Quality Limited Segment under Section 303(d) of the Clean Water Act, which establishes more stringent effluent water quality requirements than are otherwise stated in the Clean Water Act. Pollutants identified on the California 303(d) list as impairing the Mokelumne River include copper and zinc. The presence of these metals is linked to the abandoned Penn Mine in the Upper Mokelumne watershed, on the southeastern shore of the Camanche Reservoir. The Camanche Dam Power House separation/retention pond also discharges to the Lower Mokelumne River and sends these metals downstream.

At the Camanche Dam, EBMUD has two facilities that discharge into the Lower Mokelumne River. The Camanche Dam Power House discharges treated industrial wastewater—drainage, washdown, and leakage waters containing lubricating oil and other petroleum products—into the Mokelumne River downstream of Camanche Dam. Additionally, the Mokelumne River Fish Hatchery also discharges into the Mokelumne River at the base of the Camanche Dam. It annually produces 4.5 million fall-run Chinook salmon and 100,000 steelhead trout. The hatchery is owned by EBMUD and operated by the California Department of Fish and Game.

The Lower Mokelumne River has limited public access points for visitors to engage in aquatic recreation. They include Lodi Lake Regional Park, Mokelumne Beach RV Park, Stillman Magee Park, and the Mokelumne River Day Use Area. Residents with property along the river also have private access to the river. However, the river is an underutilized recreational resource with little public access because the majority of land along the river is privately owned and prohibits trespassers (LMRWSPC, 2002). From the public access points, the Lower Mokelumne River affords recreational activities that include boating, kayaking, swimming, paddle boarding, fishing, hiking, and bird watching. Lodi Lake Regional Park hosts a boat launch, from which motorized boats can travel up the Mokelumne River at speeds under five mph. Many of these recreational areas operate from approximately April until September.

2.2 Upper Mokelumne River Watershed Summary

2.2.1 Upper Mokelumne River Watershed Description

Upstream of the Lower Mokelumne River Watershed is the Upper Mokelumne River Watershed. The area covered by this watershed includes an extensive network of tributaries that feed into two reservoirs, Pardee and Camanche. The Upper Mokelumne River is the primary flow source that connects the watershed. This watershed provides drinking water for more than 1.3 million customers primarily in the San Francisco Bay Area. The Upper Mokelumne River Water Authority (UMRWA), a Joint Powers Authority, comprises six water agencies and three counties that perform water resource planning for the watershed. EBMUD, a member of UMRWA, prepared the Upper Mokelumne River Watershed Sanitary Survey in 2006 and 2011.

The Upper Mokelumne River Watershed comprises 378 square miles in the foothills and the mountains of the Sierra Nevada Mountain Range. The watershed consists primarily of open space and forestland with large tracts of designated wilderness and small concentrations of

residential developments. The land in the Upper Mokelumne River Watershed is more sparsely populated than the Lower Mokelumne River Watershed. Figure 2-3 and Figure 2-4 show a map of the Upper Mokelumne River Watershed and the Camanche and Pardee Reservoir respectively.

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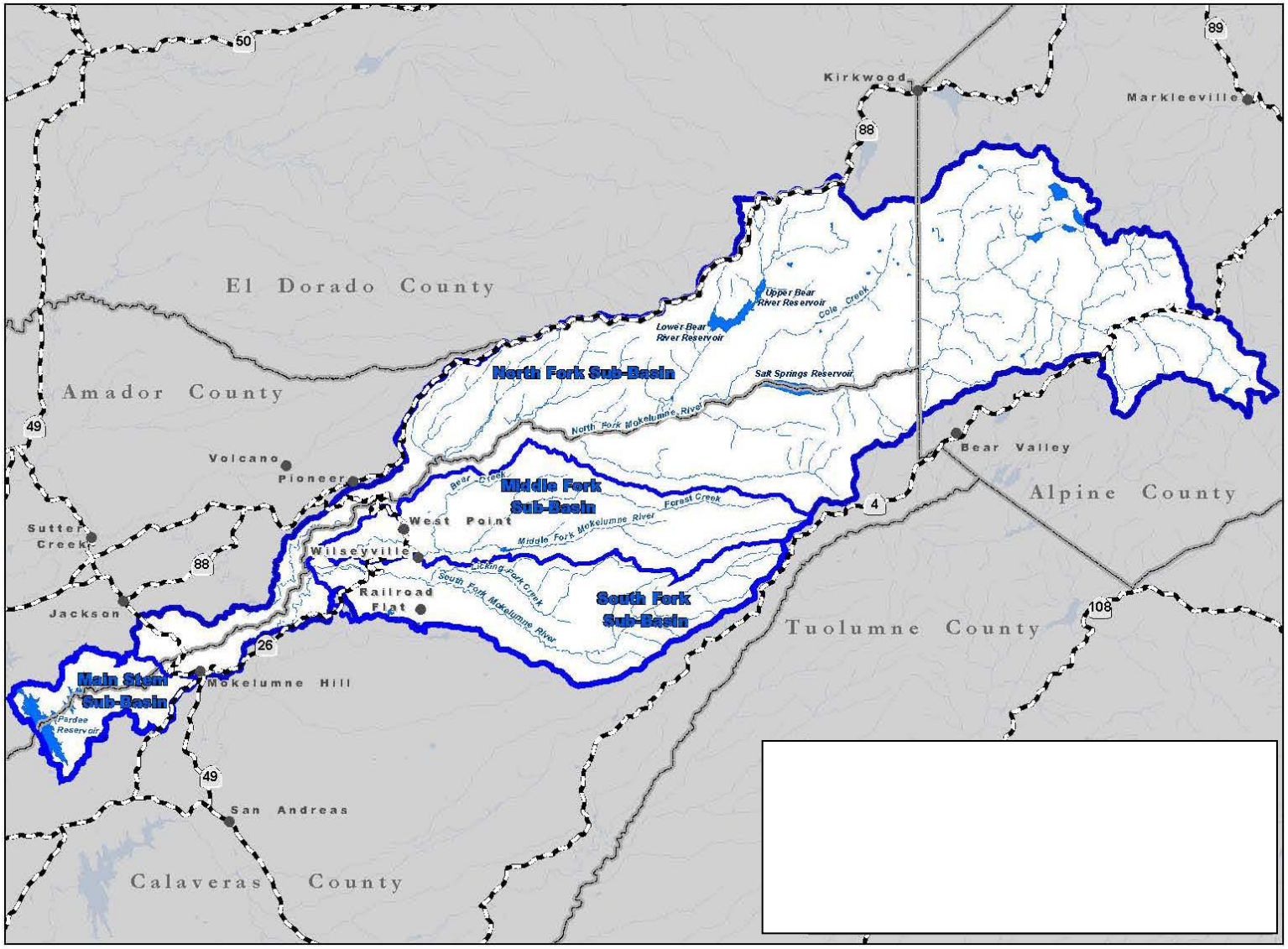
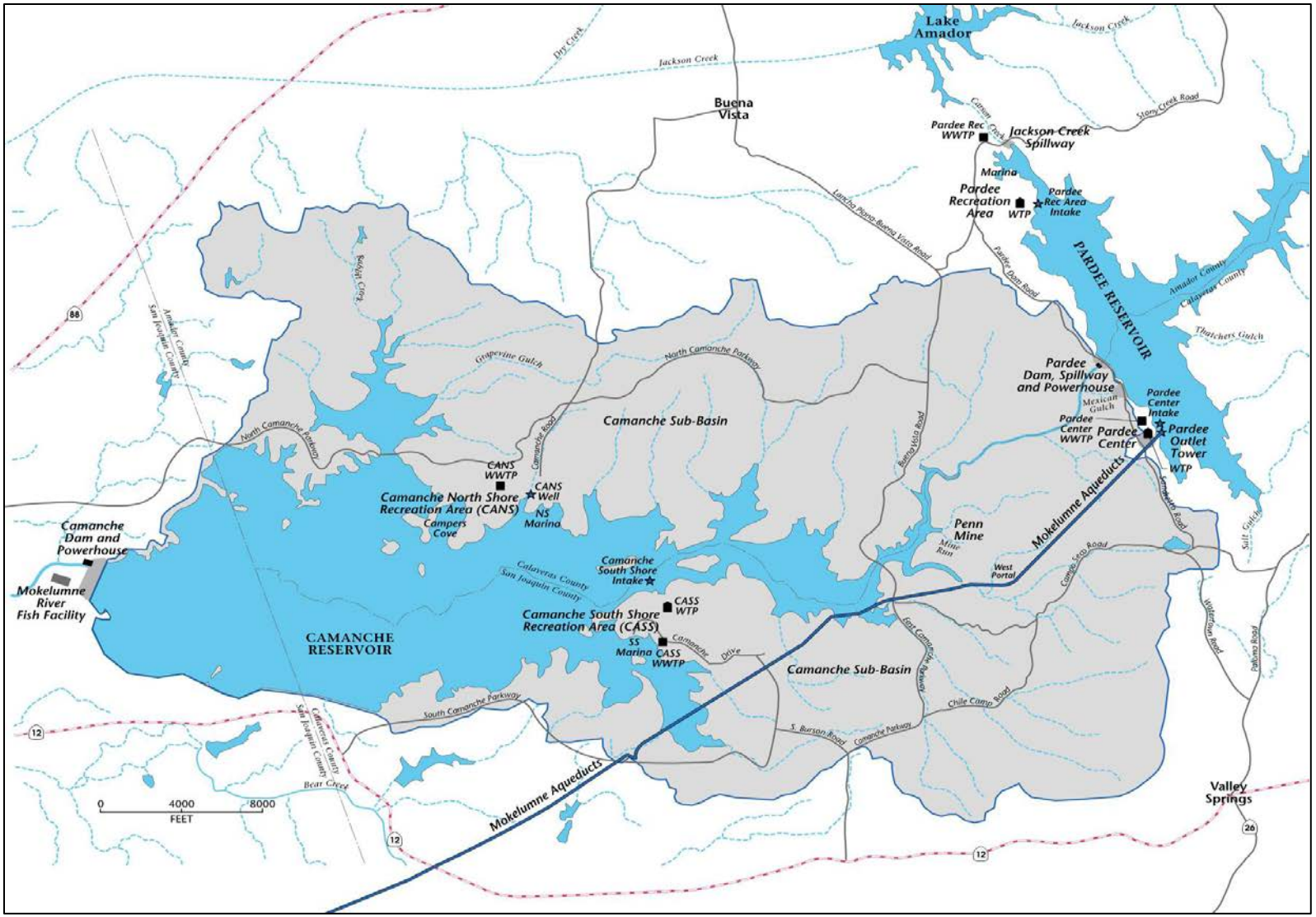


Figure 2-3. Upper Mokelumne River Watershed



From EBMUD's 2011 Watershed Sanitary Survey

Figure 2-4. Camanche and Pardee Reservoir

2.2.2 Summary of the 2011 Upper Mokelumne River Watershed Sanitary Survey

In the 2011 report, EBMUD claimed that the raw water exhibited excellent water quality characteristics (EBMUD, 2011). Water quality data was taken at both the Pardee and Camanche Reservoirs. The raw water had turbidity and coliform levels that exceeded MCLs for treated drinking water. All organic and radioactive chemicals had concentrations below the detection limit for reporting (DLRs). Of the metals, aluminum exceeded primary and secondary drinking water MCLs, and iron and manganese exceeded secondary MCLs. After treatment, all constituents in the raw water had concentrations lower than their respective MCLs.

Potential contaminant sources and their potential to impact water quality are summarized in Table 2.3. It is noted that the contaminant sources with the highest potential impact on water quality have been identified as fire and fuels management, geologic hazards, grazing, district facilities, recreation, mines, and logging. The watershed has experienced major fires in the past that have been hazardous to water quality. Recreation in the form of hiking, swimming, boating, and other aquatic activities has remained popular in the reservoirs and in the Upper Mokelumne River. Noncompliance with grazing plans has potential to cause erosion in the watershed, potentially impacting water quality.

Table 2.3. Potential contaminant Sources in the Upper Mokelumne River Watershed

Contaminant Source	Potential to Impact Drinking Water Quality
Fires and Fuel Management	Medium to High
Geologic Hazards	Medium to High
Wildlife and Livestock	Medium to High
EBMUD Facilities	Medium to High
Recreation	Medium to High
Mines	Medium to High
Logging	Medium to High
Hydroelectric Power Generation	Low to High
Residential Rural Area Runoff	Low to High
Sanitation Facilities	Low to High
Transportation Corridors	Low to Medium
Illegal Dumping and Unauthorized Activities	Low to Medium
Agriculture	Insignificant

Summary of Contaminant Sources and Their Impact on Water Quality, EBMUD Water Sanitary Survey, 2011

In its Watershed Sanitary Survey, EBMUD identified several watershed management and control practices that will limit the impact of the potential contaminant sources on water quality in the watershed, including:

- Controlled human access to sensitive watershed land, e.g., motor vehicles restricted to designated roads and trails;
- Limited recreational space in the Camanche Reservoir;
- Protected reservoir shorelines to prevent erosion;

- Increased construction of fire roads; and
- Increased installation of fences to keep livestock from sensitive watershed locations.

EBMUD plans to submit the next survey for the Upper Mokelumne River Watershed in 2016.

2.3 Water Supply System for the Lower Mokelumne River Watershed

Prior to construction of the SWTF, the City utilized a network of 26 groundwater wells as its sole water supply source to residents and customers. To reduce its groundwater pumping, the City contracted with WID in May 2003 to purchase 6,000 AFY of WID's pre-1914 Mokelumne River water entitlement for a period of 40 years (City of Lodi and WID, 2003). To utilize the purchased water, the City constructed the 10 MGD SWTF utilizing a Pall Microza Microfiltration Model UNA-620A system with the possibility of expanding to 20 MGD in the future.

The treated surface water is blended with reclaimed water at the SWTF to provide about one-third of the drinking water supply for the City of Lodi. Depending on day-to-day water demands, the SWTF will provide 18 to 100 percent of the total delivery to the drinking water system. The remainder of the water supply will be groundwater, supplied by the City's 28 existing wells, which have been improved to meet regulatory requirements.

2.3.1 Surface Water Treatment Facility Description

The SWTF is located at 2001 West Turner Road, Lodi, CA 95242, adjacent to Lodi Lake. The Raw Water Pump Station is located at 1079 East Carolina Street, Lodi, CA 95242, adjacent to the WID Canal where the raw water intake exists.

The location of the SWTF and Pump Stations are shown on Figure 2-5**.**

Figure 2-6 shows the location of the components of the SWTF.

A flow schematic for the SWTF is provided in Figure 2-7, demonstrating the following steps in water treatment at the facility:

1. Raw water from the WID fish screen is pumped through the Raw Water Pump Station to the SWTF.
2. The raw water is blended with the reclaimed water from the reverse filtration system and passes through to the sedimentation basin. A pre-oxidant (sodium hypochlorite) may be added to the raw water. Coagulation and flash mixing follow pre-oxidation based on incoming raw water quality and membrane performance.
3. Water from the sedimentation basin is first pumped through several auto cleaning strainers and then through the Pall Microza Microfiltration Membrane USA-620A units, into the 3.0 million gallon clearwell.
4. Water from the clearwell is disinfected and pumped from the High Service Pump Station to the City of Lodi distribution system.

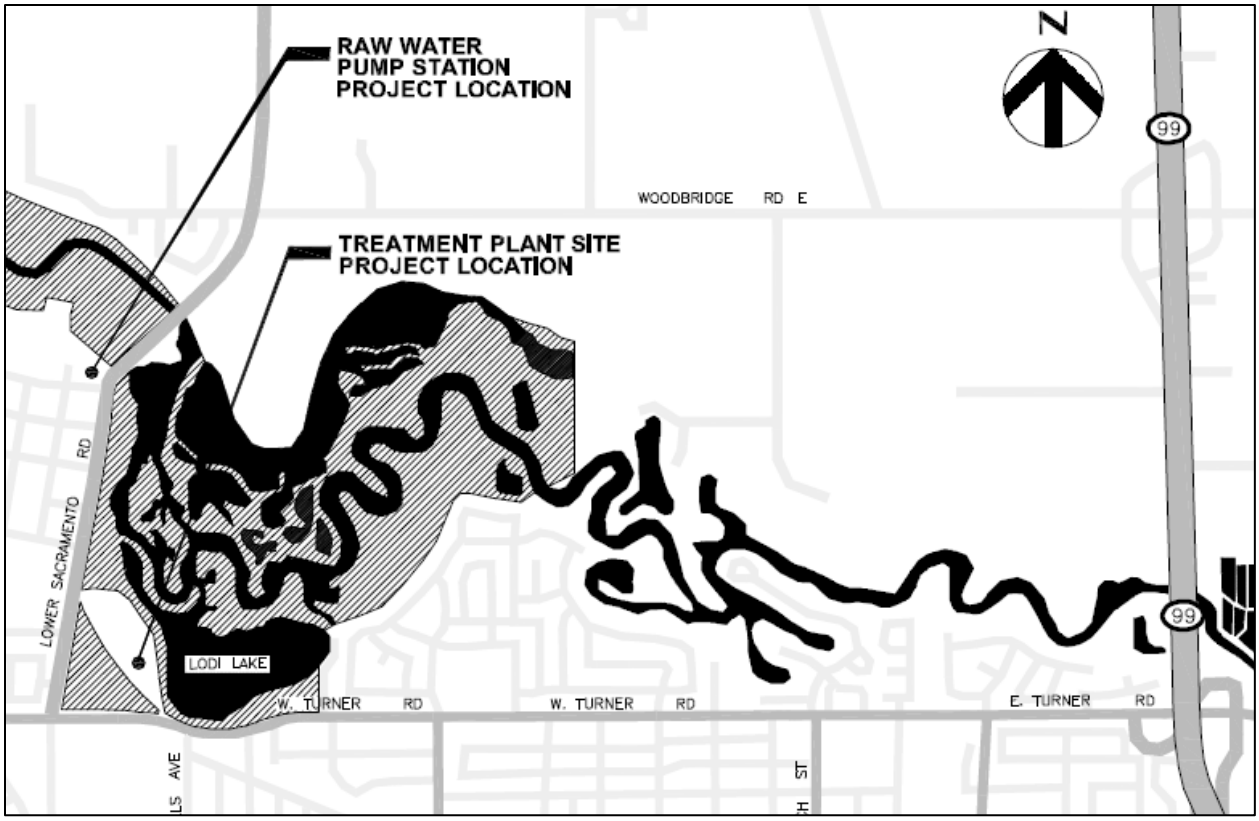


Figure 2-5. Location of SWTF and Pump Station

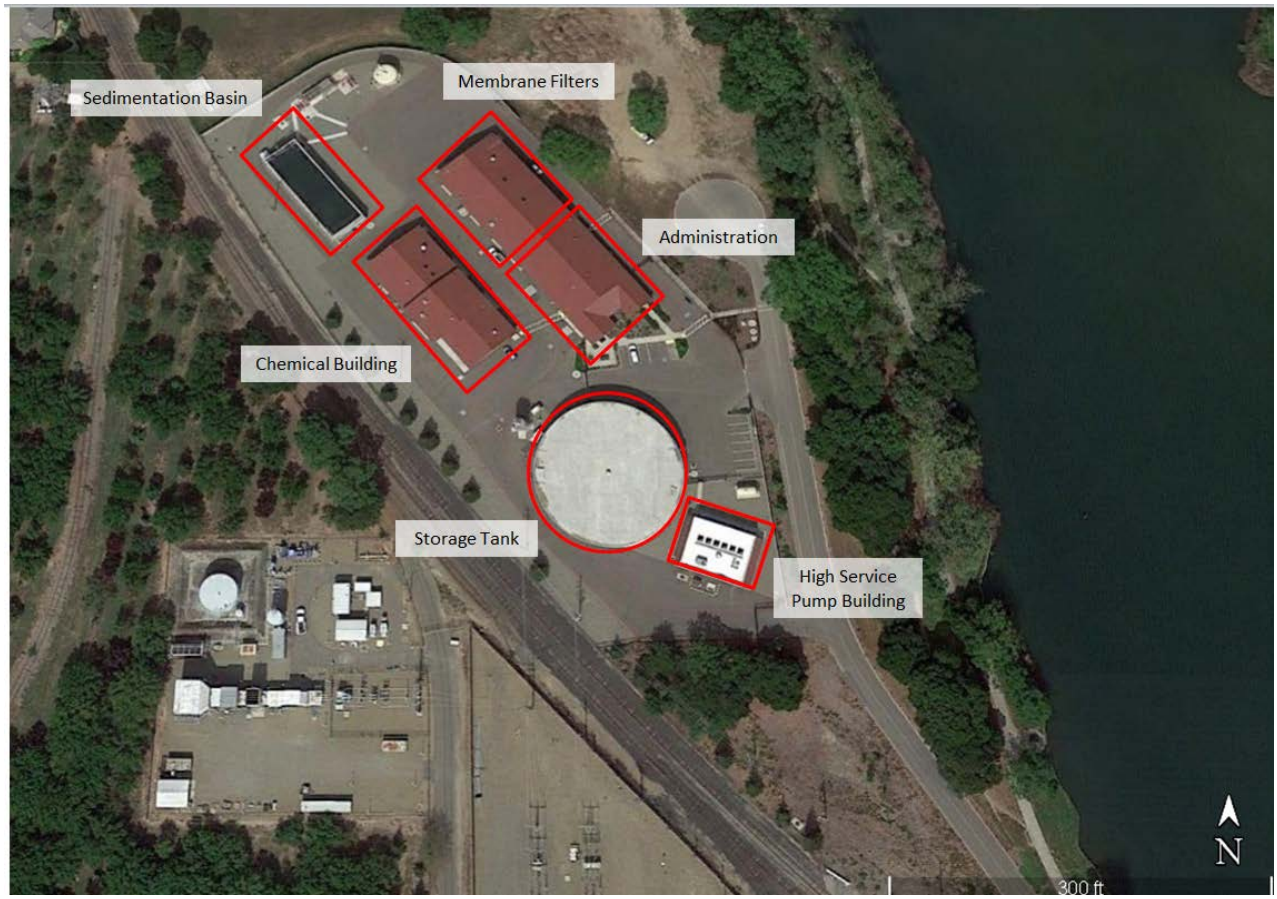


Figure 2-6. Location of SWTF Facilities

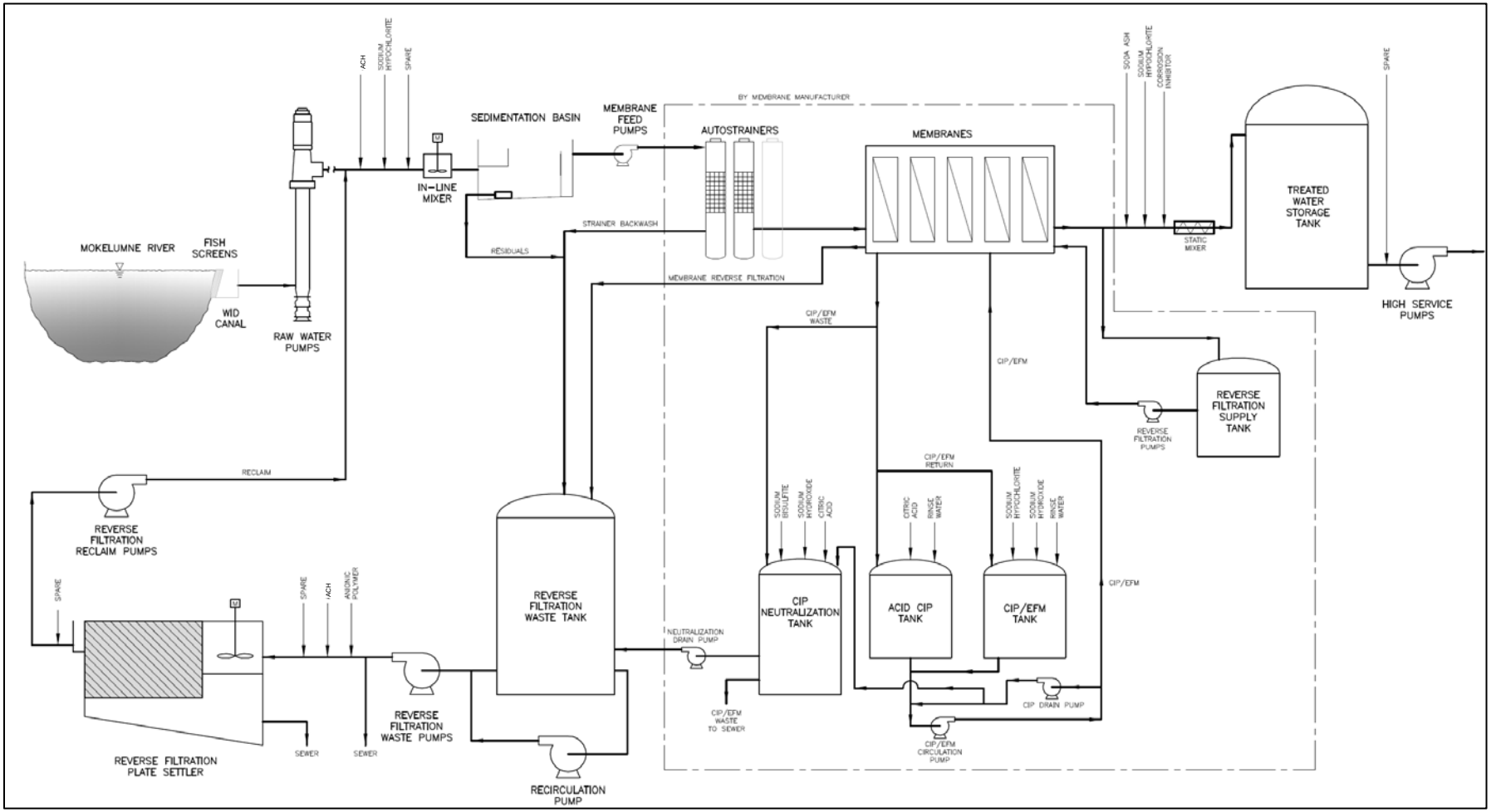


Figure 2-7. Flow Schematic of the City's Surface Water Treatment Facility

2.3.2 Description of Technology

2.3.2.1 INTAKE STRUCTURE

During construction of the WID fish screen structure, a 48-inch pipe was included in the structure to supply surface water to the City. From the 48-inch pipe, a 36-inch raw water pipeline extends to the raw water pump station. From the raw water pump station, a 30-inch discharge pipeline discharges to the SWTF.

2.3.2.2 SEDIMENTATION (GRIT) BASIN

The sedimentation (Grit) basin is approximately 113 feet long by 35 feet wide and can handle 12 mgd at a water depth of 16 feet. The basin is split into three parts: inlet channel, grit basin, and effluent chamber. After being injected with a pre-oxidant, as needed, and coagulant, the raw water enters a two-foot-wide inlet channel that spans the width of the basin. A sludge collector was installed on the basin floor to collect and discharge settled particles directly to the backwash waste tank. The final section of the basin includes an eight-foot wide-effluent chamber that supplies the membrane feed pumps. Initially, the sedimentation basin is intended to remove heavier particles such as fine sand and large particles that may make it through the fish screens. The basin is configured to allow for future installation of flocculators and plate settler packs should full conventional pretreatment be required.

2.3.2.3 MEMBRANE FEED PUMPS

Raw water from the sedimentation basin feeds the centrifugal membrane feed pumps. Three 200-horsepower (hp) pumps were installed (two duty; one standby) each having a capacity of 4,164 gallons per minute (6 mgd) to provide a firm capacity of 12 mgd.

2.3.2.4 AUTOSTRAINERS

Two strainers were installed. Each autostrainer has a screen opening size no greater than 400 microns and is equipped with an automatic cleaning system that operates without the unit being taken out of service.

2.3.2.5 MEMBRANES

The SWTF utilizes a Pall Microza pressure membrane system. The membrane system has a total production capacity of 10 mgd. Five-equally sized trains (2 mgd each) are used to produce 10 mgd. The interval for CIP had been 30 days since start of operation, but was extended to an interval of 45 days beginning in 2015. The design criteria for the membrane system are presented in Table 2.4.

Table 2.4. SWTF Membrane System Design Criteria

Item	Design Criteria
Treatment Capacity, total	**10.0 million gallons per day**
Treatment Capacity, (1 train out of	**8.0 million gallons per day**
Net Capacity, each train	**2.0 million gallons per day**
Number of Trains	**5**
Water Temperature	**15^{0}C summer, 7^{0}C winter**
Instantaneous Flow per Module	**17.5 gallons per minute**

Design Flux	**54 gallons per square foot per day (gfd)**
Backwash Interval	**30 minutes**
CIP Interval	**30 to 60 days**
Chlorine Maintenance Wash Interval	**24 hours**
Acid Maintenance Wash Interval (if	**120 hours**
Estimated Recovery	**95%**
Giardia/Cryptosporidium removal	**4-log**
Virus removal credit	**0.5-log**

2.3.2.6 DISINFECTION

Disinfection is achieved at the SWTF through the addition of sodium hypochlorite. Sodium hypochlorite is generated onsite to produce a 0.8 percent solution for use as the primary disinfectant and to achieve 0.5-log *Giardia* disinfection in the treated water clearwell. Pall Corporation, the membrane manufacturer, also utilizes the onsite generated hypochlorite solution to prepare batch make-up solution for enhanced flux maintenance (EFM) and CIP solutions for the membranes. Additionally, sodium hypochlorite can be added as a pre-oxidant to assist with natural organic matter, iron, and manganese removal (if present). Disinfection at the well sites is accomplished with a 12 percent sodium hypochlorite solution delivered to each well site.

The finished water tank at the SWTF will be a partially buried, prestressed concrete tank. The tank serves as a storage tank for finished water at the SWTF, providing chlorine contact time to inactivate disease-causing organisms and storage of treated water prior to pumping into the City's water distribution system. The 130-foot-diameter tank will store three million gallons of water with three to four feet of free board.

2.3.3 Emergency Response Plans

The City of Lodi's Surface Water Treatment Facility has an emergency response plan for both the water treatment plant and the pump station. The Operations and Maintenance Manual for the SWTF, updated March 2015, contains a comprehensive response plan to follow in case of an emergency. Events that constitute an emergency include fire, floods, earthquake, chemical release, toxic spill, storms, power outages, lightning, construction accidents, and vandalism. This would also include a catastrophic event.

The Emergency Contact Notification List includes municipal, county, and state-level agencies such as the Lodi Police and Fire Departments, the CA Water Resources Control Board, CA EPA, San Joaquin County Office of Emergency Services (SJCOES), and the San Joaquin County Environmental Health (SJCEH). SJCOES initiates an Emergency Alert System to broadcast to residents via radio, television, and online. In case of a fire, hazardous materials spill, or any other incident of contaminant discharge that could pose a threat to public health in the watershed, SJCOES and SJCEH coordinate a response according to their emergency plans.

The quality and integrity of treated water is protected by the plant's instrumentation, alarms, stand-by equipment, and groundwater wells. The main computer monitors pH, chlorine residual, turbidity, and water level at multiple stages in the water treatment process. Readings that fall outside of set parameters trigger alarms to which operators respond with corrective action. Additionally, the need for membrane maintenance is alarmed by either high turbidity in the filter effluent or length of filter run; loss of head; high trans-membrane pressure; or high or low flux. After working hours, alarms call the plant general phone, operator, superintendent, and on-call mechanic.

Equipment failures also trigger alarms. This notifies operators to switch to standby units. Standby chemical feed pumps and booster pumps enable the process to continue while the failed piece of equipment is serviced. The level of each chemical storage tank is monitored to ensure adequate volumes of chemicals are available. "Low" level alarms are sent to the plant computer to alert operators of the need for chemical deliveries.

The plant is capable of treating 8 MGD with one membrane filter train out of service. Additionally, an integrity test (IT) is performed on a regular basis to test the integrity of the filters to ensure that there are no leaks in the membrane fibers. ITs are performed on a regular basis automatically, or at the operators' discretion. Chemical washes are similarly done on a regular basis but are initiated by the operators. Plant operation will not continue without proper chemical washes. These include the Enhanced Flux Maintenance (EFM) and Clean-In-Place (CIP) processes.

A 100-kW standby diesel engine generator will provide electrical power to the SWTF in case of a utility power outage. During a power outage the RWPS will be without power and therefore the SWTF treatment systems will shut down. The standby generator system will only provide back up power to operate the facility lighting, HVAC equipment in the administration area of the Operations Building, and SCADA equipment during power outages. The cooling system is a self-contained radiator with no connection to the water system. Diesel fuel storage is provided in a double walled base tank below the engine generator. The City's wells have sufficient back-up power to supply water to the distribution to meet demands without the need for the SWTF to operate.

Additional standby provisions include standby pumps for the RWPS and high service pump station, membrane system, and all chemical feed systems, i.e., ACH, sodium hypochlorite, soda ash, and corrosion inhibitor. The membrane trains have a capacity of 8 MGD with one train out of service.

The purpose of the Lodi SWTF is to augment the existing groundwater supply of water to the City. However, the groundwater wells can still provide daily demand for treated water for extended periods of time without severely depleting aquifers. Therefore, in the case of an emergency in SWTF operations or water quality in the raw water supply, plant operations will shut down at the SWTF and the groundwater wells will supply the required drinking water demand for the City.

2.3.4 Water Quality Complaints

The City has tracked the number of water quality complaints per constituent from 2012-present, as shown in Table 2.5. Most complaints were observed in summer months when temperature increased and in the vicinity of construction areas where individual service lines and water mains were being replaced as part of a water metering program (Personal Communication, August 2015).

Table 2.5 Number of Water Quality Complaints by Constituent, 2012-2015

Constituent	2012	2013	2014	2015 (through July)
Taste and Odor	15	69	71	13
Color	2	1	0	0
Turbidity	3	1	2	2
Pressure	21	0	1	0
Totals	41	71	74	15

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3 Potential Contaminant Sources

This section contains a brief discussion the potential contaminant sources that exist in the Lower Mokelumne River Watershed, and others that may be upstream in the Upper Mokelumne River Watershed. The potential contaminant sources addressed by this sanitary survey include the following.

1. Wastewater	9. Recreational Use
2. Septic Tanks	10. Solid and Hazardous Waste Disposal Facilities
3. Reclaimed Water	11. Unauthorized Activity
4. Urban Runoff and Industrial Runoff	12. Transportation Corridors and Bridges
5. Agriculture	13. Geologic Hazards
6. Grazing Animals & CAFs	14. Fires
7. Wild Animals	15. Invasive Species
8. Mine Runoff	

For each potential contaminant source, the source location(s) is/are identified, related water quality concerns are identified, and the regulation and management of the potentially contaminating activity are described. The watershed management recommendations regarding these potential contaminant sources are summarized in Section 6.

3.1 Wastewater

Wastewater treatment plant discharges and sanitary sewer overflows (SSOs) can result in contamination of surface water supplies. NPDES permitting allows point source discharges that are managed by the Central Valley Regional Water Quality Control Board (CVRWQCB).

3.1.1 Water Quality Concerns

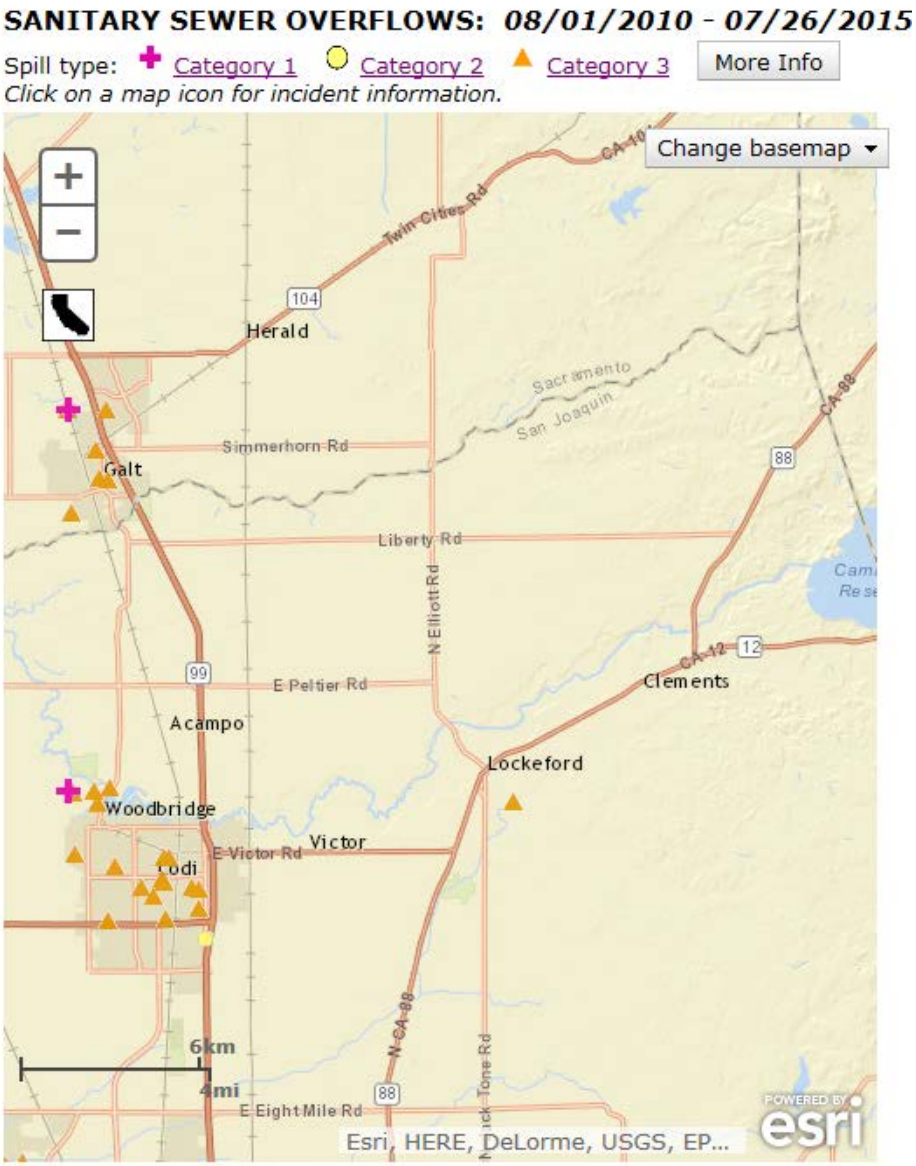
Sanitation facilities collect, treat, and dispose of human waste, and can pose a variety of water quality risks when they fail and also when they are operating properly. Failure of these systems may result in the introduction of disease-causing microorganisms to the raw water supplies, and an increase in the nutrient loading to the watershed. Municipal and industrial sewage effluent can contain synthetic organic chemicals, metals, microorganism, and significant organic matter that contribute to disinfection byproduct production. The key contaminants of concern are pathogenic organisms, nutrients, and oxygen demanding substances.

3.1.1.1 WASTEWATER TREATMENT FACILITIES MANAGEMENT

No wastewater treatment plants are located on the Mokelumne River between Camanche Dam and the City of Lodi. The City's wastewater treatment plant, White Slough Water Pollution Control Facility, is located six miles southwest of the City. The community of Lockeford is served by Lockeford Community Services District, which has a wastewater treatment facility that uses land application to dispose of its effluent. Other unincorporated area around Lodi uses septic systems or is served by the Woodbridge Treatment Plant downstream of the watershed.

3.1.1.2 SANITARY SEWER OVERFLOW MANAGEMENT

The State Water Resources Control Board (SWRCB) provides information regarding recorded SSOs that occur across the state, including in San Joaquin County. From August 2010-July 2015, there were 15 recorded spills in the City of Lodi, Woodbridge, and Lockeford (SWRCB, 2015), inside the watershed. SWRCB assigns a category for each discharge that occurs from an SSO. All 15 recorded SSOs in the watershed fell in Categories 2 and 3, meaning that they did not reach surface water or drainage channels. Figure 3-1 shows SSOs that have occurred in the watershed.



From the State Water Resources Control Board, 2015

Figure 3-1. Sanitary Sewer Overflows in the Watershed, 2010 - 2015

3.1.1.3 DISCHARGER MANAGEMENT

There is currently one organization with an NPDES permit to discharge into the Mokelumne River in the watershed. EBMUD'sCamanche Dam Power House, a previous discharger, elected to discharge up to 20,000 to a evaporation/ percolation pond in 2008 and is no longer permitted to discharge to the Mokelumne River. The discharge practices and total allowable discharges for the NPDES permit holders are summarized in Table 3.1. The NPDES discharge permits are provided in Appendix B.

Table 3.1. List of Facilities with NPDES Permits to Discharge to Mokelumne River

NPDES Permit No.	Order No.	Facility Name	Treated Effluent Discharge Practices	Total Allowable Discharge (GPD)
CA0082040	R5-2008-0071	EBMUD Camanche Dam Power House	Remove petroleum products; reduce and monitor copper discharge concentrations; evaporation/percolation (EP) pond provides storage	20,000 (monthly average discharge to EP pond); 0 to Mokelumne River
CA0004791	R5-2010-0018-017	CA Dept. of Fish & Game, EBMUD River Fish Hatchery	Control flows to Mokelumne River in 3 outfalls: (1) overflow discharge into Mokelumne River; (2) hold water in ponds and raceways; (3) discharge from fish tanks and sand filters	46,000,000

NPDES regulates organizations that can discharge onto land and into water. To regularly discharge effluent, the organization must request an order from the SWRCB. The Stormwater Multiple Applications and Report Tracking System lists 25 stormwater discharge permits in the watershed: 14 construction and six industrial permits in Lodi, one construction and one industrial permit in Lockeford, and one construction and two industrial permits in Acampo.

3.2 Septic Tanks

Rural areas are generally too dispersed to be served by wastewater treatment plants, and instead use septic leach fields or individual septic tank systems. In the unincorporated area outside of Lodi and the city of Lockeford, residents use septic leach fields or individual septic tank systems.

3.2.1 Water Quality Concerns

The contribution of contaminants by properly-operating septic systems may be minimal, but a plugged leachfield or septic tank can send untreated sewage directly into a waterbody or into the groundwater. In household with septic systems, improper disposal of household chemicals including substances containing, metals, pesticides, or herbicides can lead to contamination from the leachfields.

3.2.2 Watershed Management

On June 19, 2012, SWRCB adopted Resolution No. 2012-0032, adopting the OWTS Policy . This Policy establishes a statewide, risk-based, tiered approach for the regulation and

management of OWTS installations and replacements and sets the level of performance and protection expected from OWTS. Septic leach fields or individual septic tank systems are covered under this policy. The OWTS Policy took effect on May 13, 2013.

The regional water quality control boards are required to incorporate the standards established in the OWTS Policy, or standards that are more protective of the environment and public health, into their water quality control plans immediately. Implementation of the OWTS Policy is overseen by SWRCB and the regional water quality control boards. Local agencies have the opportunity to implement local agency management programs if approved by the applicable regional water quality control board. As part of the OWTS policy, the systems can be classified into one of five tiers (Tier 0 – Tier 4, in increasing order of severity):

- **Tier 0: Existing OWTS**. Existing OWTS that are properly functioning, and do not meet the conditions of failing systems or otherwise require corrective action (for example, to prevent groundwater impairment) as specifically described in Tier 4, and are not determined to be contributing to an impairment of surface water as specifically described in Tier 3, are automatically included in Tier 0.
- **Tier 1: Low-Risk New or Replacement OWTS**. New or replacement OWTS that meet low risk siting and design requirements as specified in Tier 1. Systems are considered Tier 1 where there is not an approved Local Agency Management Program per Tier 2.
- **Tier 2: Local Agency Management Program for New or Replacement OWTS**. Local agencies may develop management programs and, upon approval, manage and approve the installation of new and replacement OWTS under that program.
- **Tier 3: Advanced Protection Management Programs for Impaired Areas**. Existing, new, and replacement OWTS that are within 600 feet of listed impaired water bodies must meet the applicable specific requirements of Tier 3, unless they are addressed by a TMDL and its implementation program, or other special provisions contained in a Local Agency Management Program.
- **Tier 4: OWTS Requiring Corrective Action**. OWTS that require corrective action or are either presently failing or fail at any time while this Policy is in effect are automatically included in Tier 4 and must follow the requirements as specified. OWTS included in Tier 4 must continue to meet applicable requirements of Tier 0, 1, 2 or 3 pending completion of corrective action.

The tier classifications provide a consistent systematic means for management by the local agency.

3.3 Reclaimed Water

Reclaimed water is provided for land application by the Lockeford Wastewater Treatment Facility (LWWTF) and the City of Lodi's White Slough Water Pollution Control Facility. While both facilities are outside of the watershed, the reclaimed water may be delivered to land in the watershed.

3.3.1 Water Quality Concerns

Reclaimed water poses concerns to water quality because the effluent is not treated to the same standard as is drinking water. Potential water quality concerns include human pathogens, organic carbon, elevated levels of salinity, and nutrients that stimulate algal growth.

3.3.2 Watershed Management

NPDES permits are issued to allow facilities to provide reclaimed water. LWWTF implemented a Disposal Improvement Project that provides reclaimed water to 133 acres for alfalfa and pasture grass production. Beef cattle are allowed to graze the pasture grass area. The White Slough facility provides reclaimed water to the Northern California Power Agency and San Joaquin County Vector Control District. Additionally, during the agricultural season, the facility provides untreated food processing wastewater blended with secondary treated municipal effluent for irrigation in the agricultural fields.

3.4 Urban and Industrial Runoff

Urban and industrial runoff sources in the Lower Mokelumne River Watershed are generally limited to the City of Lodi and the more densely populated downtown regions in the watershed.

3.4.1 Water Quality Concerns

Urban runoff contains numerous contaminants as a result of vehicle emissions, vehicle maintenance wastes, outdoor washing, outdoor material storage, landscaping chemicals, household hazardous wastes, pet wastes, trash, and other manmade waste sources. Fertilizer usage in urban areas contributes nutrients to urban runoff. Leaves, woody debris, and insects, degrade and release nutrients that are carried to receiving waters. Urban runoff is known to contribute to metal loads in the watershed.

Urban runoff generally contains high levels of coliform bacteria, relative to the levels found in receiving waters. Sources of fecal contamination in urban runoff include domestic and wild animals, in addition to human sources from illegal camping and dumping, illicit connections to the storm drain system, septic system leaks, or sewage spills to the storm drain system. Since fecal coliforms are used as indicators of fecal contamination, their presence indicates that urban runoff carries a significant amount of fecal material into tributaries. The primary impact of fecal contamination on water bodies is the potential presence of pathogens that may be associated with feces. The actual amount of pathogens from urban runoff cannot be extrapolated from indicator organism data.

Industrial runoff tends to provide similar water quality contaminants to surface water as does urban runoff. Typically, contaminants in the runoff depend highly upon the variety of industries in the surrounding area. Some of the contributions of concern include metals, organics, sulfates, nitrates, phosphates, and inorganics.

3.4.2 Watershed Management

Most of the land within the City of Lodi slopes away from the Mokelumne River toward the southwest. Because of the predominant slope to the southwest, most of the City's stormwater enters the WID Canal system past the WID Intake (Jones & Stokes, 1990). Runoff from 4,070 acres in the City of Lodi’s drainage area is pumped into the WID Canal. About 1,340 acres

discharge runoff into the Mokelumne River through gravity lines, and approximately 2,290 acres pump runoff into the Mokelumne River through pipes.

The City of Lodi maintains a gravity-based stormwater system built around a number of stormwater detention basins and disposes of runoff by pumping it to 18 storm outlets on the WID Canals, Lodi Lake, or the Mokelumne River. The detention basins are scattered throughout the City and are maintained as parks and recreational facilities during non-runoff periods.

The City of Lodi is regulated for stormwater runoff under Phase II of the NPDES Program. The City has developed a Stormwater Management Plan to meet the terms of General Permit Number CAS000004, Water Quality Order No. 2003-0005-DWQ issued in 2003. The Draft Waste Discharge Requirements for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (Small MS4), revised and effective July 1, 2013 by the State Water Resources Control Board, outlines the requirements the City must follow.

The guidance requires cities to develop, implement, and enforce a program to ensure controls are in place that will prevent or minimize water quality impacts from stormwater runoff from construction sites. The program applies to all construction projects that disturb sites greater than or equal to one acre (including projects less than one acre that are part of a larger common plan of development or sale that would disturb more than one acre) and that discharges into a Small MS4. At a minimum, cities must:

1. Engage in public education and outreach;
2. Obtain public participation and involvement;
3. Detect and eliminate illicit discharge;
4. Control construction site runoff;
5. Control post-construction runoff; and
6. Prevent pollution and maintain good house keeping.

According to the City's *Stormwater Management Program* (City of Lodi, 2003), in addition to the minimum measures required per the NPDES regulations, the City identified extra control would need to be taken for floatable debris in stormwater. Floatable debris comes from a variety of sources and can cause a variety of problems, such as lowered efficiency and hydraulic capacity, aesthetic degradation of waterways, possible toxic effects to aquatic species, and damage to human health or property. The major source of floatable debris in the City's stormwater system is litter generated from the improper disposal of waste within the drainage area. Litter left in the city has the potential to ultimately enter the Mokelumne River, as one-third of the city drains to the river. The remaining two-thirds of the City drains to WID canals (for which the main outfalls are equipped with trash racks) or Bear Creek. Following the preparation of the *Stormwater Management Program*, the City doubled the frequency of street sweeping. In addition, under the direction of the City's Parks and Recreation Department is the "Clean-A-Curb" program in which elementary and high schools perform curbside clean-ups.

Since 2003, the City of Lodi has focused its efforts on construction site runoff control by educating developers and producing an information flyer on Stormwater Pollution Prevention for construction sites. In addition, in 2004, the City introduced Ordinance No. 1747 amending the City's Municipal Code Title 13 – Public Services – by reenacting Chapter 13.14, Stormwater Management and Discharge Control, relating to stormwater.

Besides the stormwater quality improvement efforts undertaken by the City of Lodi, the Lower Mokelumne River Watershed Stewardship Plan Steering Committee has developed the *2012 Mokelumne River Watershed Owner's Manual* (Appendix C) to educate the public on the impacts of non-point sources of pollution on the river. The manual identifies common sources of pollution and outlines strategies that homeowners can take to minimize their impact. Chapters include: Stormwater Management, Household Wastewater, Managing Household Hazardous Products, and Yard and Garden Care.

The current City of Lodi General Plan (Appendix D), updated in 2010, contains various policies applicable to stormwater management:

- Minimize storm sewer pollution of the Mokelumne River and other waterways by maintaining an effective street sweeping and cleaning program.
- Require, as part of watershed drainage plans, Best Management Practices (BMPs), to reduce pollutants to the maximum extent practicable.
- Require all new development and redevelopment projects to comply with the post-construction BMPs called for in the Stormwater Quality Control Criteria Plan, as outlined in the City's Phase 1 Stormwater NPDES permit issued by the California Water Quality Control Board, Central Valley Region. Require that owners, developers, and/or successors-in-interest to establish a maintenance entity acceptable to the City to provide funding for the operation, maintenance, and replacement costs of all post-construction BMPs.
- Require, as part of the City's Storm Water NPDES Permit and ordinances, the implementation of a Grading Plan, Erosion Control Plan, and Pollution Prevention Plan during the construction of any new development and redevelopment projects, to the maximum extent feasible.
- Require use of stormwater management techniques to improve water quality and reduce impact on municipal water treatment facilities.
- Reduce the use of pesticides, insecticides, herbicides, or other toxic chemical substances by households and farmers by providing education and incentives.

Additional educational efforts include the Storm Drain Detectives program, which brings community volunteers, water professionals, and local high school students together to monitor water quality at storm drains located along the Mokelumne River one to two times monthly. The program was established in 2007 and is still conducting water quality tests along the Mokelumne River. Students from elementary, middle, and high schools in Lodi also work with water quality professionals to produce *The Mokelumne Current*, a newspaper that discusses

water conservation, storm water management, and other water quality issues to protect the Mokelumne River. The newspaper engages students in water quality topics and encourages parents to also consider how their actions may impact water quality in the area. An example of the *Mokelumne Current* is included in Appendix E.

3.5 Agriculture

Agricultural land is the predominant land usage in the Lower Mokelumne River Watershed. Proper water management in the watershed prevents contaminants from seeping into the water supply.

Outside of the City of Lodi and the town centers for the unincorporated communities in the watershed, land is primarily used for agriculture. The approximate percentages for the watershed are (LMRWSPC, 2002):

- Vineyard – 51%
- Grazing – 31%
- Orchard – 9%
- Annual Cropland – 8%
- Idle – 1%

In 2012, approximately 9,555,980 pounds of pesticides were applied to 5,811,110 acres in San Joaquin County (PAN Pesticides Database, 2012). Note that the watershed includes only a portion of San Joaquin County. The top five pesticides used in the watershed are sulfur, mineral oil, 1,2-dichloropropene, copper hydroxide, and glyphosate, isopropylamine salt. Sulfur is the major pesticide used; it is applied as a fungicide against powdery mildew. Sulfur is oxidized by bacteria and becomes sulfate, which does not adversely affect water quality (USGS, 2010).

Pesticide use is categorized by season of application, with application occurring either during the irrigation or dormant season. During the dormant season, pesticides are carried to surface water by storm water runoff. Pesticide residues deposited on trees and on the ground migrate with runoff water during rain events. During the irrigation season, pesticides migrate with irrigation water, and occasionally storm water, from agricultural fields and enter water bodies. During both seasons, localized drift from pesticide applications and atmospheric deposition can also contribute to pesticides being introduced into surface water.

Photo 3-2. Vineyards near Lodi

3.5.1 Water Quality Concerns

Agricultural nonpoint source pollution enters receiving waters by direct runoff to surface waters or seepage to groundwater. Runoff of nutrients can result from excessive application of fertilizers and animal waste to land, and from improper storage of animal waste. Farming activities can cause excessive erosion, which results in sediment entering receiving waters. Improper use and over-application of pesticides and herbicides can result in these contaminants being discharged to adjacent waterways. Chemigation tanks could leak, with the chemical potentially reaching water bodies. Improper grazing management can cause erosion, soil compaction, and excessive nutrients, all of which impair sensitive areas. Over-irrigating can cause runoff of sediments and pesticides to enter surface water or seep into groundwater.

3.5.2 Watershed Management

Programs established to control nonpoint source pollution from agriculture in California include joint efforts by local, state, and federal agencies. The USDA Natural Resources Conservation Service (NRCS) and University of California Cooperative Extension Service provide technical and financial services for farmers. NRCS provides conservation assistance through a nationwide network of resource conservation districts and local service centers. Resource conservation districts also provide guidance, training, and technical assistance.

NRCS works through the local conservation districts and others to help landowners, as well as federal, state, tribal, and local governments, and community groups, conserve natural resources on private land. The NRCS has three strategies to implement their goals of high quality,

productive soils, clean and abundant water, healthy plant and animal communities, clean air, an adequate energy supply, and working farms and ranchlands:

- Cooperative conservation, by seeking and promoting cooperative efforts to achieve conservation goals;
- Watershed approach, by providing information and assistance to encourage and enable locally-led, watershed-scale conservation; and
- Market-based approach, by facilitating the growth of market-based opportunities that encourage the private sector to invest in conservation on private lands.

The SWRCB, the California Coastal Commission, and other state agencies have identified seven management measures to address agricultural nonpoint source pollution of state waters: (1) erosion and sediment control, (2) animal waste, (3) nutrient management, (4) pest and weed management, (5) grazing management, (6) irrigation water management, and (7) groundwater protection. The management measures consist of a suite of plans, practices, technologies, operating methods, or other alternatives that may be used in combination to control nonpoint source pollution. Associated with each management measure are management practices that are designed to reduce the quantities of pollutants entering receiving waters. Many of the practices have been approved for use by NRCS.

The California Department of Pesticide Regulation (CDPR) protects human health and the environment by regulating pesticide sales and use and by fostering reduced-risk pest management. CDPR requires full reporting of all agricultural pesticide use and structural pesticides applied by professional applicators. CDPR works closely with each county's agricultural commissioners, who serve as the primary enforcement agents for state pesticide laws and regulations.

Farmers obtain site-specific permits from their county agricultural commissioner to purchase and use agricultural chemicals. County agricultural commissioners regulate pesticide use to prevent misapplication or drift, and possible contamination of people or the environment. The commissioner evaluates the farmer's permit application to determine whether it is near a sensitive area, such as wetlands, water courses, etc. The county agricultural commissioner may deny a permit or require specific-use practices to mitigate hazards, such as the method of application, time of day, weather conditions, and use of buffer zones. The commissioner decides the need for a particular pesticide and whether a safer pesticide or better method of application can be used and still prove effective. County agricultural commissioner staffs also enforce regulations to protect ground and surface water from pesticide contamination, and work with the SWRCB and Regional Water Quality Control Boards (RWQCBs).

3.6 Grazing Animals & Confined Animal Facilities

Grazing animals and confined animal facilities (CAFs) may contribute to erosion, and can be a source of pathogenic microorganisms, especially if large numbers have access to creeks and reservoirs or if there is considerable runoff from grazing and CAF areas. Unobstructed grazing practices become problematic at a point when livestock congregate in close proximity to or

within creek channels and/or contributing drainages where manure accumulates. The preferable method for mitigating grazing affects is to establish riparian buffer standards, which outline minimum setback requirements.

Agricultural products raised in the watershed also include livestock and poultry. Cattle, both beef and dairy; turkeys; chickens; sheep and other livestock are found in the watershed (LMRWSPC, 2002).

Cattle are primarily raised for beef within the watershed. Rangeland operations are found primarily north of the Mokelumne River in the eastern portion of the watershed. However, cattle operations can be found throughout the watershed with ranches of several hundred heads of cattle. Fewer than 10 dairies are located within the watershed ranging in size from less than 150 and up to 2,100 cows. Turkeys are also raised within the watershed, primarily north of the Mokelumne River. An estimated six turkey ranches are located in the watershed (LMRWSPC, 2002). In a study conducted by the U.S. Department of Agriculture (USDA), the number of farms in San Joaquin County has decreased by about 40 farms from 2007-2012 (Census of Agriculture, 2012). In the same study, the USDA found that the inventory in cattle for San Joaquin County remained stable from 2007-2012 (Census of Agriculture, 2012).

3.6.1 Water Quality Concerns

Livestock grazing in a watershed can be a significant contaminant source due to the potential for the animals to be carriers of *Giardia* and *Cryptosporidium* oocysts. Calves younger than six months appear to be the most likely to shed oocysts; however, all cattle can contribute microbial contaminants to a waterbody when their feces are deposited directly into the water, or when runoff carries feces into the water. Livestock also can increase erosion, causing particulate, turbidity, and disinfection byproduct precursor problems, if they are allowed to overgraze an area and remove the vegetative cover. Direct access of cattle to waterbodies can also contribute to erosion. Common pollutants from dairies include coliform, ammonia, nitrates, total dissolved solids, bacteria, and pathogens.

3.6.2 Watershed Management

Grazing sites in the Lower Mokelumne River Watershed are typically managed through private or county leases. CAFs that exist in the watershed are managed by CVRWQCB. Some grazing sites in the watershed encroach on the Mokelumne River, allowing cattle to enter the river. According to Headwaters Boathouse, a company that leads kayak tours up the Mokelumne River, there are two primary locations where cattle enter the river while grazing (Personal Communication, July 2015). One is across from the Nature Area near Lodi Lake, as seen in the photo in Photo 3-2 below. The other is about 1,500 feet downstream of the Mokelumne River Day Use Area.

Photo 3-1. Location of Cattle Grazing Entry to Mokelumne River

The SWRCB and NRCS programs were established to control nonpoint source pollution from agriculture as discussed. The SWRCB management measures for protecting range, pasture, and other grazing lands are:

- Implementing one or more of the following to protect sensitive areas (such as streambanks, wetlands, estuaries, ponds, lake shores, and riparian zones): (a) exclude livestock, (b) provide stream crossings or hardened access to watering areas, (c) provide alternative drinking water locations away from surface waters, (d) locate salt and additional shade, if needed, away from sensitive areas, or (e) use improved grazing management (e.g., herding) to reduce the physical disturbance and reduce direct loading of animal waste and sediment caused by livestock; and

- Achieving either of the following on all range, pasture, and other grazing lands not addressed under (1) above: (a) implement the range and pasture components of a CMS as defined in the USDA NRCS *Field Office Technical Guides* by applying the progressive planning approach of the USDA NRCS to reduce erosion, or (b) maintain range, pasture, and other grazing lands in accordance with activity plans established by the Bureau of Land Management of the U.S. Department of the Interior or the USDA Forest Service or the California Rangeland Water Quality Management Plan.

The CVRWQCB regulates several types of confined animal operations, including dairies, feedlots, poultry facilities, and horse facilities. Currently, the CAF Program primarily focuses on dairies. Central Valley Water Board staff plan to draft General Waste Discharge Requirements for feedlots and for poultry facilities in the near future.

3.7 Wild Animals

Wildlife, like livestock, has the potential to move nutrients closer to waterbodies, pass along microorganisms, and increase erosion. Mammalian wildlife along the Mokelumne River includes black-tailed deer that use riparian woodlands for cover. Common furbearer species are also found in this area including skunk, raccoon, long-tailed weasel, badger, opossum, beaver, river otter, muskrat, mink, gray fox, and black-tailed jackrabbit. Bobcat and coyote potentially occur in the area, and various small rodents are also present.

There are large flocks of geese residing in Lodi Lake and the adjacent segment of the Mokelumne River, just upstream of the WID Intake to the SWTF. The beach and nearby ground is often littered with goose feces. Fluctuating reservoir levels cause recent droppings to be submerged, and recreational activities stir up fecal matter and release solids into the water above this shallow outcropping. Geese populations can be seen in Photo 3-3.

Photo 3-2. Geese near Lodi Lake

3.7.1 Water Quality Concerns

Wild animals are a potential source of *Giardia*, *Cryptosporidium*, viruses, bacteria and other pathogenic microorganisms. Birds, in particular, can be a significant source of pathogens to water bodies because of the direct nature of their deposits, and tendency to roost in large numbers on water surfaces. Birds are a particular concern if there is a large year round population of waterfowl (as opposed to a migratory bird population), as well as cattle if they are not fenced off from the river.

3.7.2 Watershed Management

Management of wild animals in the watershed occurs through CDFW, county animal control officers, and local recreational area management. The City of Lodi Public Works Department governs Lodi Lake and the surrounding park land within city limits. Due to the increase in geese population, the Public Works Department received a permit to addle goose eggs to limit the goose population in Lodi Lake (Personal Communication, July-August 2015), starting in 2015. Goose addling was performed in spring and summer 2015.. As seen in Photo 3-3, there are still large flocks of geese that reside in Lodi Lake and the surrounding Mokelumne River area.

The Public Works Department is also involved in water quality monitoring at Lodi Lake. Historically, there have been instances of beach closures several occasions per year due to high bacterial content in Lodi Lake (Personal Communication, August 2015). Table 3-2 shows the number of days where health department standards were exceeded between 2010-2014. In 2015, the same year that goose egg addling began, no beach closures occurred due to high coliform counts. While there is not an established correlation between geese population and bacterial content in the surface water, the Public Works Department is interested in continuing to explore the effects of geese feces on bacterial content in the surface water.

Table 3.2. Samples in Exceedence of Local Health Standards

Year	Number of Days Total Coliform Standard Exceeded (5 consecutive samples)[1]	Number of Days Fecal Coliform Standard Exceeded (5 consecutive samples)[2]	Number of Days Fecal Coliform Standard Exceeded (1 sample)[3]
2010	0	6	3
2011	0	1	1
2012	0	5	1
2013	0	4	1
2014	3	10	4

Notes:
[1] *Five consecutive samples taken within a 30 day period exceed a mean of 1000 Total Coliforms/100mL, or*
[2] *Five consecutive samples taken within a 30 day period exceed a mean of 200 Fecal Coliforms/100mL, or*
[3] *One sample exceeds 400 Fecal Coliforms/100mL (one sample is the average sample for each sampling day)*

3.8 Mine Runoff

Mines can contribute to elevated levels of metals in surface water. The Clements Rock Plant, operated by George Reed, Inc., is a sand and gravel mine on the north side of the Lower Mokelumne River. While there are no other mines in the Lower Mokelumne River Watershed, the Upper Mokelumne River Watershed has abandoned mines that have historically contributed a variety of contaminants to the watershed, primarily zinc and copper. Penn Mine, located on the southeastern shore of the Camanche Reservoir, has discharged mine drainage that ultimately ended up in the Lower Mokelumne River.

3.8.1 Water Quality Concerns

Existing and abandoned mines can contribute a variety of contaminants to surface water supplies depending upon the type of mining activity. When abandoned, a mine can continue to discharge drainage downstream. Additionally, this drainage can be characterized by low pH, which acidifies the water supply. Mines may also contribute sediment.

3.8.2 Watershed Management

For several decades, the Penn Mine contributed mine acid drainage into the Upper and Lower Mokelumne River Watersheds, characterized by low pH and elevated levels of copper and zinc. Fish losses were reported in the Mokelumne River periodically since the 1930s. In 1999, the Penn Mine Environmental Restoration Project sealed the mineshaft to prevent leakage from entering the watershed. In 2013, necessary repairs were made to continue to prevent this leakage. Since the mine was sealed, copper and zinc concentrations have been reduced in the raw water (EBMUD, 2011).

Copper and zinc concentrations are also controlled by the Clean Water Act. The segment of the Lower Mokelumne River that falls in the scope of this sanitary survey is recognized as impaired for zinc and copper on the Section 303(d) list. The contaminant limits for Section 303(d) control copper and zinc concentrations to levels that are lower than those required federally or by the state.

Other mines are not known to contribute significant concentrations of metals to the Lower Mokelumne River Watershed. Clements Rock Plant is permitted to harvest sand and gravel from its site, as approved by agencies including SWRCB. It is located near Clements, CA, as shown in Figure 3-2. Clements Rock Plant does not have a permit to discharge into the Mokelumne River. There are also dredge tailings are located on the south bank of the river near the junction of CA-88 and CA-12 that do not have permits to discharge into the river.

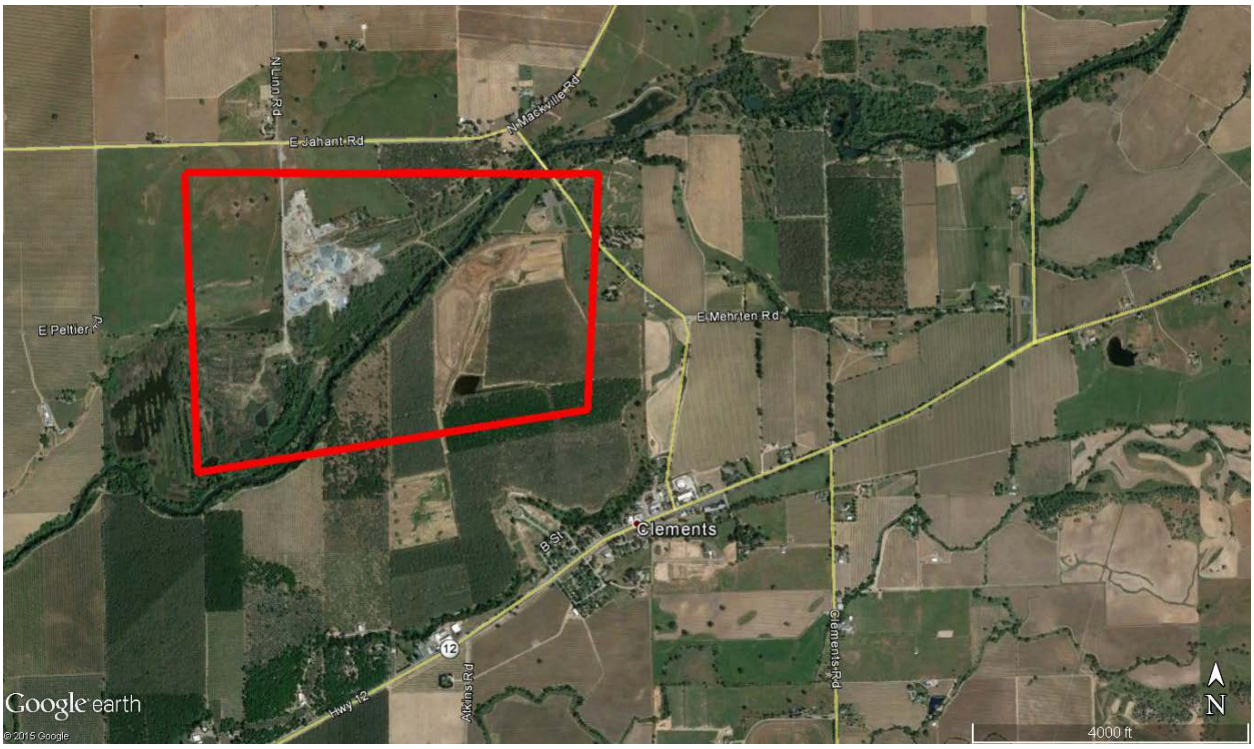


Figure 3-2. Location of the Clements Rock Plant

The California Office of Mine Reclamation periodically publishes a list of mines regulated under the Surface Mining and Reclamation Act that meet provisions set forth under California's Public Resources Code. Mining operations not on the list are precluded from selling sand, gravel, aggregates, or other mined materials to state or local agencies. The CVRWQCB maintains a list of active mines in the Sacramento and San Joaquin River Basins that pose a risk to water quality. The California Office of Mine Reclamation maintains a list of Principal Areas of Mine Pollution, which includes nearly 2,500 mining operations and their water quality problems.

In 2007, the State Water Resources Control Board considered a new draft policy for mercury discharge offsets for discharges to the San Francisco Bay and Sacramento-San Joaquin River Delta and tributaries (SWRCB, 2007). This policy describes offsets as "voluntary abatement efforts by a discharger to remove a specified pollutant from a different existing source, to compensate for all or a portion of the discharger's own discharge of that same pollutant." Offsets may be used to: meet current load allocations; to allow an increase as a result of expansion that would otherwise result in an increase in their mercury loading; or initiate a new discharge that would otherwise result in new mercury loading. Several public "scoping meetings" were held in 2007 but in the intervening years there has been no further action on the policy.

3.9 Recreation

Recreational use of a waterbody poses a wide range of water quality risks, depending on the specific activity. The Mokelumne River upstream of the WID Dam provides several access points for visitors to engage in recreational activities that include boating, kayaking, swimming,

paddle boarding, fishing, hiking, camping, picnicking, and bird watching. The primary recreational areas are Lodi Lake Regional Park, Mokelumne Beach RV Park, Stillman Magee Park, and the Mokelumne River Day Use Area. Residents with property along the river also have private access to the river. Many of these recreational areas operate from approximately April until September.

3.9.1 Water Quality Concern

Recreational use of the reservoir and shoreline can result in pathogenic organisms and sediment loading to the reservoir. Both body contact and non-body contact recreation on surface waters can lead to higher total and fecal coliforms. Additionally, higher *Giardia* and *Cryptosporidium* levels may also occur if a contaminated individual does not use a proper restroom facility. Waterside camping and picnicking along the river can also lead to elevated coliform, *Giardia*, and *Cryptosporidium* counts, even if proper restroom facilities are used. Other contaminants associated with sediment, such as nutrients and organic carbon could also be introduced to the reservoir. Boating accidents can lead to elevated levels of oil or petroleum products. If invasive mussel species are introduced via watercraft, they can eventually clog intakes and water supply conveyance systems. Watershed Management

3.9.1.1 LODI LAKE MANAGEMENT

Lodi Lake Park is located adjacent to the Mokelumne River, one-quarter mile upstream of the WID Intake. Lodi Lake Park is managed by the Lodi Parks and Recreation Department (LPRD) and the Public Works Department. The park includes a 25-acre lake whose water level is controlled by the WID's Woodbridge Dam. WID's policy is to keep the lake full at all times except for a four to six week period in February, when the lake will be drained for maintenance of the WID Canal.

Recreation in Lodi Lake occurs seasonally between April and October. In 2014, Lodi Lake recorded 14,277 visitors; however, this may be an underestimate since many visitors do not pay to receive access and therefore may not be recorded. LPRD estimates 40,000-50,000 people visit the park annually (Personal Communication, June 2015). The activities allowed in Lodi Lake include boating, swimming, fishing, camping, picnicking, paddle boarding, and kayaking. The Park also features a Nature Area that is home to several wild animals, including deer, foxes, and birds. Approximately 0.25 acres of the lake is allocated for swimming, which is strictly prohibited in other areas of the lake. There is a small beach on Lodi Lake that is operational during the summer months. In periods with high *E. coli* or coliform counts, LPRD closes the beach. **Error! Reference source not found.** shows an image of the swimming beach at Lodi Lake, which was closed on the day of the field visit.

Photo 3-3 Swimming Beach Closed at Lodi Lake

Additionally, the beach is closed two days a week, which helps prevent erosion. The lake has one boat ramp, which allows motorized boats to access the lake and the Mokelumne River at speeds less than 5 MPH, and pontoon boats are allowed to host tours of the river. The City of Lodi is proposing to build another boat ramp on the north side of the lake in December 2015 before the lake is emptied, which may increase boat traffic in the lake. The Lodi Lake Boathouse provides kayaks, canoes, paddle boards, and other non-motorized water vehicles to visitors.

Some best management practices used by LPRD include preventing paint and fuel from entering the water, and sweeping leaves and mowed grass onto land rather than in the water.

Photo 3-4 Motorized Vehicle Exits Lodi Lake Using the Boat Ramp

3.9.1.2 STILLMAN MAGEE PARK MANAGEMENT

Stillman Magee Park is a regional park managed by San Joaquin County Parks (SJCP). It is located near the community of Clements. It features water rafting, swimming, picnicking, and fishing. A camping site was also opened at the park in 2014. According to management at the park, most of the traffic at Stillman Magee comes from visitors who float down in rafts from the Mokelumne River Day Use Area. About 14,500 people visit the park annually, primarily in the summer months from about Memorial Day to Labor Day.

3.9.1.3 MOKELUMNE BEACH RV PARK MANAGEMENT

Mokelumne Beach RV Park is a regional park managed by SJCP. It is located just outside of Lodi near the CA-99 Bridge over the Mokelumne River. The RV Park provides swimming access into the Mokelumne River, but prevents vehicles from entering the water.

3.9.1.4 MOKELUMNE RIVER DAY USE AREA MANAGEMENT

The Mokelumne River Day Use Area is located at the base of Camanche Dam. EBMUD's Recreation Department oversees administration and management of the day use area. The 47-acre park offers picnicking, hiking, fishing, rafting, swimming, and camping. In 2014, the park recorded approximately 60,000 visitors. While the park is open year round, the most popular time for visitors to attend is from April to October during the summer months, especially on holiday weekends. The management allows visitors to raft down the Mokelumne River, who subsequently increase traffic at other parks like Stillman Magee Park.

3.9.1.5 GENERAL RECREATION MANAGEMENT

The San Joaquin County Resource Conservation District's (SJCRCD) primary focus is to promote resource conservation in rural San Joaquin County. Areas of emphasis include irrigation water conservation, providing soil survey information, water quality management, conservation and education. The SJCRCD has also developed the *Lower Mokelumne River Watershed Stewardship Plan*, which provides a road map for the Lower Mokelumne River Watershed community to take charge of the maintenance and improvement of the watershed's resources (1993). The SJCRCD has worked closely with local stakeholders to identify and implement restoration projects on the Lower Mokelumne River.

EBMUD's *Lower Mokelumne Management Plan* was implemented in 1993 to provide a reliable water supply, and to sustain and enhance the Lower Mokelumne River fisheries, especially fall-run Chinook salmon and steelhead trout, and other aquatic and riparian resources.

The current City of Lodi General Plan (2010, Appendix D) contains various policies applicable to recreational use:

- Support improvements along the Mokelumne River in consultation and cooperation with the County and creek restoration and design professionals.
- Improve accessibility to the Mokelumne River and Lodi Lake Wilderness Area with walking and biking trails. Site park use and new facilities and trails in Lodi Lake Park such that they will not degrade or destroy riparian or sensitive habitat areas.
- Monitor the water quality of the Mokelumne River and Lodi Lake, in coordination with San Joaquin County, to determine when the coliform bacterial standard for contact recreation and the maximum concentration levels of priority pollutants, established by the California Department of Health Services, are exceeded.
- Monitor the presence of pollutants and variables that could cause harm to fish, wildlife, and plant species in the Mokelumne River and Lodi Lake.
- Post signs at areas used by water recreationists warning users of health risks whenever the coliform bacteria standard for contact recreation is exceeded.
- Require new industrial development to not adversely affect water quality in the Mokelumne River or in the area's groundwater basin.
- Control use of potential water contaminants through inventorying hazardous materials used in City and industrial operations.

3.10 Solid and Hazardous Waste Disposal Facilities

Authorized solid waste disposal sites are permitted and monitored, and are unlikely to be significant source of contamination under normal operation. Within the watershed, there are four waste disposal sites, summarized in Table 3.3. The Central Valley Waste Services facility, Sanitary City Disposal Site, and Valley Landscaping facility are all located away from the Mokelumne River. The Lodi City Landfill, closed in 1988, is located adjacent to the Mokelumne

River. Historically, it was primarily used as a dump site for street sweeping and other debris. Ford Construction Inc., the owner of the site in 1988, organized remediation and clean-up of the site. No known leakage has been detected from the landfill.

Table 3.3. Solid Waste Facilities in the Watershed

SWIS Number	Name	Activity	Capacity (cu. yds)	Status
39-CR-0023	Lodi City Landfill	Solid Waste Disposal Site	--	Closed
39-AA-0017	Central Valley Waste Services	Large Volume Transfer Facility	2,914	Active
39-CR-0030	Sanitary City Disposal Site	Solid Waste Disposal Site	--	Closed
39-AA-0044	Valley Landscaping	Composting Facility	TBD	Planned

Cal Recycle Solid Waste Information System (SWIS), 2015

3.10.1 Water Quality Concern

Improper maintenance, negligent operation, or natural disasters, such as earthquakes or fires, may lead to a release of leachate containing bacteria, pathogens, metals, or other contaminants. Leachate from solid and hazardous waste disposal facilities can contain a variety of contaminants of concern to drinking water supplies, such as iron, lead, dissolved solids, nutrients, and a variety of organic chemicals. Facilities that are no longer active can still leak contaminants to the watershed.

3.10.2 Watershed Management

The California Department of Resources, Recycling, and Recovery (CalRecycle) is the agency that manages landfills within California. The Waste Permitting, Compliance and Mitigation Division oversees, manages, and tracks waste generated each year. Landfills are also subject to CVRWQCB waste discharge requirements.

CalRecycle provides funds to clean up solid waste disposal sites and co-disposal sites (those accepting both hazardous waste substances and nonhazardous waste). These funds are available when the responsible party cannot be identified, or is unable or unwilling to pay for a timely remediation, and where clean up is needed to protect public health and safety or the environment.

Central Valley Waste Services is the only active waste disposal facility in the watershed. It is a private waste management company that provides refuse and recycling service for Lodi residents and businesses. CalRecycle conducts approximately monthly inspections of the Central Valley Waste Services facility. On its reports, CalRecycle cites potential areas of concern or violations of CCRs. Since November 2014, Central Valley Waste Services has been cited three times for litter control being an “area of concern,” but it has not received any violations.

3.11 Unauthorized Activity

Unauthorized activities include swimming in undesignated locations, which can introduce microorganisms into the water; dumping of chemicals or debris, which can introduce synthetic organic chemicals, metals, and disinfection byproduct precursors into the water; and vehicle access to the banks of the river, which can cause erosion and increase particulates and turbidity. Illegal camping and water recreation generally result in the improper disposal of fecal waste.

There are two large homeless camps that are located along the Mokelumne River within the City's city limits. One is on the closed City of Lodi landfill near the intersection of Lincoln and Turner Road. The other is under the CA-99 Bridge that crosses the Mokelumne River. There are approximately 50 homeless who reside underneath the CA-99 Bridge. The encampment is shown in Photo 3-6.

Photo 3-5. Homeless Encampment under CA-99 Bridge

3.11.1 Water Quality Concerns

Illegal dumping could introduce food waste, hazardous materials, and erodible materials into the water supply, causing synthetic organic chemicals, metals, and disinfection byproduct precursors to enter the water. Swimming and water recreation in unauthorized areas can contribute to microorganisms and viruses in the water. Illegal vehicle access can contribute to erosion. Camping in unauthorized areas can lead to erosion and improper disposal of fecal waste.

3.11.2 Watershed Management

San Joaquin County is the primary agency responsible for controlling unauthorized activity that may contribute to contaminants entering the Lower Mokelumne River. The City of Lodi has organized trash cleanups within its city limits along the Mokelumne River to prevent debris from entering the river during precipitation events.

San Joaquin County has a zero tolerance policy toward illegal dumpers. The first offense results in a $238 citation, the second $526 and probation, and the third $1,000 and jail time.

The homeless camp on the previous landfill is within City Limits and falls under the jurisdiction of the City of Lodi. In late July 2015, the City cleared the homeless camp and its inhabitants. However, these clear outs tend to be temporary solutions to the homeless camps, which are re-established soon after (Personal Communication, June 2015).

The homeless camp underneath CA-99 is on Caltrans land outside City Limits; therefore, Caltrans has ultimate jurisdiction over this homeless camp. This particular homeless camp is littered with trash and debris. It is believed that the homeless transmit feces directly into the Mokelumne River (Personal Communication, June 2015). In the past, the City has organized efforts to clear out the homeless camps but the effects have been temporary, and many of their previous residents have returned to the same sites. The City of Lodi has organized a task force that engages in trash clean ups and other operations at the homeless camps. The homeless camp on the previous landfill is within City Limits and falls under the jurisdiction of the City of Lodi. In late July 2015, the City cleared the homeless camp and its inhabitants. However, these clear outs tend to be temporary solutions to the homeless camps, which are re-established soon after (Personal Communication, June 2015).

The homeless camp underneath CA-99 is on Caltrans land outside City Limits; therefore, Caltrans has ultimate jurisdiction over this homeless camp. This particular homeless camp is littered with trash and debris. Photo 3-7 shows a pile of trash at the CA-99 homeless encampment, located about 50 yards from the Mokelumne River. In the case of flooding or a large rain event, debris from the trash could easily enter the surface water and infiltrate the drinking water supply.

Photo 3-6. Trash at the CA-99 Homeless Camp

While on the field survey, an RV disposal station adjacent to Lodi Lake was observed to be closed and overflooded, as shown in Photo 3-8. This dump station was located about 50 feet from surface water in Lodi Lake. LPRD plans to have the dump station to back online in 2016 for RV campers at the park only, and not available for general public use (Personal Communication, August 2015).

Photo 3-7 Closed RV Dump Station Near Lodi Lake

3.12 Hazardous Materials Spills and Traffic Accidents

Hazardous materials spills include fuel spills from traffic accidents, the rupture of containerized hazardous materials under transport, as well as those resulting from non-vehicle-related sources.

Eight highway and railroad bridges cross the Mokelumne River and its tributaries upstream of the WID Dam in the following locations:

- State Route 99 at Mokelumne River in northeast Lodi
- Bruella Road near Victor
- Trethe Way Road west of Lockeford
- Elliott Way Road near Lockeford
- Mackville Road near Clements
- State Route 88 between Clements and Camanche Reservoir
- Union Pacific Railroad at Mokelumne River near Awani Drive in Lodi
- Union Pacific Railroad at Mokelumne River near Lodi's eastern city limit

3.12.1 Water Quality Concerns

Water quality concerns related to highways and railroads include road surface runoff that contains metals, oil, grease, solvents, and other hydrocarbons from general automobile use, and potentially herbicides used in weed control along right-of-ways. However, the greatest threat to water quality is from potential accidents that can occur on or near bridge crossings, because of the immediate potential for spilled material to entire the river system.

Factors that influence the level of risk for vehicle spills include overall traffic volume, volume of hazardous materials in transit, highway characteristics, and weather conditions. While more stringent regulations have been applied to hazardous material transport vehicles, the volume of materials being transported has steadily increased over the years.

Railroad companies are allowed to transport any goods over railway lines as long as they follow the Federal Department of Transportation guidelines on transportation of hazardous materials.

3.12.2 Watershed Management

The City of Lodi and the SWTF will be contacted by the sheriff's dispatch center, CDFW, Caltrans, SJCOES, or SJCEH in case of a hazardous material spill. The SWTF has an emergency response plan that can either change treatment methods or shutdown the plant so that the City can continue to provide clean water to its customers.

Four documented spills have occurred in the Lower Mokelumne River Watershed since 2011 that have entered the water supply system. The staff at the SWTF and SJCOES/SJCEH coordinate an emergency response plan to handle any spills that could contribute contaminants to the surface water.

Table 3.4. Summary of Spills that Entered Surface Water in the Watershed, 2011 - 2015

Spill Date	Location	Description	Quantity
15 May 2015	Mokelumne River	BBQ grill; metal shelves; wood; a tarp, other miscellaneous items	N/A
16 Apr 2014	Mokelumne River	Gasoline	Unknown
10 Jul 2014	Lodi Lake	Paint	3 gallons
23 Nov 2013	Mokelumne River	Rainbow orphan sheen (gasoline)	Unknown

Data retrieved from the CA Office of Emergency Services, July 2015

3.13 Geologic Hazards

The primary geologic hazards in the watershed include:

- Landslides—the Central Valley has no risk due to landslides, while the watershed in the foothills have a relatively low risk of landslides.
- Subsidence—Subsidence affects the runoff patterns in the watershed. Subsidence occurs in the valley area of the watershed near the Mokelumne River due to groundwater withdrawal by the City of Lodi.
- Earthquakes—Potential seismic activity is generally along the Foothills fault zone. Impacts tend to occur in erosive soil.

3.13.1 Water Quality Concerns

Earthquakes, landslides, and subsidence all have the potential to introduce higher levels of sediment into the water. Turbidity, organic carbon, and nutrients can increase in the raw water supply as a result. Earthquakes also have the potential to damage the water supply infrastructure, resulting in disruptions in service.

3.13.2 Watershed Management

Geologic hazards in the watershed are managed by various San Joaquin County departments. In the case of a geologic hazard, each department would follow its emergency response plan to alert the City's SWTF if the hazard has the potential to impact raw water quality. The City of Lodi has the ability to shut down SWTF service to its customers and rely on its groundwater supply for an extended period of time if an earthquake were to occur.

3.14 Fires

Wildfires are a major hazard to water quality because they often result in erosion, and can be a source of sediment and contaminants to adjacent water bodies.

The predominant land use in the Lower Mokelumne River Watershed is agricultural. Because agricultural land is regularly irrigated and maintained, fire hazard potential tends to be minimal. However, the foothill regions of the watershed are considered wild land fire hazard areas. Additionally, the land in the Upper Mokelumne River Watershed primarily comprises dense forest, which is prone to fires, especially in the dry summer months. Ash and other particles from fires can be carried downstream and their contaminants can impact watersheds nearby.

Table 3.5 lists all fires that have occurred near the Lower Mokelumne River Watershed in San Joaquin County, and in Amador and Calaveras Counties since 2011.

Table 3.5. Summary of Fires in the Watershed and in Amador and Calaveras Counties, 2011 – 2015

County	Fire	Date	Location	Approximate Size
San Joaquin	North Fire	June 2015	Dry Creek & E Prouty Rd, 4 miles north of Lockeford	60 acres
San Joaquin	Collier Fire	June 2015	Jack Tone Rd & Collier Rd, 6½ miles north of Lockeford	122 acres
Amador	Amador Lightning Complex	July 2012	Across Amador County	41 acres, 19 total fires
Amador	Roadrunner Fire	June 2013	Roadrunner Dr, south of Lone	96 acres
Amador	Sand Fire	July 2014	East of CA-49, 5 miles north of Plymouth	4,240 acres
Calaveras	Telegraph Fire	June 2011	CA-4 & Telegraph Rd, south of Copperopolis	25 acres
Calaveras	Middle Fire	July 2011	Middle Bar Bridge near Mokelumne River	100 acres
Calaveras	Murray Fire	July 2011	Murray Dale Lane, San Andreas	83 acres
Calaveras	Freccero Fire	September 2011	Fresccero Rd, near Mountain Ranch	57 acres
Calaveras	TCU September Lightning	September 2011	Near Countywide	1,135 acres
Calaveras	Tuolumne-Calaveras Wind Event	December 2011	Multiple locations across Calaveras county	5 fires spanning 781 acres
Calaveras	Paloma Fire	June 2012	CA-26 & Paloma Rd, southwest of Mokelumne Hill	37 acres
Calaveras	Welch Fire	June 2012	Welch Rd & Calaveras Rd near Sunol	60 acres

County	Fire	Date	Location	Approximate Size
Calaveras	Horseshoe Fire	June 2012	CA-4 & South Horseshoe, northeast of Copperopolis	95 acres
Calaveras	Gopher Fire	July 2012	South of CA-4, near Copperopolis	75 acres
Calaveras	Penn Fire	July 2012	Skunk Ranch Road, East of Murphys	134 acres
Calaveras	Ramsey Fire	August 2012	CA-4, east of Dorrington in Stanislaus National Forest	1,137 acres
Calaveras	Salt Fire	September 2012	Spring Valley Rd & Hunt Rd, northwest of Copperopolis	84 acres
Calaveras	Michal Fire	September 2012	500 Michal Rd, Mountain Ranch	23 acres
Calaveras	Chuckwagon Fire	July 2013	Chuckwagon Dr, near Copperopolis	31 acres
Calaveras	Bridges Fire	August 2013	Ferry Road, near Vallecito	46 acres
Calaveras	Lake Fire	May 2014	CA-132 & Lake Rd, near LaGrange	37 acres
Calaveras	Reed Fire	June 2014	George Reed Dr	120 acres
Calaveras	Oak Fire	June 2014	Oak Valley Rd & Pool Station Rd, south of San Andreas	85 acres

Data from http://cdfdata.fire.ca.gov/incidents/incidents_current

3.14.1 Water Quality Concerns

Wildfires can result in loss of soil surface cover and forest duff, such as needles and small branches, and make the watershed more vulnerable to erosion. Erosion can bring in sediments and contaminants—such as microbes, organics, and inorganics— to adjacent water bodies. Increased sediment loads following a fire can impact both ecological health of water bodies and drinking water operations by increasing turbidity, total suspended and dissolved solids. Nutrient loads into water bodies, particularly phosphorus and nitrogen have also been reported to increase after wildfires. The ash from a wildfire consists of fine, small particles that are very difficult to remove with conventional water treatment processes.

3.14.2 Watershed Management

CAL FIRE has primary responsibility for wild land fires and counties have primary responsibility for structural fires. After a wild land fire, CAL FIRE assists with hydroseeding, mulching, and other slope stabilization techniques. CAL FIRE attempts to restore the disturbed area. Erosion mitigation response conducted after a wildfire depends on how much vegetation was removed, soil type, steepness of slope, and other factors.

In the Sacramento and San Joaquin County portions of the Lower Mokelumne River Watershed, regardless of whether incorporated or unincorporated, the respective county retains primary

jurisdiction because these are Local Responsibility Areas. In Amador County, CAL FIRE has primary jurisdiction because the watershed land is in a State Responsibility Area. The portions of the watershed that lie in the foothills are considered to be in a moderate fire hazard severity zone. In case of a fire, the responsible agency would alert the SWTF.

3.15 Invasive Species

Aquatic invasive mussels typically include four species: quagga mussels (*Dreissena rostriformis bugensis*), zebra mussels (*Dreissena polymorpha*), golden mussels (*Limnoperna fortunei*), and conrad false mussels (*Mytilopsis leucophaeta*). Of these species, quagga and zebra mussels have been a source of significant operational problems and maintenance expenditures for water operators in the eastern United States for decades. Zebra mussels arrived in North America from Europe in the 1980s followed shortly thereafter by their close relative the quagga mussel. Quagga mussels were found in four western states in 2007, quickly expanding their geographic reach in the western United States. The zebra mussel was found in California for the first time in January 2008 at the San Justo Reservoir in San Benito County. These mussels could threaten California's entire water delivery system, irrigation network and freshwater ecosystems by clogging intake pipes and other conveyance structures (California Department of Fish and Game [CDFG, 2008]). Figure 3-3 depicts the confirmed locations of quagga and zebra mussels in California. There are occurrences of New Zealand mud snail, another invasive species, scattered throughout California. They have been found in over 30 California water bodies (CDFW, 2013).

Zebra mussels heavily colonize hard substrates while quaggas colonize both hard and soft substrates. It appears as though quaggas colonize deeper than zebra mussels, infesting a wider range of habitats. In locations where both mussels exist, the quagga mussel appears to compete with the zebra mussel, eventually replacing it. Quagga/zebra mussels clog water intake structures, such as pipelines and screens, reducing pumping capabilities for power and water treatment facilities. Recreation-based industries and activities are also affected by the mussels which take up residence on docks, breakwalls, buoys, boats and beaches. For boaters, quagga/zebra mussels increase drag, clog engines causing overheating and can affect steering mechanisms.

Mussels are introduced to water bodies from the hulls of boats and through ballast water collected in mussel-invaded waters. The larval mussel life stage is free-floating and microscopic; consequently, they can freely enter ballast water as well as bilges, live wells, or other equipment that holds water. Although they range from microscopic to the size of a fingernail, the mussels are prolific breeders and attach themselves to hard and soft surfaces, such as boats and aquatic plants. They can survive out of water for up to a week.

Because boating is common in Lodi Lake, the water bodies are vulnerable to the introduction of invasive species such as quagga and zebra mussels. Based on the impacts of these mussels to other water treatment systems, and the high cost of controlling the population once it has been introduced, an invasion of quagga mussels would be a significant water quality and operational concern for the City of Lodi.

Mussels require consistent nutrient source from suspended water bodies like plankton to survive. Because Lodi Lake is subject to emptying and refilling, there would be 4-6 weeks in which the invasive mussels would not have water from which to draw sufficient food. Therefore, the longevity of mussel populations in Lodi Lake is not as likely as in other consistent water bodies. However, mussels pose a significant water quality risk even in the short term.

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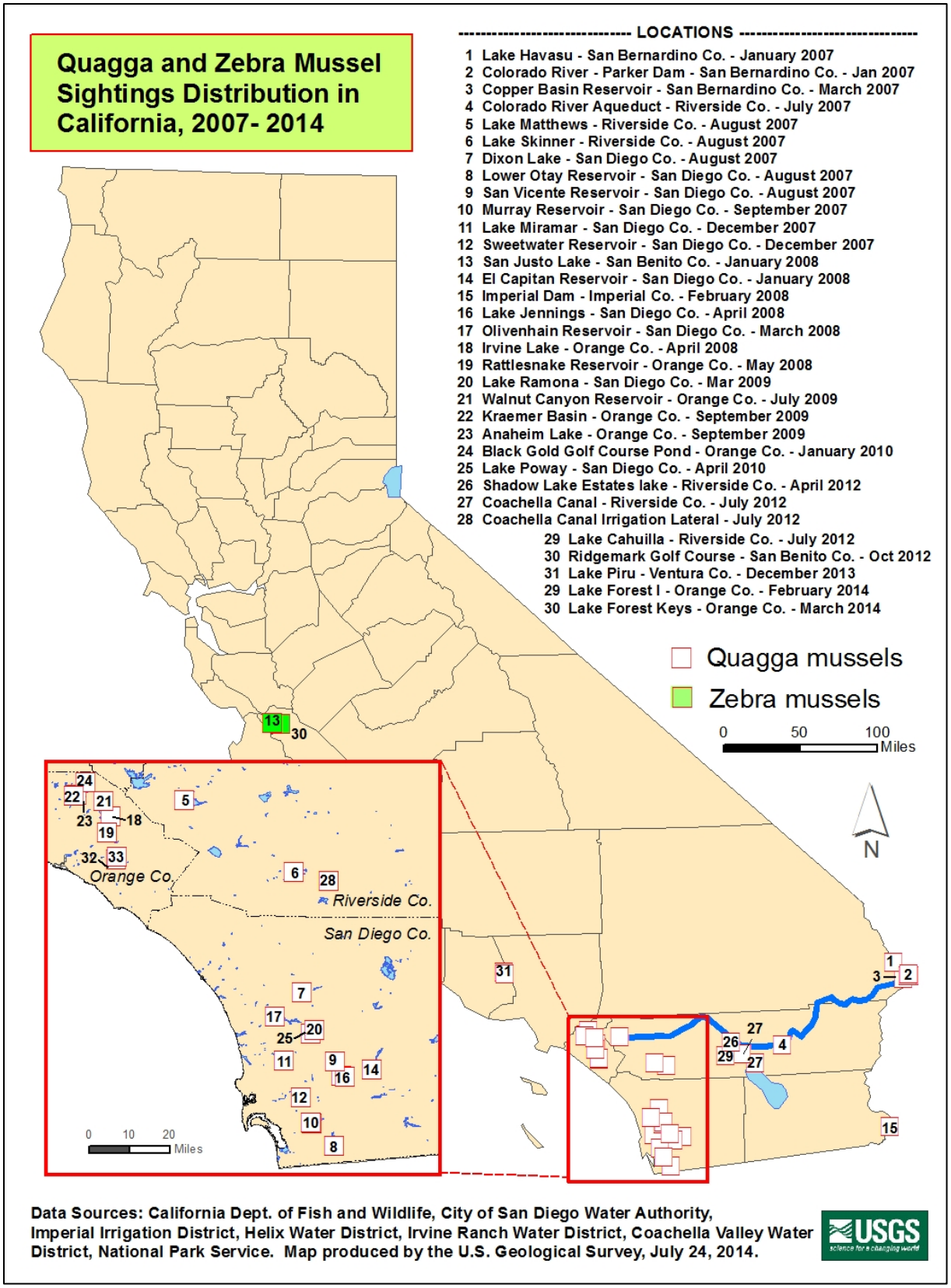

Figure 3-3. Quagga and Zebra Mussel Sightings in California, 2007 – 2014

3.15.1 Water Quality Concerns

As prodigious water filterers, the mussels remove substantial amounts of phytoplankton, zooplankton and suspended particulate from the water, which reduces the food sources for zooplankton and small fish, altering the lake ecosystem. With the filtering out of suspended particulates and phytoplankton, water clarity increases allowing sunlight to penetrate the water deeper triggering increased vegetation growth that can affect oxygen levels resulting in fish die offs.

Quagga/zebra mussels accumulate organic pollutants within their tissues to levels more than 300,000 times greater than typical concentrations in the environment. The mussels' wastes significantly lower the oxygen levels, lowering the pH to an acidic level and generating toxic by-products. The mussels have also been associated with outbreaks of botulism poisoning in wild birds.

To date, there has been little research on the potential impacts of New Zealand mud snails on other aquatic resources. Impacts could be significant if nothing is done to control its spread. If the snails become very dense and comprise a large percentage of the macroinvertebrate biomass, impacts can be substantial. They can reduce food resources and populations of other macroinvertebrates, particularly mayflies, caddisflies and chironomids. They can also reduce whole-stream algal production (CDFW, 2012).

3.15.2 Watershed Management

State and federal agencies have coordinated a unified response for protection of California waters. The primary state agencies involved include the CDFW, DWR, and the California Departments of Food and Agriculture, Boating and Waterways, and Parks and Recreation; the primary federal agencies involved include the United States Department of the Interior Fish and Wildlife Service (USFWS), United States Bureau of Reclamation (USBR), and the National Park Service. Guidance documents at https://www.wildlife.ca.gov/Conservation/Invasives/Quagga-Mussels, developed by numerous agencies, provide assistance in watershed protection.

In August 2013, the California Department of Parks and Recreations proposed an emergency regulation for a Quagga and Zebra Mussel Infestation Prevention Fee. The objective of the regulation is to clarify the procedures related to administering the mussel fee, which is intended to cover the costs of Dreissenid mussel prevention activities as required by statute. The fee administration includes identification of the fee amount and collection procedures and must be spent within the authority granted by the statutes. The mussel fee amount is $16, payable with bi-annual recreational vessel registration renewals by December 31. This regulation went into effect for 2014 vessel registrations.

In the Lower Mokelumne River, boating and kayaking primarily occurs in Lodi Lake and the portions of the Mokelumne River in close proximity. The City of Lodi has begun to engage in invasive mussel prevention, primarily based on a stewardship approach. The City has trained boathouse staff and Lodi Lake park entry staff to inspect and look for mussels on boats and kayaks entering the water. Additionally, the Storm Drain Detectives Program has begun to include mussel sightings in its investigations. Since invasive mussel prevention awareness

began, no mussels have been sighted. No public education has been included in the prevention program.

3.16 Anticipated Growth within the Watershed

The current City of Lodi General Plan (Appendix D) projects growth for the City from 63,400 in 2008 up to 99,500 at buildout (City of Lodi, 2010). From 2010 to 2013, Lodi's population has increased 1.9%, from 62,134 to 63,338 (US Census Bureau). The Background Report for the San Joaquin County 2010 General Plan predicts most growth development to occur in Lodi and Lockeford and discourages growth in rural, unincorporated communities, e.g., Acampo, Clements, and Victor, except for minimal infill development. The plan discourages growth in rural areas outside designated communities since agriculture and open space are the dominant land uses in these areas. Therefore, except for Lodi and Lockeford, there will be relatively little growth in the watershed. As a result, contaminants will increase only in the growth areas.

Agriculture has remained steady since 2007 in most crops. However, the Lodi viticulture sector expects increases in popularity and demand in the near future. The potential impacts of the expansion in the wine industry include increased human traffic in the watershed, increased herbicide and pesticide usage, and over-irrigation. These factors may contribute to erosion and higher sediment concentrations in the water, higher levels of pesticides and herbicides in the water supply, and increased microorganism presence in the water.

Additionally, the City of Lodi intends to build an additional boat launch in Lodi Lake in December 2015 or January 2016. The boat launch may increase motorized boat traffic in the lake and the river, potentially leading to higher concentrations of VOCs and solvents, and increasing the risk of traffic accidents and spills.

3.17 Watershed Protection Regulatory Update

Federal and state laws protect water quality from point and nonpoint sources. The federal Clean Water Act requires states to adopt water quality standards and to submit those standards for approval by the US EPA. Clean Water Act Section 303(d) requires states to list surface waters not attaining (or not expected to attain) water quality standards after the application of technology-based effluent limits, and states must prepare and implement a Total Maximum Daily Load (TMDL) for all listed waters. For point source discharges to surface water, the Clean Water Act authorizes USEPA or approved states to administer the NPDES Program. In California, SWRCB and RWQCBs administer many of the Clean Water Act's provisions.

The Porter-Cologne Water Quality Control Act is the principal state law governing water quality regulation in California. The Porter-Cologne Act established a comprehensive program to protect water quality and the beneficial uses of water, and established the SWRCB and nine RWQCBs which are charged with implementing its provisions, and which have primary responsibility for protecting water quality in California. The SWRCB provides program guidance and oversight, allocates funds, and reviews RWQCB decisions. The RWQCBs have primary responsibility for individual permitting, inspection, and enforcement actions within each of nine hydrologic regions. The Sacramento-San Joaquin Delta falls under the jurisdiction of the Central Valley RWQCB. The RWQCBs regulate point source discharges primarily through issuance of

NPDES and waste discharge requirement permits. The SWRCB and RWQCBs also have numerous nonpoint source-related responsibilities.

Most of the surface water bodies that are currently listed as impaired on the state's Section 303(d) list are impaired due to nonpoint source discharges. Over the past several years, SWRCB and RWQCB programs have shifted from focusing on site-specific problems to a watershed-based approach targeting non-point sources of pollution.

As part of the new watershed-based approach, the state is identifying impaired water bodies pursuant to the Clean Water Act. In addition, TMDL development, which focuses on river reaches, has begun to be used to address runoff. Basin Plan (Appendix F) amendments are designed to establish water quality objectives for specific pollutants in lieu of focusing on only the particular water bodies where impairment has been caused by a particular pollutant. The SWRCB and RWQCB have developed a Watershed Management Initiative to integrate programs and control both point and nonpoint sources within a watershed. These programs are described further below.

3.17.1 Clean Water Act Section 303(d) List and TMDL Development

Under Section 303(d) of the Clean Water Act, California is required to compile a list of impaired waters that fail to meet applicable water quality standards or that cannot support their designated beneficial uses. Water bodies are listed due to deleterious impacts from a pollutant or pollutants and may be delisted when evidence reveals that such impacts have ceased or never existed. The waters on the list do not meet water quality standards, even after point sources of pollution have installed the minimum required levels of pollution control technology. Applicable water quality standards include the designated beneficial uses, the adopted water quality objectives, and the state's antidegradation policy.

For 303(d) listed water bodies, a pollutant watershed budget is established, which defines the maximum amount of pollutants, or TMDL, that can be assimilated by that water body. If the sum of allowable pollutants from both point and nonpoint sources exceeds this maximum amount, a TMDL implementation (or clean-up) plan is required. By providing watershed-specific information, TMDLs will help target specific sources and corresponding corrective measures and will provide a framework for using more stringent approaches that may be necessary to achieve water quality goals and maintain beneficial uses. TMDLs are established at the level necessary to implement the applicable water quality standards. A TMDL requires that all sources of pollution and all aspects of a watershed's drainage system be reviewed, not just the pollution coming from discrete conveyances (i.e., point sources). TMDLs must include numeric targets, source analysis, determination of the carrying capacity of the water body, establishment of load allocations for sources in the watershed, a margin of safety, and a public process. When loads are exclusively from point source discharges, and when one action by the RWQCB addresses all the significant loads, TMDL requirements can be included directly in NPDES permits. More often, TMDLs involve loads from a combination of point and nonpoint sources and they are established through Basin Plan amendments.

The RWQCBs must establish priority rankings for water bodies on the lists, and submit the Section 303(d) list and TMDL priorities to the US EPA for approval. The RWQCBs developed

this list in 2010, and the US EPA gave final approval to California's Section 303(d) List of Water Quality Limited Segments in October 2011.

Based on a review of the US EPA-approved 2010 final list and its associated TMDL Priority Schedule, the entire 29.6 mile segment of the Lower Mokelumne River that flows through the watershed is listed as state impaired for copper and zinc.

The TMDL program serves as the RWQCB's focal point for addressing California's most difficult, long-term surface water quality problems. TMDL planning activities are closely coordinated with the RWQCB's regulatory programs to ensure compatibility with those programs and feasibility of implementation. TMDLs are incorporated into water quality control plans. The US EPA requires that NPDES permits be revised to be consistent with any approved TMDL (40 CFR 122). The TMDL program is also coordinated with the agricultural waiver program.

3.17.2 Watershed Management Initiative

The SWRCB and RWQCB developed the Watershed Management Initiative to integrate surface and groundwater regulatory programs within a watershed, to control both point and nonpoint sources, and to draw solutions from all interested parties within a watershed. The SWRCB and RWQCB developed this initiative to protect water quality within a watershed context, considering a mix of point and nonpoint source discharges, ground and surface water interactions, and water quality/water quantity connections.

In 1996, the SWRCB, the RWQCBs and the US EPA prepared a Watershed Management Initiative Plan. The plan is now updated as needed by the RWQCB or by a directive from the SWRCB. The Central Valley RWQCB Watershed Management Initiative Integrated Plan State of the Watershed for the San Joaquin River and the Delta was last updated in 2001 but sections have been updated as needed, last in November 2004.

3.17.3 Regulation of Point Sources of Potential Contaminants

It is the responsibility of the SWRCB and RWQCBs to preserve and enhance the quality of the state's waters through the development of water quality control plans and the issuance of waste discharge requirements. The RWQCBs regulate point source discharges (i.e., discharges from a discrete conveyance) under the Porter-Cologne Act primarily through issuance of NPDES and waste discharge requirement permits. NPDES permits serve as waste discharge requirements for surface water discharges. Waste discharge requirements and NPDES permits within the Sacramento-San Joaquin Delta fall under the jurisdiction of the CVRWQCB.

Anyone discharging or proposing to discharge materials to land in a manner that allows infiltration into soil and percolation to groundwater (other than to a community sanitary sewer system regulated by an NPDES permit) must file a report of waste discharge to the local RWQCB (or receive a waiver). Following receipt of a report of waste discharge, the RWQCB issues waste discharge requirements that prescribe how the discharge is to be managed.

An NPDES permit is required for municipal, industrial and construction discharges of wastes to surface waters. Typically, NPDES permits are issued for a five-year term, and they are generally issued by the RWQCBs. An individual permit (i.e., covering one facility) is tailored for a specific

discharge, based on information contained in the application (e.g., type of activity, nature of discharge, receiving water quality). A general permit is developed and issued to cover multiple facilities within a specific category.

The beneficial uses and receiving water objectives to protect those uses are established in the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins, known as the Basin Plan (CVRWQCB, 1998, Appendix F) and most recently revised in 2011. The CVRWQCB establishes effluent limitations for wastewater dischargers based on the beneficial uses and the water quality objectives of the water body that receives the discharge. Effluent limitations are specific to each discharge and vary throughout the Central Valley. If a discharge is to an ephemeral stream or a stream that the CVRWQCB determines does not have any assimilative capacity for a contaminant, the discharger must meet the receiving water quality objectives in the effluent. If there is dilution capacity available in the receiving water, the CVRWQCB establishes effluent limitations that allow for a mixing zone and dilution of the effluent in the receiving water. The CVRWQCB establishes effluent limitations for a number of contaminants in waste discharge permits. However, the Basin Plan does not contain water quality objectives for some of the key drinking water constituents of concern (disinfection byproduct precursors, pathogens, nutrients) and the current objectives are not based on drinking water concerns (salinity, chloride). Therefore, there are limited data on the quality of wastewater effluent for many of these constituents because the dischargers are not required to conduct monitoring.

3.17.4 Regulation of Non-Point Sources of Potential Contaminants

Currently, discharges from nonpoint sources such as agriculture, silviculture, urban runoff, past mining activities, dairies, and individual wastewater disposal systems (i.e., septic systems) cause the most significant and widespread surface and groundwater quality problems. Nonpoint source pollution is not typically associated with discrete conveyances; it includes landscape scale sources such as storm water and agricultural runoff, and dust and air pollution that find their way into water bodies.

Urban runoff in the Central Valley and Delta is regulated by the CVRWQCB through municipal separate storm sewer system (MS4) NPDES permits. These permits require large (populations >250,000) and medium (populations 100,000 to 250,000) municipalities to develop storm water management plans and conduct monitoring of storm water discharges and receiving waters. The permits also require programs to control runoff from construction sites, industrial facilities, and municipal operations; eliminate or reduce the frequency of non-storm water discharges to the storm water system; educate the public on storm water pollution prevention: and better control and treat urban runoff from new developments. Since 2003, small communities—defined as having a population of at least 10,000, and a population density of at least 1,000 persons per square mile, that lie within an urbanized area having a population of between 50,000 and 100,000, and a population density of at least 1,000 persons per square mile—have been required to develop storm water management plans. The City of Lodi is the only city or unincorporated town in the watershed that has a storm water management plan.

Some of the most significant surface water quality problems result from nonpoint source discharges from agricultural lands. The nonpoint source pollutants typically associated with agriculture are nutrients, animal waste, sediments, and pesticides. Agricultural nonpoint source pollution enters receiving waters by direct runoff to surface waters or seepage to groundwater. Runoff of nutrients can result from excessive application of fertilizers and animal waste to land, and from improper storage of animal waste. Farming activities can cause excessive erosion, which results in sediment entering receiving waters. Improper use and over application of pesticides cause pesticide pollution. Improper grazing management can cause erosion, soil compaction, and excessive nutrients, all of which impair sensitive areas. Over application of irrigation water can cause runoff of sediments and pesticides to enter surface water or seep into groundwater. Sediment, pesticides, and excess nutrients all affect aquatic habitats by causing eutrophication, turbidity, temperature increases, toxicity, and decreased oxygen.

3.18 Summary of Potential Contaminant Sources

Table 3.6 presents a summary of potential contaminant sources in the watershed. Their ability to affect drinking water quality is based on ranking of contaminants, distance upstream, magnitude of the source, and any mitigating factors.

The most significant contaminant sources are those associated with pathogens because of the public health risk and the difficulty in removing these contaminants through the treatment process. The primary sources of microorganism concern are livestock accessing the river, wildlife, i.e., geese, and swimming at Lodi Lake. Public access to the river from either public streets or from residential areas is of significant concern due to the increasing risks associated with illegal dumping of chemicals and other forms of vandalism.

Table 3.6. Summary of Contaminant Sources and their Potential to Impact Drinking Water Quality

Contaminant Source	Potential to Affect Drinking Water Quality	Comments
Wastewater Discharge	Low	No wastewater treatment plant discharges to the Mokelumne River in survey area; only three NPDES discharge to the river
Septic Tanks	Low	Most located away from Mokelumne River or its tributaries; high groundwater can cause leach field failures.
Reclaimed Water	Low	City of Lodi and community of Lockeford use reclaimed water
Urban and Industrial Runoff	High	City of Lodi discharges its storm water to Mokelumne River; industrial runoff permitted and monitored by RWQCB

Contaminant Source	Potential to Affect Drinking Water Quality	Comments
Agricultural Crop Land Use	Medium	Approximately two-thirds of all agricultural land (main land use) in watershed is used for crops; agricultural runoff potential is considered moderate; Pesticide/herbicide has moderate potential to introduce synthetic organic chemicals to drinking water supply
Grazing Animals & Concentrated Animal Facilities	High	One-third of all agricultural land (main land use) in watershed is used for grazing; cattle are a well-known source of protozoa; few concentrated animal facilities located in watershed near the Mokelumne River; no grazing management plans for private or county leases; two identified locations along Mokelumne River where cattle enter the water while grazing
Wild Animals	High	Mammalian wildlife known source for protozoa, E. coli, other microbes; geese in Lodi Lake pose significant risk to water quality; potential for erosion
Mine Runoff	Medium	Penn Mine empties into Camanche Reservoir; Lower Mokelumne River is listed on California 303(d) list for copper and zinc
Recreational Use	High	Body contact recreation in watershed; source of protozoa, viruses, and coliform bacteria; boating may introduce VOCs and solvents into river
Solid and Hazardous Waste Disposal Facilities	Low/Medium	Central Valley Waste Services located along river; no previous concerns about waste management
Unauthorized Activity	Medium	Few access points to Mokelumne River; unauthorized activity difficult to document; homeless camps pose threat to water quality
Transportation Corridors and Spills	Low	Potentially high, if spills occur at crossings; high volume of traffic; low number of historical incidents involving hazardous materials spills
Geologic Hazards	Low	Areas of moderate to high landslide and erosion potential located far from the WID Intake
Fires	Low	Potential wildfire areas located far from proposed intake; wildfires more likely to occur upstream of watershed

Contaminant Source	Potential to Affect Drinking Water Quality	Comments
Invasive Species	Low	Increased mussel prevention awareness; boating and kayaking do no occur in high volumes in Lodi Lake; refilling of Lodi Lake prevents sustainable mussel populations

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4 Water Quality

The purpose of this section is to identify changes in raw water quality that may impact the ability of SWTF to meet current and anticipated drinking water regulations. Additionally, this section identifies water quality changes that may indicate deterioration of the source waters. This section includes a regulatory review, an evaluation of raw and finished water quality data, and recommended monitoring improvements.

4.1 Regulatory Overview

This section summarizes the state and federal drinking water regulations that relate directly to contaminant concentrations in the watershed. The regulations apply to treated water as opposed to raw water, but provide the basis for the water quality review of the watershed. The regulations discussion in this report includes microbiological water quality, disinfectants and disinfection by-products, chemical contaminants, and emerging contaminants.

4.1.1 Federal Regulations

Federal water quality regulations are summarized in Table 4.1. The most recently promulgated federal regulations relevant to SWTF are the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and the Stage 2 Disinfectants/Disinfection By-Products (Stage 2 D/DBP) Rule. The goal of the new rules is to provide a higher level of protection against microbial contaminants, while limiting the production of potentially carcinogenic disinfection by-products (DBPs).

The USEPA is responsible for developing and implementing drinking water regulations under the federal Safe Drinking Water Act (SDWA) of 1974. States can either adopt the federal regulations or develop their own regulations with more stringent standards. State Water resources Control Board Department of Drinking Water (DDW), formerly the California Office of Public Health (CDPH), has been delegated the authority to implement drinking water regulations within the state. For nearly all regulated drinking water contaminants, the state has adopted the federal regulations.

State requirements are identified and discussed only when they are more stringent than the corresponding federal regulations. The numeric maximum contaminant levels (MCLs) and secondary standards are summarized in Appendix G. The Basin Plan, administered by SWRCB, provides recommendations for water quality control in San Joaquin County and other regions in the Central Valley.

Table 4.1. Summary of Federal Water Quality Regulations

Regulation	Major Requirements
National Primary Drinking Water Regulations, 1975	• Currently established for 92 contaminants, including turbidity, 8 microorganisms, 4 radionuclides, 19 inorganic contaminants, and 60 organic contaminants. • 83 of the contaminants have maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs), with treatment technique requirements for the remaining 9. • 15 additional contaminants have secondary (aesthetic) standards.
Surface Water Treatment Rule, 1989	• Requires that a detectable disinfectant residual be present in all portions of the distribution system (heterotrophic plate count [HPC] less than 500 colony forming units [CFU]/mL equivalent to a detectable residual). • Requires 3-log Giardia inactivation/removal. Conventional systems receive a 2.5-log credit and direct filtration systems receive a 2-log credit for meeting filter effluent turbidity requirements. Remaining requirements must be met through disinfection. • Requires 4-log virus inactivation/removal. Conventional systems receive a 2-log credit and direct filtration systems receive a 1-log credit for meeting filter effluent turbidity requirements. Remaining requirements must be met through disinfection. • Requires combined filter effluent turbidity not exceed 0.5 NTU (nephelometric turbidity units) in more than 5 percent of samples each month.
Total Coliform Rule, 1989	• Requires that less than 5 percent of distribution samples collected each month be positive for total coliform. • Requires a detectable disinfectant residual at all points in the distribution system (HPC less than 500 CFU/mL considered equivalent to a detectable residual).
Interim Enhanced Surface Water Treatment Rule (IESWTR), 1998	• Establishes an MCLG of zero for Cryptosporidium. • Requires combined effluent turbidity of less than 0.3 NTU in 95 percent of samples collected each month. • Establishes requirements for individual filter effluent turbidities, with associated requirements for a Comprehensive Performance Evaluation of underperforming filters. • Requires that new finished water reservoirs be covered. • Requires sanitary surveys at three year intervals. • Requires disinfection benchmarking.

Regulation	Major Requirements
Stage 1 Disinfectants/ Disinfection By-Products (D/DBP) Rule , 1998	• Establishes MCLs for the following disinfection by-products (DBPs): Trihalomethanes [THMs] (80 µg/L), haloacetic acids [HAA] (60 µ/L), bromate (10 µg/L) and chlorite (1 mg/L). THM and HAA compliance is based on an RAA of distribution system samples. • Establishes maximum residual disinfectant levels (MRDLs) for the following disinfectants: free chlorine (4 mg/L), chloramines (4 mg/L), and chlorine dioxide (0.8 mg/L). Compliance based on an average of distribution system samples. • Establishes enhanced coagulation requirements requiring TOC removals based on raw water TOC and alkalinity. Purpose is to optimize removal of DBP precursors.
Modified Lead and Copper Rule, 2000	• Maintains MCLGs (0 mg/L for lead and 1.3 mg/L for copper) and action levels [ALs] (0.015 mg/L for lead and 1.3 mg/L for copper) established in the 1991 Lead and Copper Rule. • Compliance requires that less than 10 percent of distribution system samples exceed action levels. • Establishes additional requirements, including demonstration of optimal corrosion control, lead service line replacements, public education, monitoring, analytical methods, etc.
Arsenic Rule, 2001	• Establishes an MCL of 10 µg/L for arsenic.
Filter Backwash Recycle Rule, 2001	• Requires that all recycle streams be returned prior to or at the point of primary coagulant addition. • Requires that information on recycle streams be provided to the CDPH for evaluation.
Long-term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR), 2002	• Extended requirements of the LT1ESWTR to utilities serving less than 10,000 persons.
Long-term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), 2006	• Assigns utilities to one of four “bins” based on raw water Cryptosporidium concentrations. • Each bin has associated requirements for additional Cryptosporidium treatment. • Includes a toolbox of options for receiving Cryptosporidium reduction credits, including watershed control, disinfection, and filtration. • Bin assignment is based on the average of the 12 consecutive highest months within a 2 year period of monthly Cryptosporidium samples.

Regulation	Major Requirements
Stage 2 D/DBP Rule, 2006	• Does not change the MRDLs or MCLs established in the Stage 1 Rule. • Requires an initial distribution system evaluation (IDSE) to identify sites with high DBP levels. • Systems with no samples with THM/HAA levels exceeding 40/30 µg/L can apply for an IDSE waiver. • Requires compliance with 80 µg/L THM and 60 µg/L HAA based on a location running annual average (LRAA) at each site.
Revised Total Coliform Rule (RTCR), Promulgated in 2013	• New approach to monitoring assessments and implementation when new sample positives occur
Perchlorate, promulgated in 2014	• Established interim health advisory for clean ups at 15 ppb

From the United States Environmental Protection Agency, 2015

4.1.2 State Regulations

DDW implements drinking water regulations within the state. DDW regulations are set forth in the DDW Drinking Water Program Title 22 Chapter 15." The most recent updated version of the Title 22 of the California Code of Regulations (CCR) was published June 25, 2015.

CDPH regulations relevant to water purveyors are summarized in Table 4.2. Only regulations and requirements that are in excess of federal requirements are mentioned.

Table 4.2. Summary of California Water Quality Regulations

Regulation	Major Requirements
State Primary Drinking Water Standards	State MCLs are more stringent than federal levels for 33 contaminants. The state also has notification levels (NLs) for 30 chemicals. NLs are health-based standards for contaminants without a current MCL. Exceedance may require public notification or switching to an alternative source.
Fluoridation	Established optimal fluoride levels and control ranges for treated water based on air temperature.
Cryptosporidium Action Plan, 1995	Sedimentation/clarification basin effluent turbidity of 1 to 2 NTU. Combined filter effluent turbidity <0.1 NTU. Reclaimed backwash water turbidity <2 NTU. Filter effluent turbidity after filter backwash or filter-to-waste <0.3 NTU. Recycle flows limited to 10 percent of influent.
The Basin Plan, Updated March 2015	Established water quality objectives for recreational waters. Provided water quality objectives for total coliform (median 240 MPN/100 mL and maximum 10,000 MPN/100 mL) and *E. coli* (126 MPN/100 mL) for five samples taken at equally spaced intervals over 30 days.

From the Department of Drinking Water, 2015

The DDW was directed to implement the CAP through Section 116360 of the California Health and Safety Code, which was passed by the legislature in 1995. Since 1995, federal rules have

been adopted to address *Cryptosporidium* (e.g., the ESWTR, Long Term 1 ESWTR, and Long Term 2 ESWTR) and, therefore, CAP requirements may be of only historical interest (DDW, 2009).

4.2 Constituents of Concern to Water Purveyors

This section describes the primary sources of each constituent of concern and the state and federal regulations which apply to that contaminant.

4.2.1 Microbiological Water Quality

One major function of water treatment is to remove or inactivate pathogenic organisms. Primary sources of microbiological contaminants are grazing and wild animals, wastewater treatment and septic spills, and to a lesser degree, body-contact recreation within surface water sources. Pathogen concentrations are reduced through a combination of removal by filtration processes and chemical disinfection. Chemical oxidants may also provide other benefits in addition to disinfection, including the destruction of compounds that cause taste and odor problems.

Both state and federal regulations are focused on the removal of four major pathogens/pathogen groups: coliform bacteria, *Giardia*, viruses and *Cryptosporidium*. For three of the pathogen groups, removal requirements are dependent on the level of microbial contamination of the source water. Turbidity is used as a surrogate for microbial water quality and is also discussed below.

4.2.1.1 COLIFORM BACTERIA

Coliform bacteria are used as an indicator of pathogenic contamination. Total coliform is a measure of the concentration of a specific group of bacteria in water that use organic carbon for energy and are lactose-fermenting. Their presence alone is not a cause for concern, but their source should be identified and controlled if possible. Fecal coliforms are a subgroup of total coliform that are found in the intestinal tracts of warm blooded animals including humans. The presence of these bacteria in water samples is indicative of the presence of fecal matter and possible pathogenic organisms, which may be of human origin. *Escherichia coli* (*E. coli*) is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination.

Coliform bacteria are directly regulated under the Total Coliform Rule, which requires that less than five percent of distribution system samples collected each month be positive for the presence of coliform bacteria. Positive samples require additional action, including further testing for fecal coliform, as well as collection of additional distribution system samples. The 2015 Basin Plan Section 3.1 includes a Water Quality Objective for both total and fecal coliform in recreational waters. The Water Quality Objective assumes a minimum of five consecutive samples equally spaced over a 30-day period. For total coliform, the Water Quality Objective is a median < 240 MPN/100 mL and a maximum of 10,000 MPN/100 mL. For fecal coliform, the Water Quality Objective is a geometric mean < 200 MPN/100 mL and 90th percentile < 400 MPN/100 mL. In 2002, the Regional Board adopted, in lieu of the fecal coliform objective, a water quality objective for *E. coli* of 126 MPN per 100 mL, based on the U.S. EPA Bacteriological Criteria for Water contact Recreation. Source water total coliform levels are also

used by the DDW to determine *Giardia* and virus removal requirements through treatment, as described in the following section.

4.2.1.2 *GIARDIA*, VIRUSES, AND *CRYPTOSPORIDIUM*

Cryptosporidium parvum and *Giardia lamblia*, commonly known as *Cryptosporidium* and *Giardia*, are naturally occurring protozoa in the intestines of most mammals, including humans. Surface water contamination from these protozoa can occur as a result of: surface runoff through urban areas, woodlands, and pastures; on-site septic tank/sewage disposal system leakage/failure; sewage treatment plant/disposal system overload or malfunction; or, raw sewage deep well injection.

Giardia and viruses are regulated under the California SWTR, with removal requirements based on source water total coliform levels, as shown in Table 4.3. Systems using conventional treatment that meet filter effluent turbidity requirements receive treatment credits of 2.5-log for *Giardia* and 2-log for viruses. Credits for direct filtration systems are 2.0-log *Giardia* and 1-log virus. Credits for alternative filtration technologies are determined by DDW.

Table 4.3. California SWTR Reduction Requirements for Giardia and Viruses

Median Monthly Total Coliform Concentrations (MPN/100 mL)	*Giardia* Cyst Log Reduction Requirements	Virus Log Reduction Requirements
< 1,000	3	4
> 1,000 – 10,000	4	5
>10,000 – 100,000	5	6

Source: Surface Water Treatment Rule Guidance Manual available at http://www.epa.gov/safewater/disinfection/lt2/compliance.html

MPN = most probable number

Reduction of *Cryptosporidium* is regulated under the LT2ESWTR. Source water monitoring required under this rule resulted in utility assignment to one of four “bins” according to average levels of *Cryptosporidium* in their source water. As shown in Table 4.4, the bin assignments have associated treatment requirements ranging from no additional treatment to a required 2.5 logs. The treatment requirements listed in Table 4.4 apply to the water purveyors if a conventional or direct treatment process is used. Requirements for alternative filtration technologies are determined by DDW.

The City of Lodi’s SWTF is classified in Bin 1 and thus does not require supplemental treatment for *Cryptosporidium* inactivation.

The CVRWQCB is working to develop a Drinking Water Policy for source water as an amendment to the Basin Plan, which includes a proposed narrative objective for *Cryptosporidium* and *Giardia* using numeric triggers tied to USEPA's drinking water requirements based on *Cryptosporidium* concentrations. Proposed language includes, “water shall not contain *Cryptosporidium* or *Giardia* in concentrations that adversely affect the public water system component of the municipal beneficial use.” The policy will include opportunities

for drinking water utilities that detect contaminants in their source water to contact the CVRWQCB who will aid in an investigation to locate the source and eliminate or control the quality of the discharge. The Drinking Water Policy was approved by the State Water Board on December 3, 2013.

Table 4.4. US EPA LT2ESTWR Bin Assignment for *Cryptosoridium* Reduction Requirements

Bin Number	Average *Cryptosporidium* Concentration	Additional Treatment Requirements [1]
1	<0.075 /L	No additional treatment
2	≥ 0.075 /L and < 1.0 /L	1-log additional treatment
3	≥ 1.0 /L and < 3.0 /L	2-log additional treatment [2]
4	≥ 3.0 /L	2.5-log additional treatment b

[1] *For conventional treatment systems in full compliance with the SWTR, IESWTR, and LT1ESWTR*
[2] *Utilities falling under Bins 3 or 4 must meet 1.0-log of the required treatment using ozone, UV, membranes, bag filtration, cartridge filtration, or bank filtration.*

4.2.1.3 TURBIDITY

Turbidity is a concern in drinking water because it can reduce the effectiveness of disinfection by shielding microorganisms. It is also used as a surrogate measure for potential pathogenic contamination and as a measure of filtration performance.

The IESWTR included new requirements for filtered water turbidities. In particular, it introduced monitoring of individual filter effluents, rather than just combined filter effluent. The rule requires that individual filter effluent turbidities not be greater than 1.0 nephelometric turbidity units (NTU) in any two consecutive (15 minute interval) samples at any time, or greater than 0.5 NTU after the filter has been in operation for four hours. Individual filters exceeding these standards are subject to a Comprehensive Filter Evaluation. The rule also requires that combined filter effluent turbidities be less than 0.3 NTU in ninety-five percent of samples collected each month.

4.2.2 Disinfectants and Disinfection By-Products

DBPs are produced through the reaction of chemical disinfectants with natural organic matter (NOM) present in the source water. DBPs are a concern due to a number of confirmed or suspected health effects, including increased rates of cancer, miscarriages and developmental defects. The DBPs of greatest concern to the SWTF are TTHMs and haloacetic acids (HAA).

TTHMs and HAA form through the interaction of chlorine with NOM in the source water. The SWTF uses sodium hypochlorite for disinfection, which can contribute chlorine as Cl_2 to react with NOM to produce these DBPs. Under the Stage 2 D/DBP Rule, both TTHMs and HAA are regulated based on samples collected at locations within the distribution system, which were identified from the Initial Distribution System Evaluation (IDSE) and which represent maximum TTHM and HAA concentrations. Compliance is based on a locational running annual average (LRAA) of quarterly samples collected at each sample location.

The SWTF collects annual samples of TTHM and HAAs at the intake as the water enters the distribution system. Daily samples of TOC, a precursor to DBPs, are collected at the WID intake.

The MCLs for DBPs are summarized in Table 4.5. Table 4.5 also includes maximum residual disinfectant levels (MRDLs) which regulate the disinfectant concentrations in the distribution system based on a system-wide annual average. All values are from the US EPA Stage 1 and 2 D/DBP Rules, which supersede previous DBP regulations.

Table 4.5. US EPA Stage 1 and 2 D/DBP Rules Disinfectants and Disinfection By-product Limits

Disinfection By-Products	
DBP	Maximum contaminant level
Trihalomethanes	80 µg/L
Haloacetic acids	60 µg/L
Disinfectant	Maximum residual disinfectant level
Chlorine	4 mg/L
Chloramines	4 mg/L

4.2.3 Chemical Contaminants

Chemical contaminants are regulated under the National Primary Drinking Water Regulations. In addition to the primary standards, secondary standards have been established for fifteen additional parameters. US EPA does not enforce these Secondary MCLs. They are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor and are not considered to present a risk to human health at the secondary level.

The federal and state primary and secondary drinking water standards are listed in Appendix G. Each contaminant generally has an established MCL: the highest level of the contaminant allowed in drinking water. Some contaminants have a treatment technology requirement in lieu of or in addition to the MCL. In some cases, DDW has established regulatory levels that are more stringent than the federal requirements; these MCLs are also listed in Appendix G. A number of the contaminants are associated with agriculture, including pesticides and herbicides.

The state also establishes health-based Notification Levels (NLs) for selected emerging contaminants for which MCLs have not yet been established. Detection of contaminant levels that exceed the NL may require utilities to take further action, such as public notification or switching to an alternative source.

4.2.4 Emerging Contaminants

Emerging contaminants are chemical and microbial contaminants that are not currently regulated, but may be regulated in the future. Two main sources of information are the US EPA's Contaminant Candidate List (CCL) and Information Collection Rule (ICR). Additional contaminants have been identified by DDW.

CCLs have been published in 1998, 2005, and 2009. A draft CCL has been published in 2015. The purpose of the CCL is to identify contaminants not yet subject to regulation but that are known or anticipated to occur in public water systems, and may require future regulation under the SDWA. The CCL classified contaminants as either being ready for regulatory determination, or in need of further research pertaining to one or more of the following: health effects, treatability, analytical methods, and occurrence. The list includes, among others, pesticides, disinfection byproducts, chemicals used in commerce, waterborne pathogens, pharmaceuticals, and biological toxins. The Draft CCL 4 (April 2015) includes 100 chemicals or chemical groups and twelve microbiological contaminants

Contaminants requiring further information on occurrence have been monitored under the Unregulated Contaminant Monitoring Rule (UCMR). EPA collects data for contaminants suspected to be present in drinking water, but that do not have health-based standards set under the Safe Drinking Water Act (SDWA). Every five years EPA reviews the list of contaminants, largely based on the CCL and regulates monitoring for up to thirty contaminants. The history of the UCM program includes:

- UCMR 3 (2012-2016) – Current regulation monitoring for 30 contaminants (28 chemicals and 2 viruses) from 2012-2015.
- UCMR 2 (2007-2011) - UCMR 2 monitoring was managed by EPA and established a new set of 25 chemical contaminants sampled during 2008-2010.
- UCMR 1 (2001-2005) – The SDWA Amendments of 1996 redesigned the UCM program to incorporate a tiered monitoring approach and required monitoring for 25 contaminants (24 chemicals and one bacterial genus) during 2001-2003.
- UCM-State Rounds 1 & 2 (1988-1997) – State drinking water programs managed the original program and required public water systems (PWSs) serving more than 500 people to monitor contaminants.

UCMR 3 includes monitoring under each of the three types of monitoring, as follows:

- Assessment Monitoring uses common analytical method technologies used by drinking water laboratories. For UCMR 3, all PWSs serving more than 10,000 people will monitor for 21 List 1 contaminants during a 12-month period from January 2013 through December 2015.
- Screening Survey monitoring uses specialized analytical method technologies not as commonly used by drinking water laboratories. All PWSs serving more than 100,000 people are required to monitor for seven List 2 contaminants during a 12-month period from January 2013 through December 2015.
- Pre-Screen Testing uses newer method technologies not as commonly used by drinking water laboratories. For UCMR 3, EPA will select 800 representative PWSs serving 1,000 or fewer people that do not disinfect. These PWSs with wells that are located in areas of karst

or fractured bedrock, will participate in monitoring for two List 3 viruses during a twelve-month period from January 2013 through December 2015.

Table 4.6 identifies the List 1, 2, and 3 contaminants.

Table 4.6. US EPA UCMR 3 Monitoring List

List 1 Assessment Monitoring	List 2 Screening Survey	List 3 Pre-Screen Testing
1,2,3-trichloropropane 1,3-butadiene chloromethane (methyl chloride) 1,1-dichloroethane bromomethane (methyl bromide) chlorodifluoromethane (HCFC-22 bromochloromethane (halon 1011 1,4-dioxane vanadium molybdenum cobalt strontium chromium[1] chromium-6 Chlorate perfluorooctanesulfonate acid (PFOS perfluorooctanoic acid (PFOA) perfluorononanoic acid (PFNA) perfluorohexanesulfonic acid (PFHxS) perfluoroheptanoic acid (PFHpA) perfluorobutanesulfonic acid (PFBS)	17-β-estradiol 17-α-ethynylestradiol (ethinyl estradiol) 16-α-hydroxyestradiol (estriol) equilin estrone testosterone 4-androstene-3,17-dione	enteroviruses noroviruses

[1] *Monitoring for total chromium – in conjunction with UCMR 3 Assessment Monitoring – is required under the authority provided in Section 1445(a)(1)(A) of SDWA.*

DDW has also identified a number of new and emerging contaminants. These include arsenic, chromium-6, manganese, methyl tert-butyl ether (MTBE), nitrate and nitrite, N-Nitrosodimethylamine (NDMA) and other nitrosamines, perchlorate, and 1,2,3-trichloropropane. The current health-based state MCL for MTBE is 13 µg/L, with a secondary standard of 5 µg/L due to taste and odor concerns. MTBE concentrations in the Mokelumne River were non-detect (less than 3 µg/L) in all samples.

4.2.4.1 CHROMIUM-6

The State of California currently regulates chromium-6 under the 50 micrograms per liter (µg/L) MCL for total chromium and 10 µg/L for chromium-6. The MCL was established to address exposures to chromium-6, which is considered to be the more toxic form of chromium. California adopted the "National Interim Drinking Water Standard" for chromium of 50 µg/L in 1977. The

US EPA adopted the same standard, but in 1991 raised the federal MCL to 100 µg/L. California retained its 50 µg/L MCL for total chromium. In 1999, California began to review the MCL which subsequently resulted in a state law requiring DDW to adopt a chromium-6-specific MCL. On July 27, 2011, Cal EPA's Office of Environmental Health and Hazard Assessment (OEHHA) established its Public Health Goal (PHG) for chromium-6 at a concentration of 0.02 µg/L. The availability of a final PHG enables DDW to proceed with setting a primary drinking water standard. Effective July 1, 2014, DDW established the MCL for chromium-6 to be 10 µg/L.

Total chromium concentrations in the Mokelumne Rive raw water averaged 1.74 µg/L.

4.2.4.2 1,2,3-TRICHLOROPROPANE

In 1999, DDW established the current 0.005 µg/L drinking water notification level for 1,2,3-Trichloropropane (1,2,3-TCP). The notification level is at the same concentration as the analytical reporting limit. Given the number of source waters with 1,2,3-TCP detections, the early steps of the regulatory process began in 2004 with the request for a PHG from OEHHA. In August 2009, OEHHA established a 0.7 nanograms per liter (ng/L) PHG for 1,2,3-TCP. DDW is currently developing an MCL for 1,2,3-TCP, but it is not currently regulated. 1,2,3-TCP was not measured by the SWTF.

4.2.4.3 1,4-DIOXANE

1,4-Dioxane was used as a stabilizer for solvents and is a probable human carcinogen. In November 2010, DDW revised the drinking water notification level for 1,4-dioxane from 3 µg/L to 1 µg/L. The response level, at which the source is recommended for removal from service, is 35 µg/L. Drinking water systems are not required by state regulations to monitor for 1,4-dioxane. 1,4-dioxane data is not available for the Lower Mokelumne River.

4.2.4.4 NDMA AND OTHER NITROSAMINES

NDMA and other nitrosamines are reasonably considered to be human carcinogens. The contribution to the body from food and from what is produced inside the body is much larger than that from drinking water, which has a contribution less than 0.1%. DDW established a notification level in 1998 for NDMA. US EPA subsequently published laboratory Method 521 for nitrosamines in drinking water, for which monitoring is required. Given the NDMA detections associated with drinking water sources and treatment, NDMA is a good candidate for future regulation. OEHHA (2006) established a 3 ng/L PHG for NDMA. An MCL for NDMA will likely not be available for several years, so 10 ng/L notification level will continue to be used to provide information to local governing agencies and consumers.

4.3 Mokelumne River Flow Data

Flows into the Lower Mokelumne River are controlled at the Camanche Dam, the outlet for the Camanche Reservoir. EBMUD manages the 431,000 acre-foot (ac-ft) Camanche Reservoir to provide flood control, irrigation water supply, municipal and industrial water supply, power generation, fishery protection, and recreation for the Central Valley and San Francisco Bay Area. The flows below the Camanche Reservoir outlet are summarized in Figure 4-1.

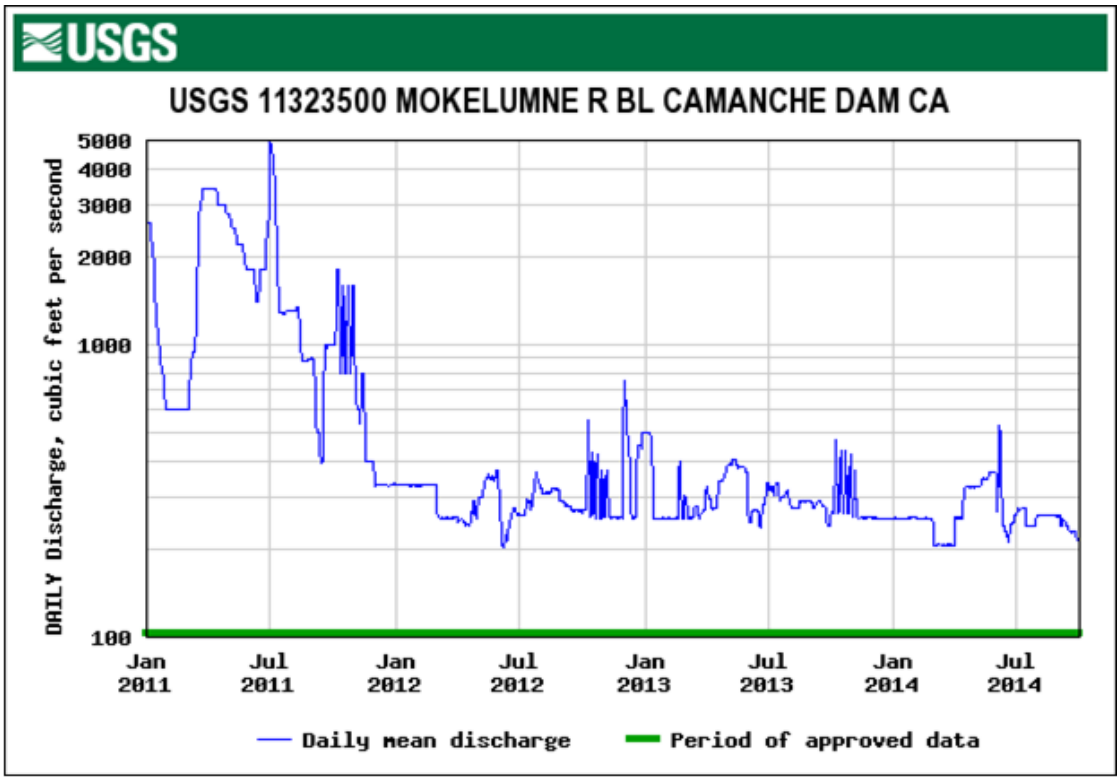

Figure 4-1. Mokelumne River Flows Below Camanche Dam, 2011-2014

Figure 4-1 shows fluctuations in daily mean discharge from the Camanche Reservoir from January 2011 to September 2014. Discharge rates are controlled by EBMUD; Cal EPA has final jurisdiction. Discharge rates have shown no specific seasonal patterns other than rapid daily fluctuations in September and October. Water levels in the Camanche Reservoir vary primarily depending on precipitation, irrigation water storage needs, and fish conservation strategies. Through contracting in 2003, EBMUD, WID, and the City of Lodi jointly manage stream flows in the Lower Mokelumne River.

The Woodbridge Dam, located ¼ miles downstream of the SWTF intake, is a weir dam that operates an inflatable bladder system. The resulting impoundment creates Lodi Lake and allows water to enter the WID Canal system and the intake to the SWTF. The bladder system is not operated for 4-6 weeks in the year, typically in February, at which time Lodi Lake and the WID Canal system are dry. Prior to SWTF operation, Lodi Lake and the WID Canal system were dry from October to April. Flows below the Woodbridge Dam are summarized in Figure 4-2. Flows into the WID Canal are summarized in Figure 4-3.

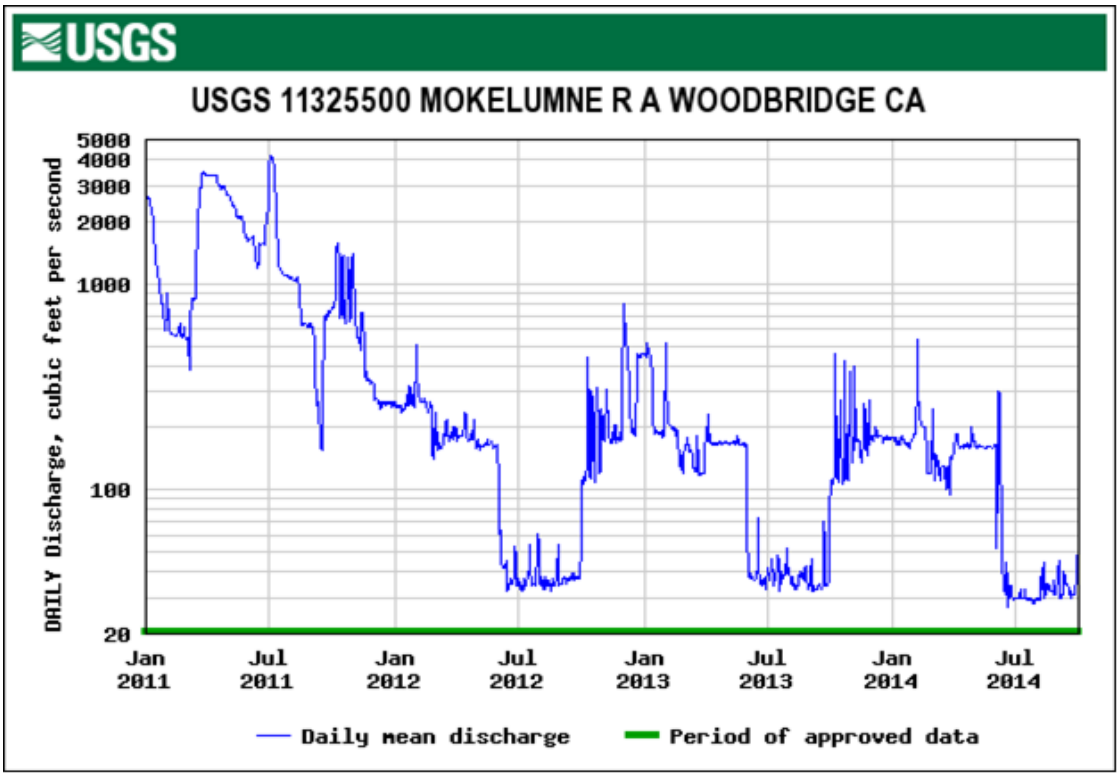

Figure 4-2. Flows Below the Woodbridge Dam, January 2011 - September 2014

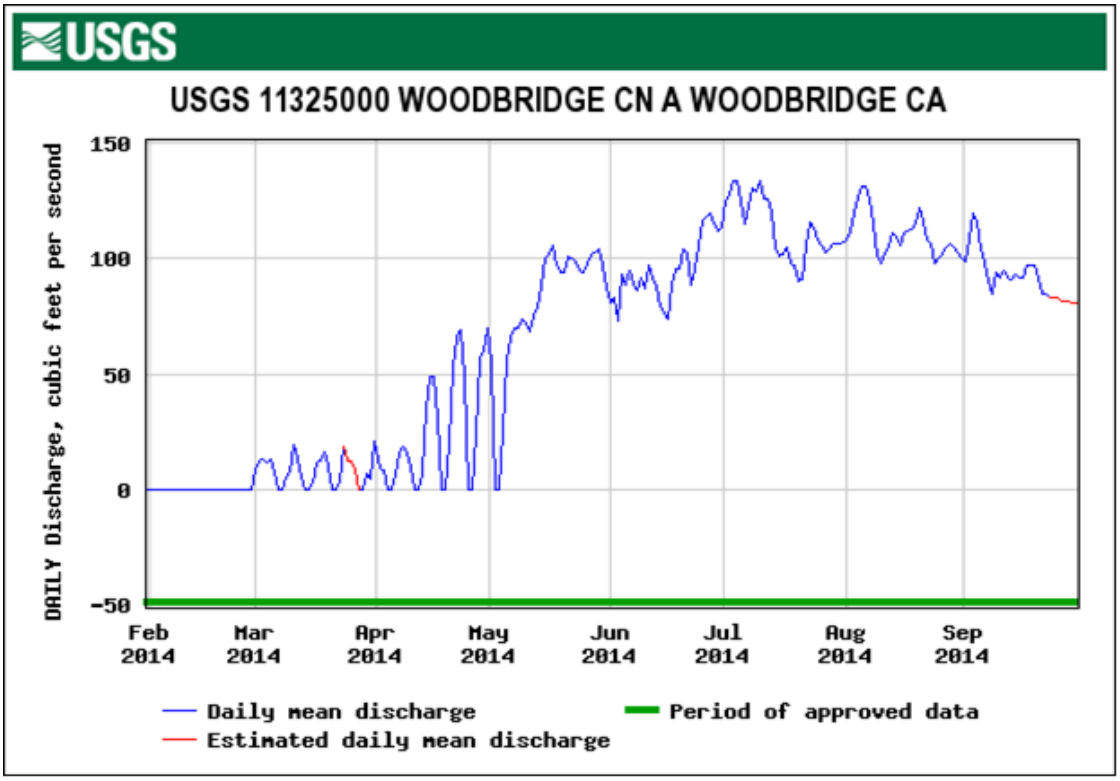

Figure 4-3. Flows in the WID Canal, February 2014 - September 2014

The figures demonstrate that there is no correlation between flows in the WID Canal and flows through the Woodbridge Dam. Discharge at the Woodbridge Dam follows a season pattern of high flows from October to April and low flows from May to September. Data for discharge in the WID Canal is only provided for 2014 because of the changes in flow control into the WID Canal and Lodi Lake that occurred after the SWTF was constructed.

Figure 4-1 summarizes the monthly precipitation in Lodi.

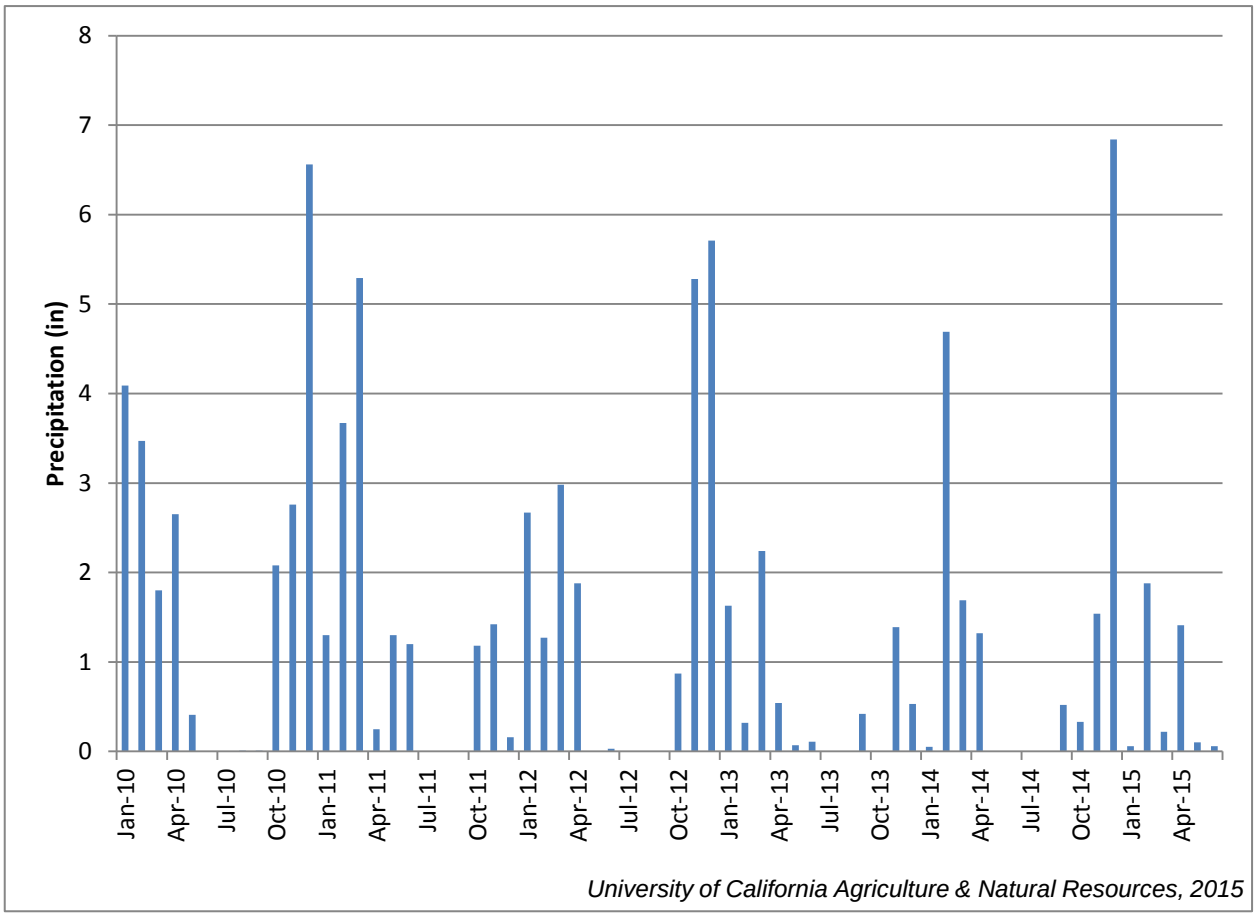

Figure 4-4. Total Monthly Precipitation in Lodi, California, 2010 – 2015

4.4 Review of Water Quality Data

This section summarizes the water quality conditions based on available data from 2006-2007 and 2010-2015 within the Lower Mokelumne River Watershed study area. The previous 2010 Watershed Sanitary Survey described water quality data for the Lower Mokelumne River at the WID Canal from 2006-2007 and in 2010. This survey also compares limited water quality data to treated water upon exiting the SWTF.

The Basin Plan (Appendix F) specifies that water designated for use as domestic or municipal supply shall not contain concentrations of chemical constituents in excess of the MCLs specified

in the provisions of Title 22 of the CCR (DDW 2010). MCLs are intended to be applied to finished tap water, but were applied to untreated water in this study as a basis for comparison.

4.4.1 Description of Sample Locations

Table 4.7 summarizes the raw water quality sampling organizations used in the analysis in this Watershed Sanitary Survey. From 2006-2007, the City of Lodi Public Works Department (PWD) sampled raw water quality about 600 feet downstream of the WID Intake, at the bridge over the WID Canal on Orange Street. From 2010-2014, PWD sampled water at the intake to the WID Canal. Sampling sites near the intake are shown in Figure 4-5.

Table 4.7. Water Sampling Overview

Sampling Organization	Location	Sampling Dates	Water Quality Parameters
City of Lodi Public Works Department	Downstream of WID Intake (Canal)	2006-2007	Inorganics, metals, microbes, alkalinity, pH, turbidity, hardness
City of Lodi Public Works Department	WID Intake	2010-2014	Inorganics, metals, microbes, alkalinity, pH, turbidity, hardness
Storm Drain Detectives	Storm drains along Mokelumne River. See Figure 4-6	2007-2015	Turbidity, TDS, pH, D.O., Nitrate as N
City of Lodi (Data from Moore-Twining Laboratory)	WID Intake	January 2013, January 2014	VOCs, inorganics, microbes, metals, pH, alkalinity, hardness, turbidity

As part of the Storm Water Management Plan, the City of Lodi initiated the SDD program in 2007 to sample water at storm drain discharge points along the Mokelumne River. One or two times per month, students from local high schools work with City volunteers to take water samples of the Mokelumne River at 12 storm water discharge sites. Figure 4-6 provides a map to show where these sites are located. It is noted that sampling is sparse during the summer months and that some data has been omitted to account for potential sampling and recording errors.

Once per year, the City is required to organize a full water quality suite to measure a comprehensive list of water quality parameters. In January 2013 and January 2014, the City conducted a full suite for raw water taken at the WID Intake; the data was provided by Moore-Twining Laboratory. Included in the testing data are volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), inorganics, metals, turbidity, alkalinity, microorganisms, pH, and hardness.

The January 2013 and 2014 full suite samples were taken at the 2010 – 2014 Sampling Site as well

Figure 4-5. Location of Public Works Department Sampling Sites

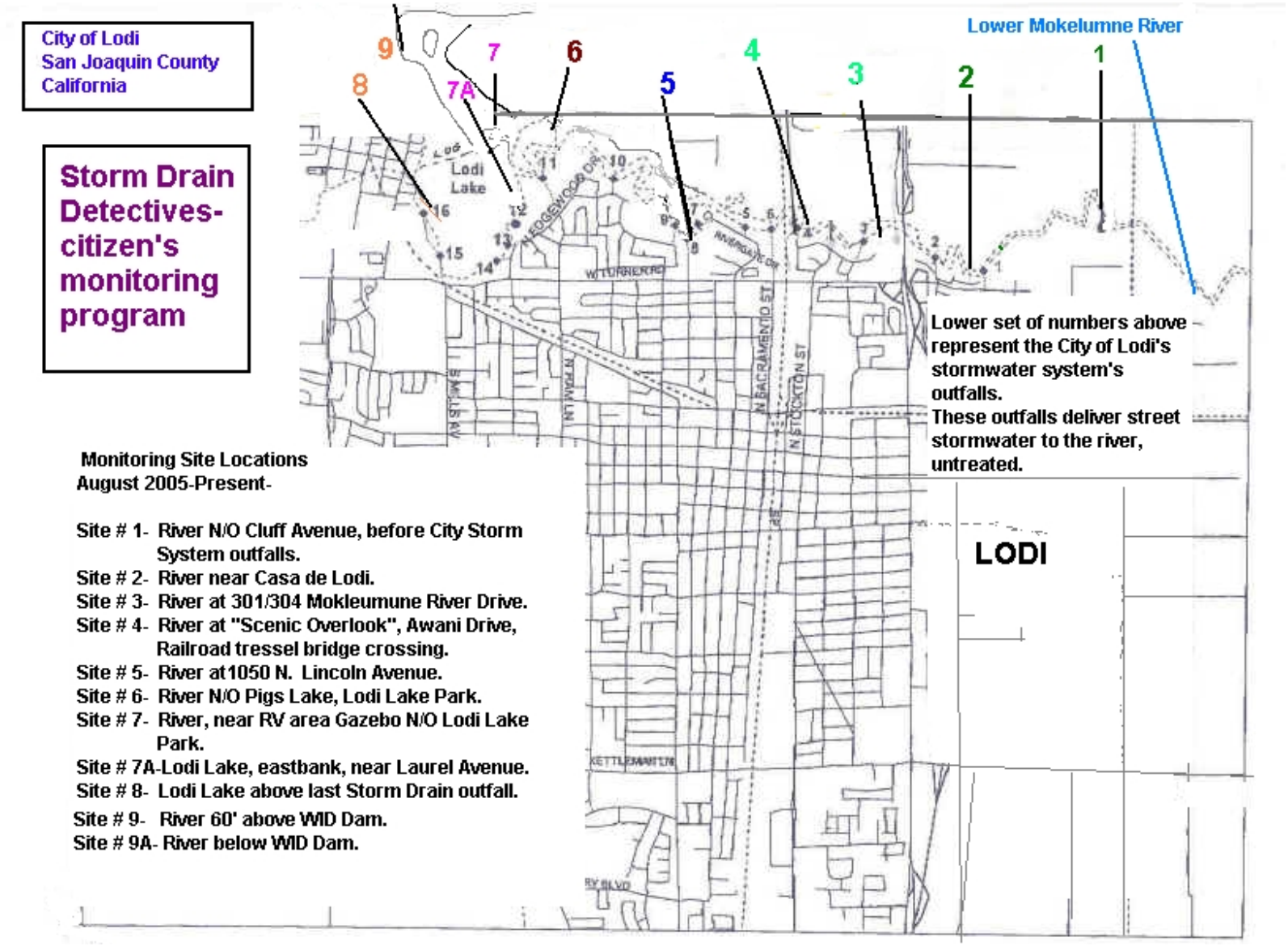

Figure 4-6. Map of Storm Drain Detective Sampling Sites

The data indicates that water quality is very good at the intake. Average values for most analytes were reported just above reporting limits. Few maximum values approached MCLs. Iron was the only constituent with concentrations that exceeded its MCL. Because the water sampled is raw, the SWTF can provide treatment as necessary to further lower constituent concentrations.

Comparison of average values from 2010-2014 with 2010 and 2007 averages for the measured analytes demonstrate that generally, water quality conditions have remained stable over time. Exceptions to this generalization are pH, total coliform, and E. coli counts. pH averages increased from 7.20 (2007) to 8.10 (2010), but then fell slightly to 7.77 (2010-2014). There may be sampling bias in the data to cause the disparity in values.

It is important to note that the PWD changed total coliform measurement technology in March 2012. Before March 2012, PWD was using IDEXX Multi-Tube ISO 9038 with up to 3 dilutions, which could only measure coliform up to 1600 col/mL. From March 2012 to October 2013, PWD changed to Multi-Tube with 4 dilutions, which increased its coliform range to above 1600, detecting levels much higher than before March 2012. From November 2013 onward, PWD has been measuring coliform levels with IDEXX Quanti-Tray, which provides more accuracy in high coliform levels. The changes in technology over time has provided more precision, but accuracy should remain constant over time, including in lower level accuracy. All methods for measuring coliform have been standard.

Previously, coliform could only be measured to 1600 col/mL. The impacts of the transfer in technology is discussed further in Section 4.4.3. Between 2007 and 2010-2014, E. coli concentrations have increased by about 300 percent on average in the raw water.

The data suggests that raw water quality along the Lower Mokelumne River is, in general, consistent. Notable outliers in the SDD data include:

- Elevated total dissolved solids concentration at Site #8 (Lodi Lake)
- Elevated turbidity at Site #2 (near Casa de Lodi) and #5 (1050 N Lincoln)
- Occasional high nitrate events at Site #1 (upstream of Lodi), #2 (near Casa de Lodi), and #8 (Lodi Lake)

Because the sampling sites are located close to storm water discharge points, it is expected that maximum turbidity, nitrate, and dissolved oxygen values will fluctuate widely across sampling sites. Some sampling may have occurred close to storm events, which may cause unusual spikes in constituent concentrations. Additionally, the variability in sampling size may cause bias to the average data provided. Data points retrieved ranged from 1 to 156 sampling events per site. Other variability may arise through frequent turnover in student groups who may use different sampling techniques.

SDD data collected on the water quality parameters above is further analyzed in Section 4.4.3.

4.4.2 Summaries of Water Quality Data

Tables 4.8 through 4.10 provide summaries of water quality data from the samples described above. In table 4.8, data points were taken approximately once monthly in 2010-2014. The averages taken are for sampling results from April 2010-December 2014, excluding data from the 2010 Watershed Sanitary Survey. 2010 and 2007 averages are taken from data compiled in the 2010 Watershed Sanitary Survey. The full set of data from 2006-2007 and 2010 sampling are presented in Appendix H.

Trends and in-depth analysis on the major constituents studied in the survey are provided in Section 4.4.3.

Table 4.8. Summary of Water Quality Data at the WID Intake, 2010 - 2014

Constituent	Units	MCL[2]	Minimum	Maximum	Average[1]	2010 Average (2010 WSS)	2007 Average (2010 WSS)
pH	SU		6.30	9.10	7.77	8.10	7.20
Temp	Deg C		7.90	22.20	14.54		
Turbidity	NTU		1.00	19.38	3.53	2.10	2.40
Total Coliform[3]	col/100ml		30.00	11006.91	2145.78	1250.00	1600.00
E. coli	MPN/100mL		2.00	900.00	121.72	134.00	38.00
Giardia	Cysts/L		ND[4]	1.65	0.24	0.35	0.18
Crypto.	Oocysts/L		ND	0.14	0.02	0.10	0.05
Peak TOC	mg/L		1.20	3.70	1.90	1.70	1.80
DOC	mg/l		1.00	4.10	1.85	1.40	1.60
Color	SU		5.00	12.00	7.08	5.00	
Odor	TON		1.00	20.00	4.94	1.00	
Peak Alkalinity	mg/L		12.00	48.00	19.26		20.00
Bicarbonate Alk.	mg/l		16.00	59.00	24.65	20.00	
Carbonate Alk.	mg/l		ND	ND	--[5]	<2.5[6]	
Hydroxide Alk.	mg/l		ND	ND	--	<2.5	
Hardness	mg/l		7.80	18.00	14.49	16.00	15.00
Uranium	pCi/L	20	ND	5.21	0.68		
Gross Alpha	pCi/L	15	ND	1.00	0.25		
Chloride	mg/l	250.00	ND	4.90	2.31		2.60
Fluoride	mg/l	500.00	ND	0.072 (J)7	--		
Nitrite	mg/l	1	ND	ND	--		

Constituent	Units	MCL[2]	Minimum	Maximum	Average[1]	2010 Average (2010 WSS)	2007 Average (2010 WSS)
Nitrate	mg/l	10	ND	0.96 (J)	--		
Sulfate	mg/l		ND	2.30	1.35		2.40
MBAS	mg/l		ND	ND	ND		
Cyanide	µg/L	0.15	ND	ND	ND		
Aluminum	µg/L	1000.00	36.00	110.00	72.56		
Antimony	µg/L	6.00	ND	0.76 (J)	--		
Arsenic	µg/L	10.00	ND	ND	0.00		
Barium	µg/L	1000.00	15.00	20.00	17.38		
Beryllium	µg/L	4.00	ND	ND	--		
Cadmium	µg/L	5.00	ND	ND	--		
Chromium	µg/L	50.00	ND	0.96 (J)	--		5.00
Copper	µg/L	1300.00	ND	1.8 (J)	--		5.00
Iron	µg/L	50.00	ND	160.00	98.76		120.00
Lead	µg/L	15.00	ND	0.11 (J)	--		
Manganese	µg/L	50.00	ND	18.00	9.74		12.10
Mercury	µg/L	2.00	ND	0.11 (J)	--		
Nickel	µg/L	100.00	ND	0.53 (J)	--		
Potassium	mg/l		ND	1.20	0.65 (J)		
Selenium	µg/L	50.00	ND	0.28 (J)	--		
Silver	µg/L	100.00	ND	0.00	--		
Thallium	µg/L	2.00	ND	0.00	--		
Zinc	µg/L	5000.00	ND	4.6 (J)	--		11.00
Perchlorate	µg/L	6	ND	0.00	--		

[1]*All data are provided in Appendix H*
[2]*All applicable MCLs provided*
[3]*Total Coliform average listed is from 2013-2014 due to measurement technology change*
[4]*ND Below the detection limit*
[5]*-- Average does not apply because of imprecision in data below detection limit*
[6]*< Less than the reporting limit for this analysis*
7(J) Estimate of the true value; value fell below reporting limit
µg/L micrograms per Liter
mg/L milligrams per Liter

Table 4.9. Summary of Storm Drain Detective Data

	Upstream ←									→ Downstream	
Constituent	Site #1	Site #2	Site #5	Site #6A	Site #6B	Site #7	Site #7A	Site #8	Site #9	Site #9A	Average
Minimum pH	5.5	5.5	5.6	--[2]	--	6.0	6.5	6.3	7.1	5.0	5.9
Maximum pH	9.6	9.3	8.5	--	--	9.3	8.8	9.3	8.1	9.0	9.0
Mean pH[1]	7.7	7.8	7.3	7.6	7.8	7.6	7.5	7.8	7.7	7.6	7.7
Minimum Dissolved Oxygen (mg/L)	4.9	5.4	7.0	--	--	7.4	6.7	5.8	7.7	3.3	6.0
Max. Dissolved Oxygen (mg/L)	13.0	13.8	12.6	--	--	13.4	11.5	13.0	10.5	12.5	12.5
Mean Dissolved Oxygen (mg/L)	9.8	9.7	9.7	9.6	9.4	9.6	9.2	9.4	9.2	9.5	9.5
Minimum Turbidity (NTU)	0.0	0.1	0.0	--	--	0.1	1.5	1.1	0.3	0.6	0.5
Maximum Turbidity (NTU)	50.0	70.0	59.4	--	--	14.8	7.4	23.8	4.9	24.7	31.9
Mean Turbidity (NTU)	3.7	5.3	9.2	3.1	3.2	2.8	3.8	4.5	1.8	3.7	4.1
Min. Total Dissolved Solids (µS)	0.0	0.0	20.0	--	--	20.0	30.0	5.0	30.0	30.0	16.9
Max. Total Dissolved Solids (µS)	90.0	60.0	70.0	--	--	80.0	60.0	1000.0	50.0	70.0	185.0
Mean Total Dissolved Solids (µS)	44.7	42.4	46.7	50.0	50.0	45.8	44.2	83.3	40.0	46.4	49.4
Maximum Nitrate, as mg/L Nitrogen	0.95	1.05	0.0	--	--	0.8	0.0	1.1	0.0	0.9	2.8
Mean Nitrate, as mg/L Nitrogen	0.1	0.1	0.0	--	--	0.0	0.0	0.1	0.0	0.0	0.0

Some data has been omitted to provide accurate averages and trends.
[1]Mean values are provided as arithmetic means for all data points collected. A complete data set for each site can be found in AppendixH.
[2]-- Sites #6A and #6B only had one data point, therefore maximum and minimum values do not apply

Table 4.10. Annual Organic, inorganic, and Metals Data, WID Intake 2013-2014

Constituent	1/29/2013 Results	1/23/2014 Results	MCL	Units
Semi-Volatile Organics				
3-Hydroxycarbofuran	J[1]	J	--[2]	µg/L
Aldicarb	J	J	--	µg/L
Aldicarb sulfone	J	J	--	µg/L
Aldicarb sulfoxide	J	J	--	µg/L
Carbaryl	J	J	--	µg/L
Carbofuran	J	J	18	µg/L
Methiocarb	J	J	--	µg/L
Methomyl	J	J	--	µg/L
Oxamyl	J	J	200	µg/L
Propoxur (Baygon)	J	J	--	µg/L
Aldrin	J	J	--	µg/L
Chlordane (tech)	J	J	2	µg/L
Chlorothalonil	J	J	--	µg/L
Dieldrin	J	J	--	µg/L
Endrin	J	J	2	µg/L
Heptachlor	J	J	0.4	µg/L
Heptachlor epoxide	J	J	0.2	µg/L
Hexachlorobenzene	J	J	1	µg/L
Hexachlorocyclopentadiene	J	J	50	µg/L
Lindane	J	J	0.2	µg/L
Methoxychlor	J	J	30	µg/L
PCBs	J	J	0.5	µg/L
Toxaphene	J	J	3	µg/L
Trifluralin	J	J	--	µg/L
Volatile Organics				
1,1,1,2-Tetrachloroethane	J	J	--	µg/L

Constituent	1/29/2013 Results	1/23/2014 Results	MCL	Units
1,1,1-Trichloroethane (TCA)	J	J	200	µg/L
1,1,2,2-Tetrachloroethane	J	J	1	µg/L
1,1,2-Trichloroethane	J	J	5	µg/L
1,1-Dichloroethane	J	J	5	µg/L
1,1-Dichloroethene	J	J	--	µg/L
1,2,3-Trichlorobenzene	J	J	--	µg/L
1,2,4-Trichlorobenzene	J	J	5	µg/L
1,2,4-Trimethylbenzene	J	J	--	µg/L
1,2-Dichlorobenzene	J	J	600	µg/L
1,2-Dichloroethane (1,2-DCA)	J	J	0.5	µg/L
1,2-Dichloropropane	J	J	5	µg/L
1,3,5-Trimethylbenzene	J	J	--	µg/L
1,3-Dichlorobenzene	J	J	--	µg/L
1,3-Dichloropropane	J	J	--	µg/L
1,4-Dichlorobenzene	J	J	5	µg/L
2,2-Dichloropropane	J	J	--	µg/L
2-Chloroethylvinyl ether	J	J	--	µg/L
2-Chlorotoluene	J	J	--	µg/L
4-Chlorotoluene	J	J	--	µg/L
Benzene	J	J	1	µg/L
Bromobenzene	J	J	--	µg/L
Bromochloromethane	J	J	--	µg/L
Bromodichloromethane	J	J	--	µg/L
Bromoform	J	J	--	µg/L
Bromomethane	J	J	--	µg/L
Carbon tetrachloride	J	J	0.5	µg/L
Chlorobenzene	J	J	--	µg/L
Chloroethane	J	J	--	µg/L

Constituent	1/29/2013 Results	1/23/2014 Results	MCL	Units
Chloroform	J	J	--	µg/L
Chloromethane	J	J	--	µg/L
cis-1,2-Dichloroethene	J	J	6	µg/L
cis-1,3-Dichloropropene	J	J	--	µg/L
Dibromochloromethane	J	J	--	µg/L
Dibromomethane	J	J	--	µg/L
Dichlorodifluoromethane (CFC-12)	J	J	--	µg/L
Di-isopropyl ether (DIPE)	J	J	--	µg/L
Ethyl tert-Butyl Ether (ETBE)	J	J	--	µg/L
Ethylbenzene	J	J	300	µg/L
Hexachlorobutadiene	J	J	--	µg/L
Isobutyl alcohol	J	J	--	µg/L
Isopropylbenzene	J	J	--	µg/L
m,p-Xylene	J	J	--	µg/L
Methyl tert-Butyl Ether (MTBE)	J	J	13	µg/L
Methylene chloride	J	J	--	µg/L
n-Butylbenzene	J	J	--	µg/L
n-Propylbenzene	J	J	--	µg/L
o-Xylene	J	J	--	µg/L
p-Isopropyltoluene	J	J	--	µg/L
sec-Butylbenzene	J	J	--	µg/L
Styrene	J	J	100	µg/L
Tert-Amyl Methyl Ether (TAME)	J	J	--	µg/L
tert-Butyl alcohol (TBA)	J	J	--	µg/L
tert-Butylbenzene	J	J	--	µg/L
Tetrachloroethene (PCE)	J	J	--	µg/L
Toluene	J	J	150	µg/L
Total 1,3-Dichloropropene	J	J	--	µg/L

Constituent	1/29/2013 Results	1/23/2014 Results	MCL	Units
Total Trihalomethanes	J	J	80	µg/L
trans-1,2-Dichloroethene	J	J	--	µg/L
trans-1,3-Dichloropropene	J	J	--	µg/L
Trichloroethene (TCE)	J	J	5	µg/L
Trichlorofluoromethane (CFC-11)	J	J	150	µg/L
Trichlorotrifluoroethane (CFC-113)	J	J	--	µg/L
Vinyl chloride	J	J	0.5	µg/L
Xylenes	J	J	1,750	µg/L
	Inorganics			
Bicarbonate Alkalinity as HCO_3	20	18	--	mg/L
Carbonate Alkalinity as CO_3	J	J	--	mg/L
Chloride	J	4.9	250	mg/L
Color (Apparent)[3]	*10*	*5.0*	*15*	*Color Units*
Cyanide (Total)	J	J	150	µg/L
Fluoride	J	J	2	mg/L
Hardness (Total)	16	16	--	mg/L
Hydroxide Alkalinity as OH	J	J	--	mg/L
Langelier Index	-2.42	-2.9	--	SI
Methylene Blue Active Substances	J	J	--	mg/L
Nitrate as NO_3	J	J	45	mg/L
Nitrite as N	J	J	1	mg/L
pH	7.1	6.6		pH Units
Specific Conductance (EC)	41	45	--	µS/cm
Sulfate as SO_4[3]	J	J	--	mg/L
Threshold Odor Number	1.0	3.0	--	T.O.N.
Total Alkalinity as $CaCO_3$	16	15	--	mg/L
Total Dissolved Solids[3]	28	14	500	mg/L
Turbidity	2.3	1.0	--	NTU

Constituent	1/29/2013 Results	1/23/2014 Results	MCL	Units
	Metals			
Aluminum[3]	62	36	1000	µg/L
Antimony	J	J	6	µg/L
Arsenic	J	J	10	µg/L
Barium	20	19	1000	µg/L
Beryllium	J	J	4	µg/L
Cadmium	J	J	5	µg/L
Calcium	4.1	4.1	--	mg/L
Chromium	J	J	50	µg/L
Copper	J	J	1,300	mg/L
Iron	*0.12*	*J*	*0.05*	*mg/L*
Lead	J	J	15	µg/L
Magnesium	1.3	1.3	--	mg/L
Manganese	0.0067	J	0.05	mg/L
Mercury	J	J	2	µg/L
Nickel	J	J	100	µg/L
Potassium	J	J	--	mg/L
Selenium	J	J	50	µg/L
Silver	J	J	100	µg/L
Sodium	2.5	2.8	--	mg/L
Thallium	J	J	2	µg/L
Zinc	J	J	5	mg/L

[1] *J* *Analyte concentration fell below the detection limit*
[2] *--* *Analyte does not have an MCL*
[3] *Secondary MCL for analyte*

The samples taken by the City of Lodi, with data provided by Moore-Twining Laboratory, are for water quality at the WID Intake. The data shows that iron exceeded its MCL in 2013, but was below the detection limit in 2014. The data indicates that none of the other analytes reached or exceeded their MCLs. Color was the only other constituent that approached (>50%) its MCL.

4.4.3 Analysis of Raw Water Constituents

This section analyzes the results of the raw water sampling data taken for the Mokelumne River. Water quality parameters are discussed, and connections to potential contaminant sources are explored.

4.4.3.1 PH, TEMPERATURE, AND ALKALINITY

The Basin Plan specifies that pH shall not be depressed below 6.5 nor raised above 8.5. There are several instances at the WID Intake and along the Mokelumne River when pH exceeded these limits, however pH rarely exceeded 9 or depressed below 6. Mean pH values tended to fall between 7.3-7.8. Therefore, raw water pH trends were generally consistent with the Basin Plan Water Quality Objective. Finished water pH was between 7-9 units. The SWTF controls finished water pH using soda ash feed, targeting a pH range of about 8-9 units. pH data for treated and raw water did not fall under the same data series and therefore could not be compared in this survey.

Figure **4-7** shows seasonal variation in raw water temperature at the intake. Water temperatures in winter ranged from approximately 9-15°C, while water temperatures in summer and fall ranged from approximately 15-22°C. Desired water temperatures are low because of the impact of high temperatures on fish in the Mokelumne River.

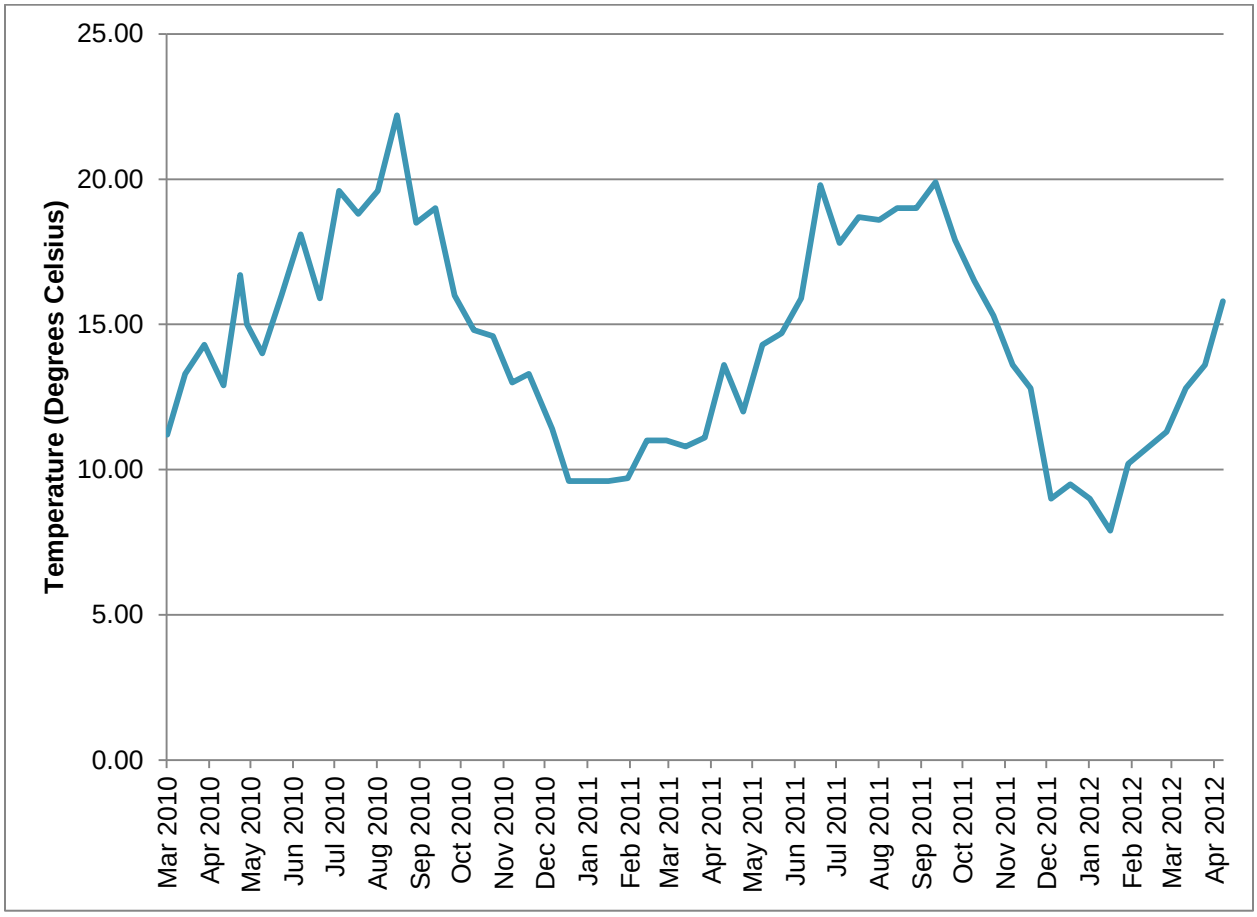

Figure 4-7. Raw Water Temperatures at WID Intake, 2010 – 2012

This low value for alkalinity indicates that the pH buffering capacity of the raw water is very low. When soda ash is added to the drinking water during treatment at the SWTF, the alkalinity is also raised. The goal for treated water at the SWTF is to have an alkalinity of 40 mg/L.

Figure 4-8 shows trends in alkalinity at the WID Intake from 2011-2014. Alkalinity typically remained consistent at the intake. The range was 12-22 mg/L, with an average of 16.4 mg/L. Most values fell between 15-17 mg/L. Occasional spikes are noted without relation to season. This low value for alkalinity indicates that the pH buffering capacity of the raw water is very low. When soda ash is added to the drinking water during treatment at the SWTF, the alkalinity is also raised. The goal for treated water at the SWTF is to have an alkalinity of 40 mg/L.

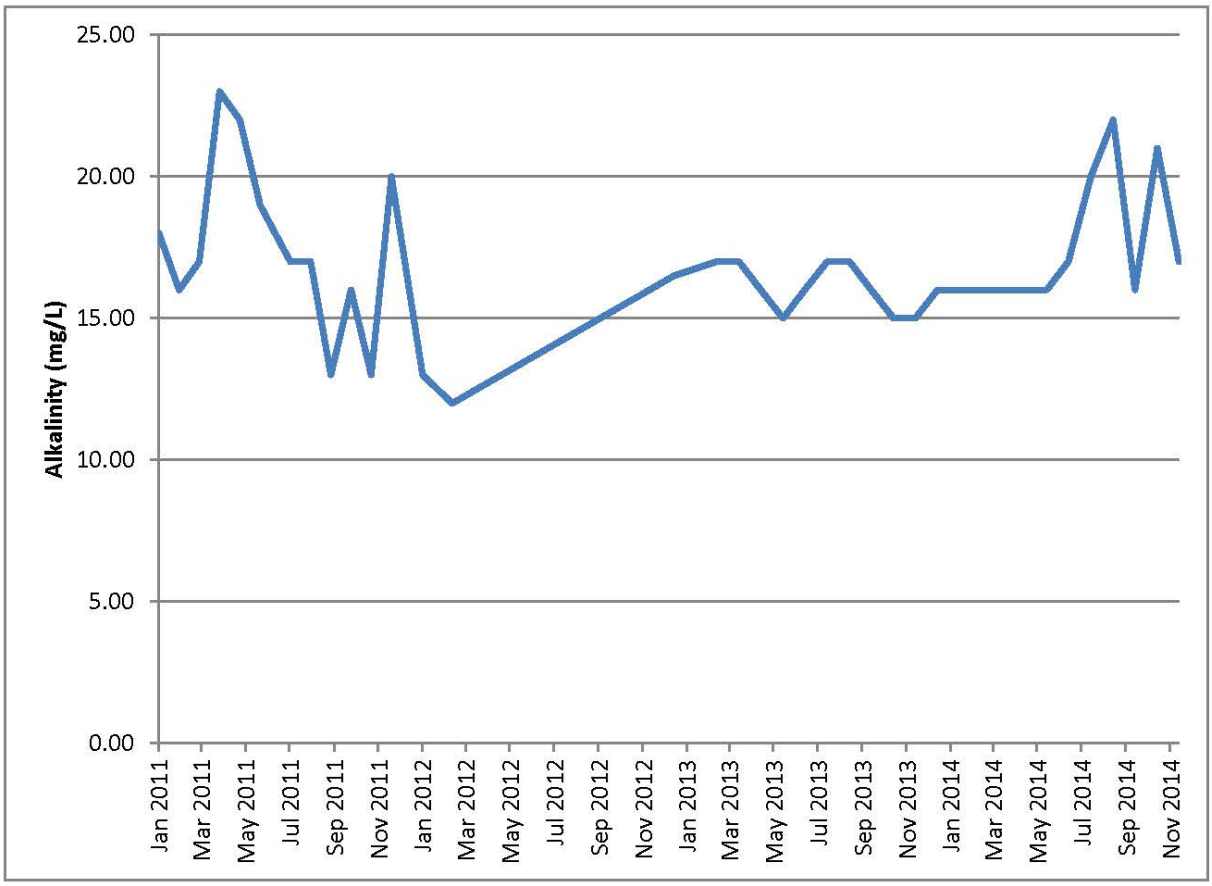

Figure 4-8. Raw Water Alkalinity at WID Intake, 2011 – 2014

4.4.3.2 TURBIDITY

Turbidity is a measure of cloudiness of water and is an indicator of microbiological water quality and filter efficiency. Turbidity spikes often occur during the winter months, potentially due to storm events that can stir up sediments.

At the intake, turbidity in raw water ranged from 1 to 19.38 NTU. Conventional water treatment and membrane treatment can generally accommodate turbidity events up to 10 NTU without pretreatment or increased backwash frequency. SDD data suggests that maximum turbidity

across the storm water drainage sites ranged from 3.1 to 70.0 NTU. These high turbidity values could have been sampled after storm events. Average turbidity over sites and sampling events was approximately 4.1 NTU, suggesting that the high turbidity events were uncommon.

Figure 4-9 shows turbidity fluctuations in raw water taken at the WID Intake and treated water from 2010-2014. No data for raw water was recorded for turbidity from April 2012 to January 2013. Treated water turbidity data collection started in November 2012 and is ongoing. Despite fluctuations in raw water turbidity, treated water turbidity remained constant and low, averaging approximately 0.016 NTU. The Interim Enhanced Surface Water Treatment Rule (IESWTR) requires combined filter effluent turbidity of less than 0.3 NTU in at least 95% of samples collected each month. Average monthly turbidity samples for treated water reflected turbidity levels that were approximately 20 times lower than the turbidity required by the IESWTR.

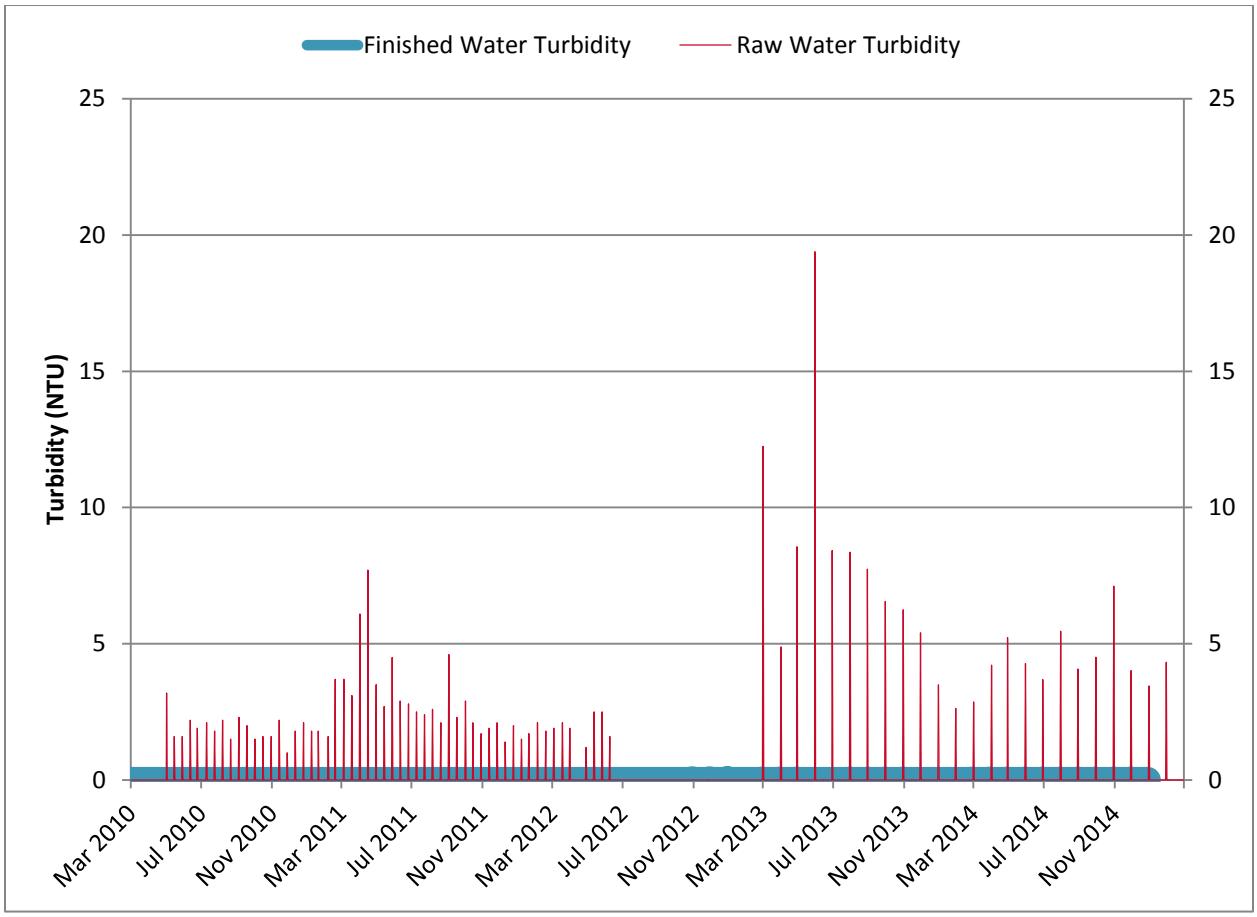

Figure 4-9. Raw and Finished Water Turbidity Fluctuations at WID Intake, 2010-2014

Figure 4-10 compares turbidity and precipitation events, demonstrating that there may be a correlation between turbidity and precipitation events. Turbidity was measured by SDD at Site #9A (just below the WID Dam); monthly average turbidity was compared to monthly average precipitation.

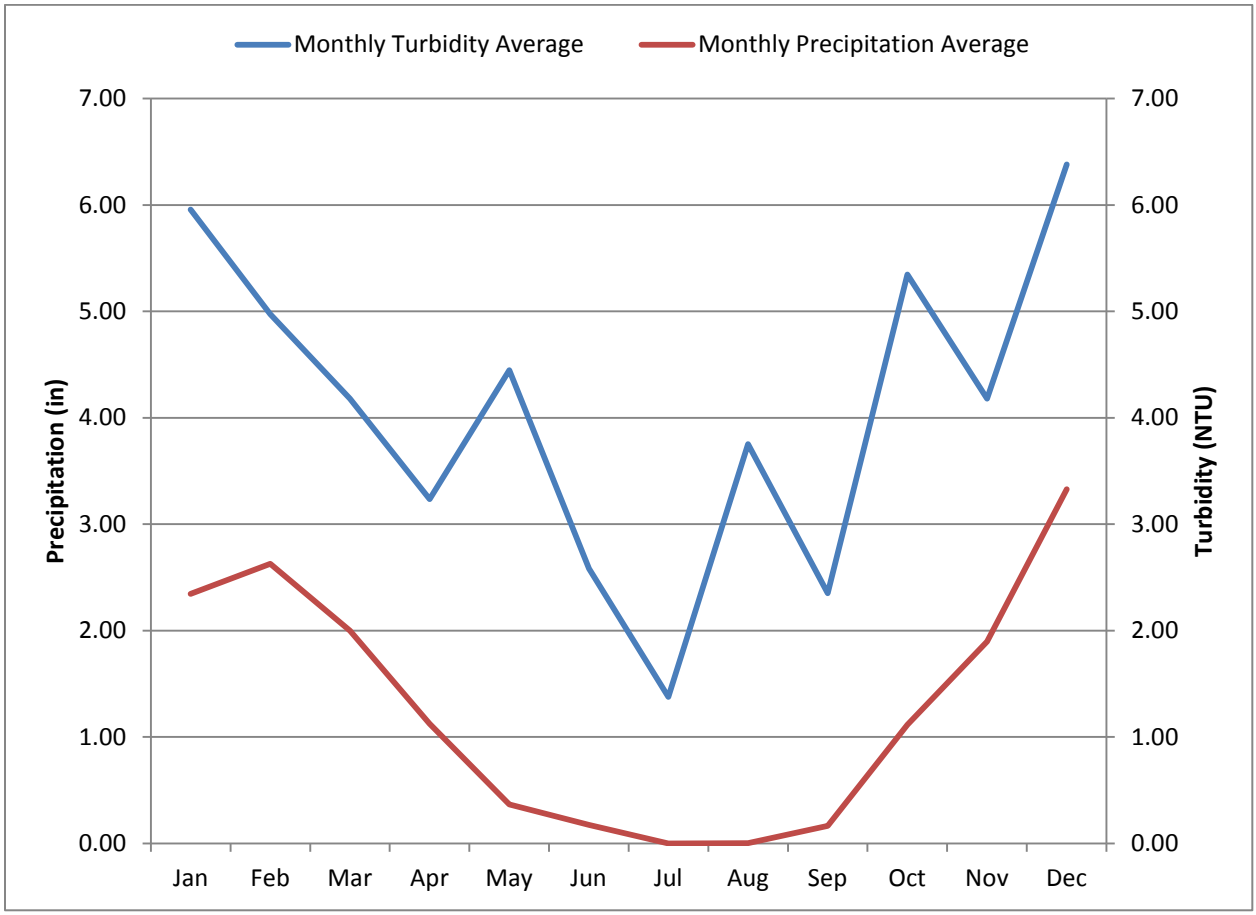

Figure 4-10. Precipitation and Turbidity Below WID Dam, 2007-2015

4.4.3.3 MICROBIOLOGICAL CONSTITUENTS

This section provides a summary and assessment of microbiological constituents in the Lower Mokelumne River. Constituents analyzed include total coliform, *E. coli*, *Cryptosporidium*, and *Giardia*. Typically, elevated concentrations of microbiological parameters are detected in the summer when water temperatures are the warmest and recreational use is the highest. The SWTF regularly monitors total coliform counts, which indicate bacterial presence, and takes approximately monthly samples of *E. coli*, *Cryptosporidium*, and *Giardia*. For all microbial constituents, Basin Plan Water Quality Objectives were used as benchmarks for comparison.

4.4.3.3.1 Total Coliform

Figure 4-11 shows monthly raw water total coliform time trends from 2010-2014. Prior to March 2012, the SWTF used measurement instrumentation that could only measure total coliform up to 1600 MPN/100 mL. While there was a maximum coliform count that could be measured, IDEXX, the manufacturer, indicated that accuracy of the results would not be impacted

(Personal Communication, July 2015). Therefore, the low-level values for coliform should not be skewed despite having a smaller range and will be accurate.

It appears that total coliform counts have increased steadily from 2010 to 2014. In 2010-2012, fewer than 50% of samples had coliform concentrations greater than 1600 MPN/100 mL. Additionally, in 2013-2014, after the SWTF began to measure coliform using four dilutions instead of just three, there were only three total readings under 1600 MPN/100 mL. The data indicates that there is an increasing trend in coliform levels at the WID Intake from 2010 to 2014.

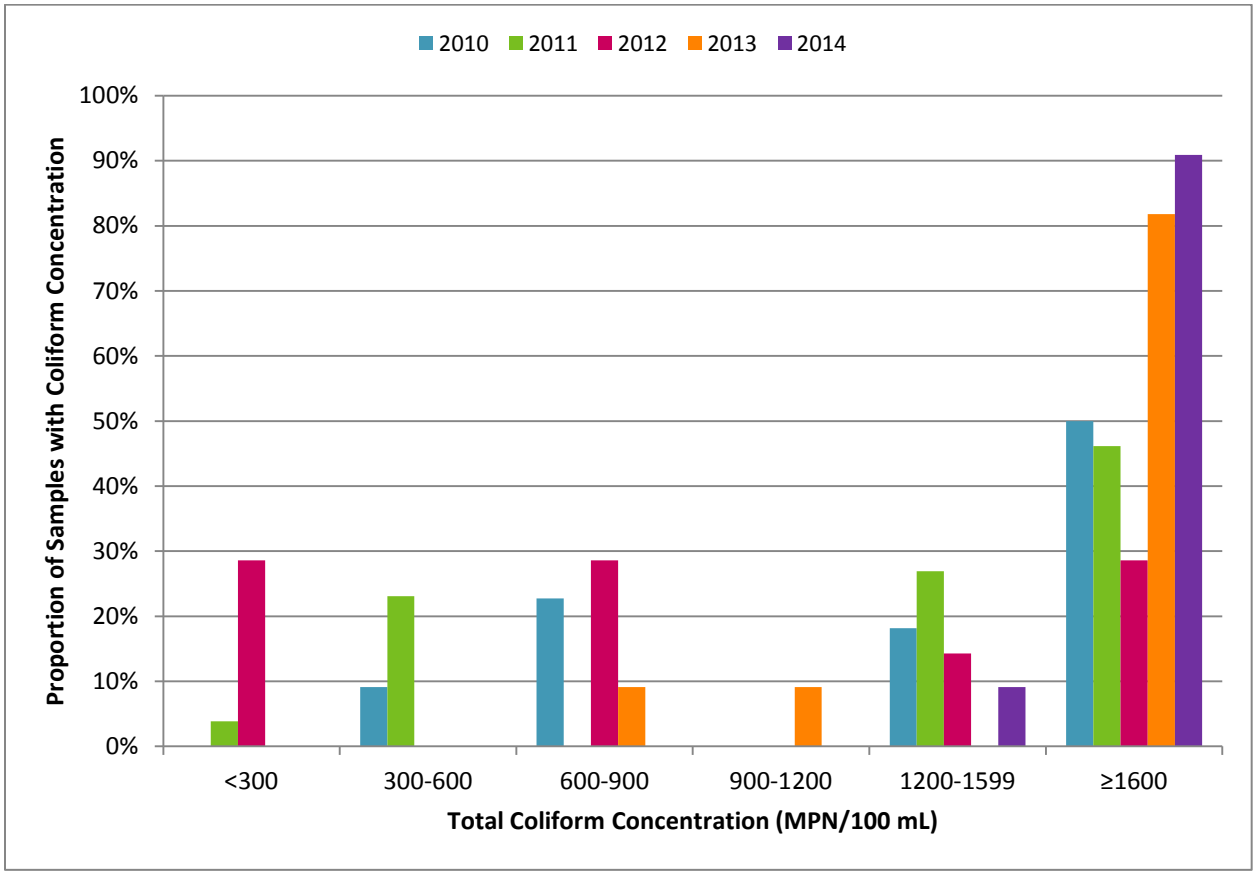

Figure 4-11. Total Coliform Counts at WID Intake, by Year, 2010 – 2014

Figure 4-12 shows monthly average total coliform counts taken at the WID Intake and precipitation. The median raw water total coliform concentration for 2013-2014 was 3,692 MPN/100 mL, which is significantly greater than the 240 MPN/100 mL Water Quality Objective stated in the Basin Plan. Samples for total coliform are taken five times per week, and the 2013-2014 median is an aggregate value for all samples. Therefore, many 30-day sampling periods, with five consecutive samples taken during that period as prescribed by the Basin Plan rule, will have median coliform concentrations that are even greater than 3,692. In December 2014, the average total coliform concentration was 11,007 MPN/100 mL, which is greater than the maximum allowable concentration of 10,000 MPN/100 mL, as stated in the Basin Plan Water Quality Objective.

Total coliform concentrations in raw water peaked in March and December 2014; precipitation also was highest in these months. There appears to be a correlation between precipitation and total coliform in the raw water. Per discussion with the City, SWTF operators notice an increase in coliform counts during rain episodes and respond accordingly by increasing coagulant dosage, as reflected in the monthly SWTF compliance report. The Standard Operating Procedure for responding to changes in water quality is provided in Appendix I.

Recreation use in Lodi Lake and the Mokelumne River is highest in the summer, but the data shows no significant increases in total coliform during the summer months.

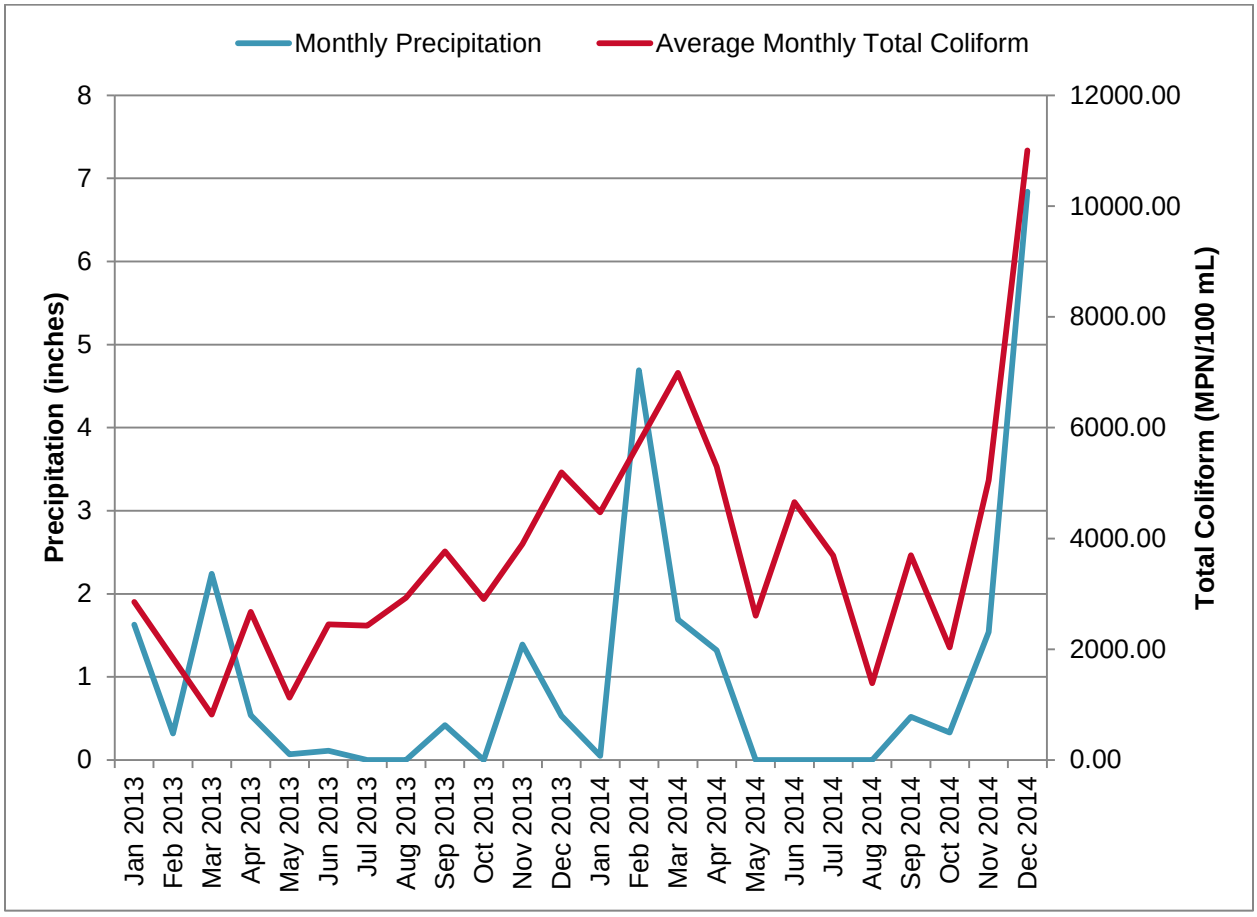

Figure 4-12. Monthly Average Total Coliform and Precipitation at WID Intake, 2013 - 2014

4.4.3.3.2 E. coli

E. coli counts were measured by the SWTF from 2010-2014. *E. coli* is indicative of fecal presence in the raw water supply. Similar to total coliform, the SWTF began using a different *E. coli* measurement technology after April 2012. There was no previous ceiling for *E. coli* measurement with the old technology, but the new technology provides more precision in measurement. Table 4-11summarizes average *E. coli* counts in 2007, 2010, and 2010-2014. The average values for 2007 and 2010 are taken from the 2010 Water Sanitary Survey.

As shown in Table 4-11, *E. coli* concentrations appear to have increased significantly since 2007. This could be due to the increased geese population residing in Lodi Lake and the Mokelumne River. The Basin Plan objective for contact recreation waters is approximately 126 MPN *E. coli*/100 mL. The average for 2010-2014 approaches the Basin Plan objective of 126 MPN/100 mL, which indicates that a large proportion of sampling events have *E. coli* counts that are higher than the objective. In 2010, the average *E. coli* concentration was greater than the Basin Plan Water Quality Objective.

Table 4.11. Average *E. coli* Concentrations by Year

Date Range	Average (MPN/100 mL)
2010-2014	121.72
2010	134.00
2007	38.00

Figure 4-13 compares trends in *E. coli* counts to water temperature at the WID Inlet from 2010-2012. It appears that there is little direct correlation between temperature and *E. coli* concentrations in the surface water, although the most significant spikes in *E. coli* tend to occur when the water temperature is colder rather than warmer. This may be related to a combination of geese breeding, agricultural seasons, and sampling bias. Figure 4-15 compares coliform and *E. coli* counts at the WID Inlet. Expectedly, the figure demonstrates that the peaks in total coliform are correlated to the peaks in *E. coli*.

Figure 4-14 shows *E. coli* counts by month from 2010-2014. The data appears to show that *E. coli* concentrations tend to decrease from approximately May-August, with significant peaks in February, September, and December. The peaks in February could be due to the refilling of Lodi Lake in February, when fecal matter from the residing geese can accumulate on the dry surface of the lake and be collected by the first inflows of water that enter the lake when it is refilled. Per discussion with the City, the impacts of lake refilling on plant operations is not tracked (Personal Communication, August 2015).

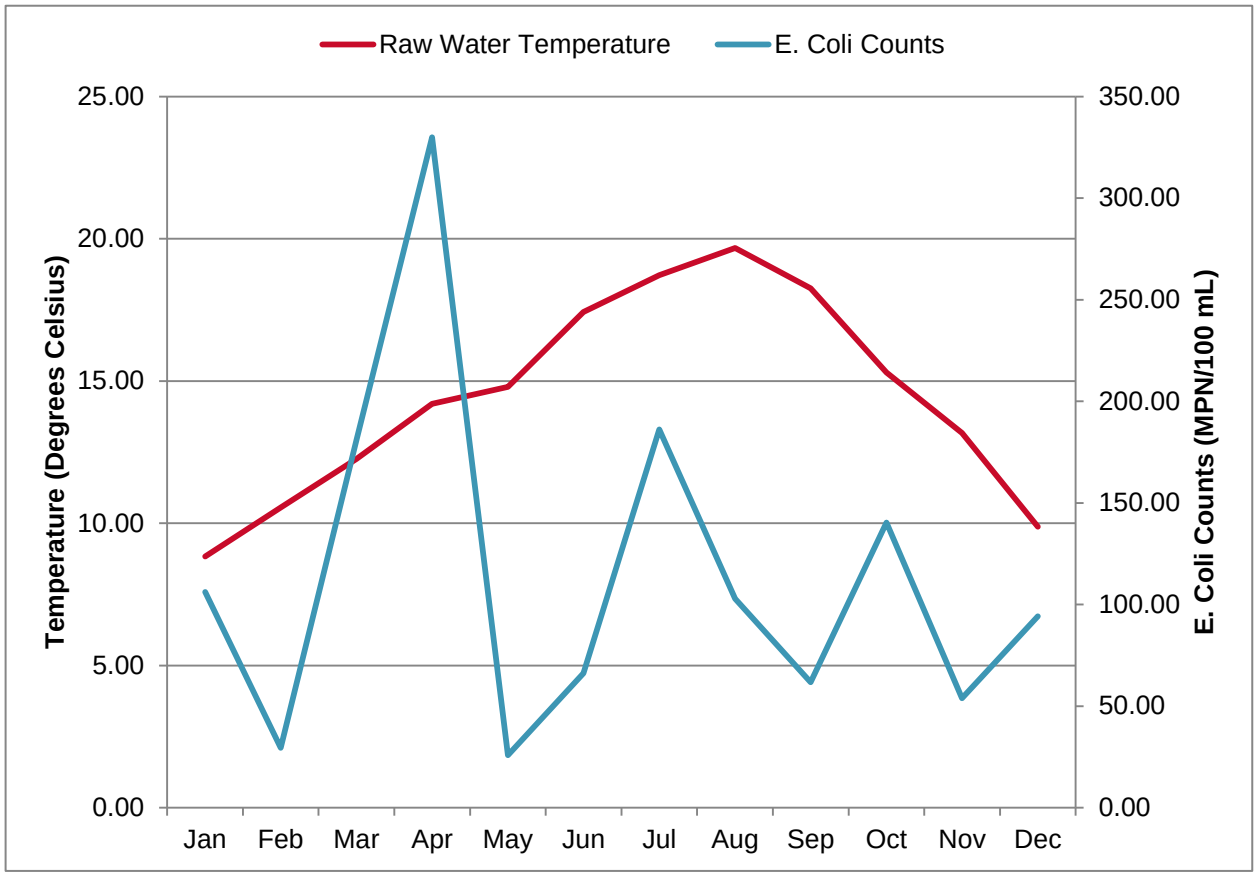

Figure 4-13 Seasonal E. Coli Counts and Water Temperature at the WID Intake, 2010-2012

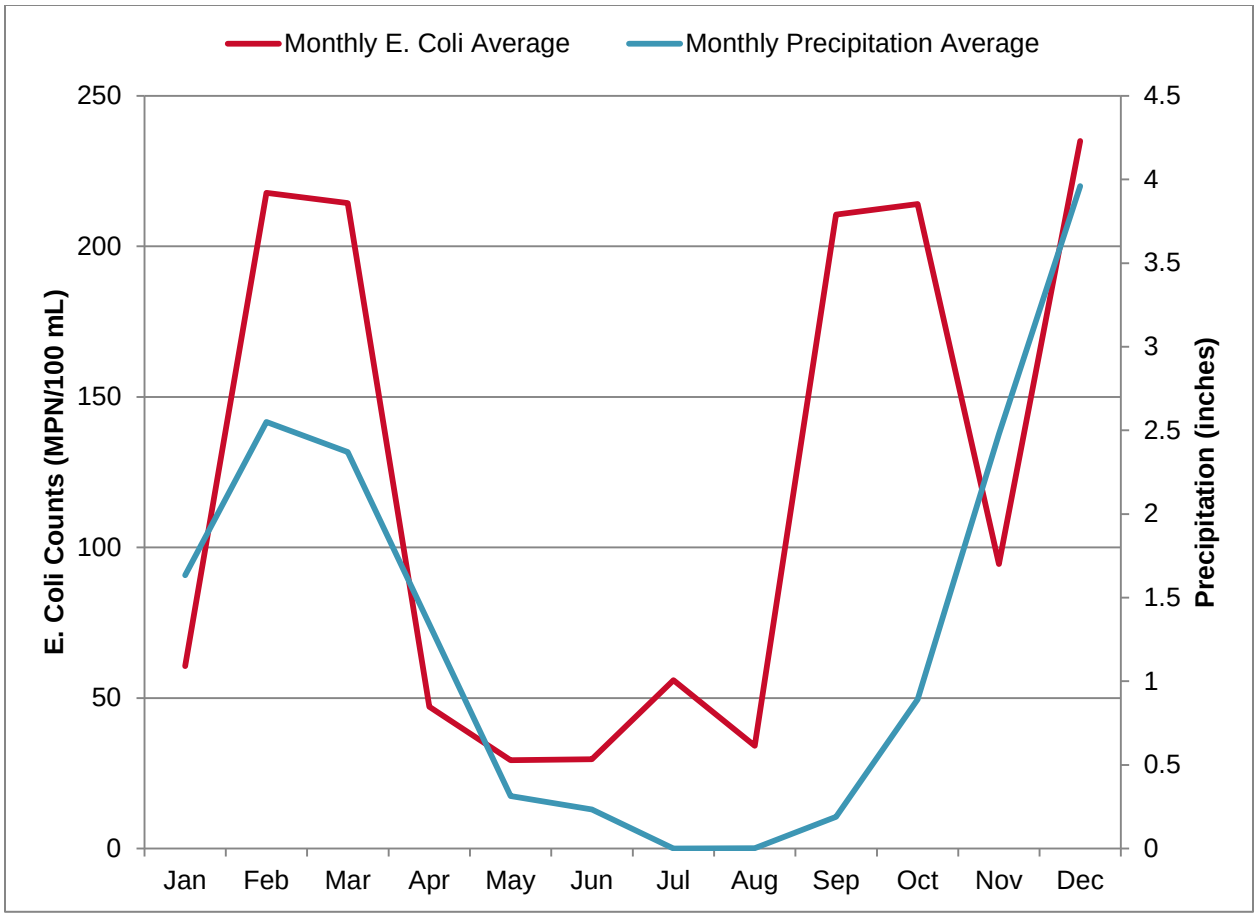

Figure 4-14 Monthly Precipitation and E. Coli Averages at the WID Intake, 2010-2014

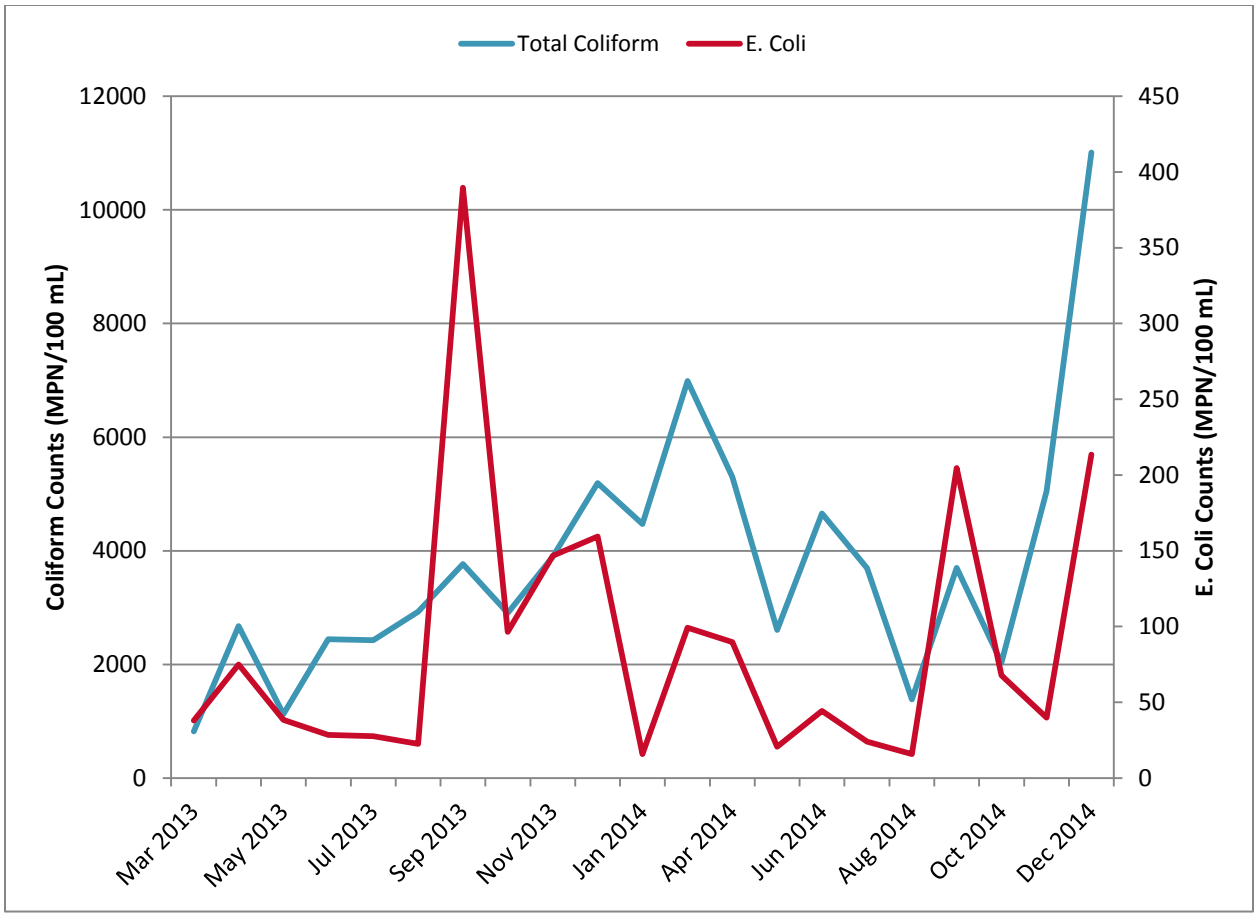

Figure 4-15. Total Coliform and *E. coli* Counts, 2013 – 2014

4.4.3.3.3 *Cryptosporidium* and *Giardia*

Table 4.12 shows average *Cryptosporidium* and *Giardia* concentrations in raw water in 2007, 2010, and for 2010-2012. 2010 and 2007 averages were taken from the 2010 Watershed Sanitary Survey. The data suggests that average values have remained constant since 2007.

Table 4.12. Average Cryptosporidium and Giardia Concentrations in Raw Water, 2007, 2010, 2010-2012

Date Range	Average *Giardia* (Cysts/L)	Average *Crypto.* (Oocysts/L)
2010-2012	0.24	0.02
2010	0.35	0.10
2007	0.18	0.05

The concentrations of total coliform, *E. coli*, and *Giardia* cysts are slightly elevated in the source water due to recreational activities along the Mokelumne River. Based on testing to date, the *Cryptosporidium* concentration averages 0.02 oocysts/L, which is less than 0.075 oocysts/L, the EPA's benchmark to achieve a Bin 1 classification. Therefore, the source water falls into the

EPA's highest quality classification and requires no additional treatment to protect public health. The source water will be re-evaluated for bin classification in October 2015. *Cryptosporidium* average concentrations have decreased slightly since the 2010 Watershed Sanitary Survey.

However, the elevated concentrations of coliform, *Giardia*, and *E. coli* require disinfection to inactivate the bacterial content in the source water. *Giardia* counts have remained high since 2007, averaging between 0.15 and 0.40 oocysts/L.

4.4.3.4 SEDIMENT AND SETTLEABLE SOLIDS

The Basin Plan specifies that suspended sediment load and suspended sediment discharge to surface waters shall not alter surface waters in such a manner as to cause a nuisance or adversely affect its beneficial uses. SDD measured total dissolved solids (TDS) at each of its sampling points, as shown in Figure 4-16..

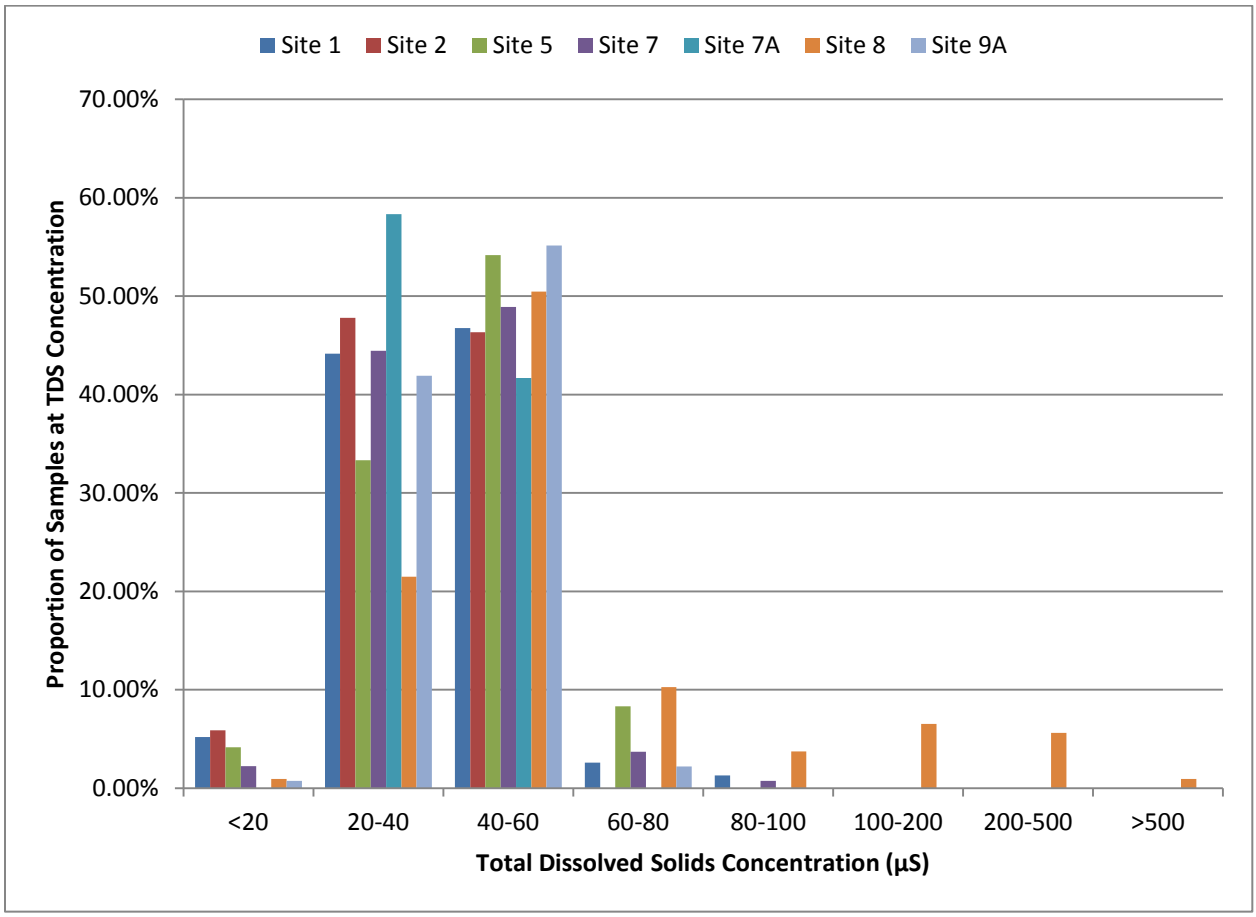

Figure 4-16. Total Dissolved Solids Concentrations at Storm Drain Sites, 2007 - 2015

TDS varied widely depending upon sample time and location. TML sampled TDS in both 2013 and 2014, finding 28 and 14 mg/L concentrations of TDS, respectively. Average TDS values tended to range from 40-50 µS (20-25 mg/L) across storm water discharge sites. Lodi Lake had particularly high TDS values, with more than three 200-1000 µS (100-500 mg/L) recorded

events per year in the winter months. This is likely due to the seasonal emptying of Lodi Lake every year. However, these values are still lower than the 1000 µS (500 mg/L) MCL for TDS.

4.4.3.5 TOTAL ORGANIC CARBON AND DISINFECTION BYPRODUCTS

Total organic carbon (TOC) is a measure of soluble and insoluble organic carbon compounds in water that are primarily contributed by decaying NOM such as humic and fulvic acids. Disinfectants added to water react with NOM to form DBPs. Because TOC is a measure of NOM present in water, this TOC concentration is considered to be a direct indicator of the potential to form DBPs during drinking water disinfection. In addition to reducing the potential to form DBPs, enhancing existing treatment to reduce TOC levels can also result in added benefits that include reduced potential for bacterial regrowth in the distribution system, improved taste and odor, reduction in disinfectant demand, and reduced levels of unknown or unregulated DBPs.

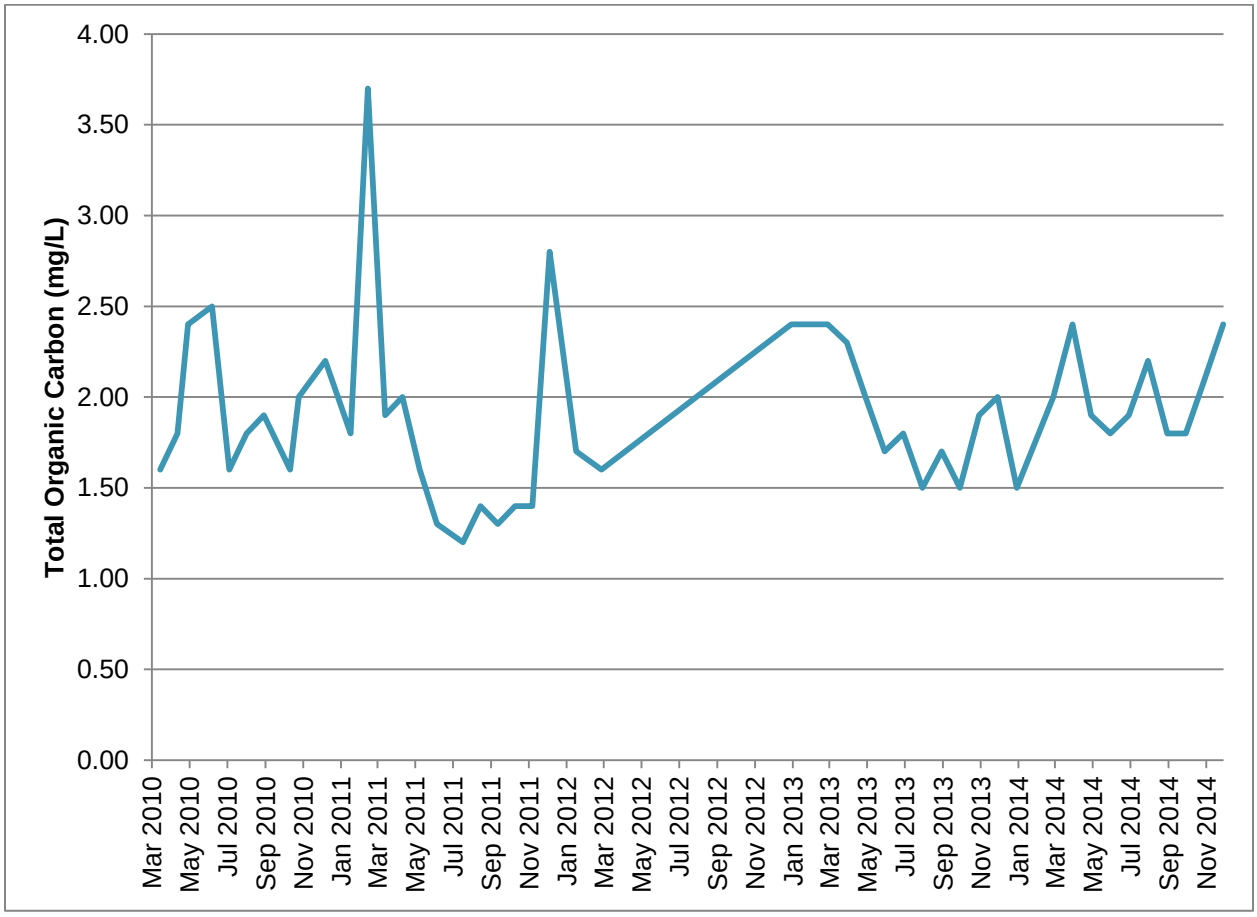

Figure 4-17 Total Organic Carbon at WID Intake, 2010-2014

TOC trends from 2013-2014 in raw and finished water are shown in Figure 4-18. Seasonal raw water TOC concentrations were relatively consistent, with a slight dip in concentrations from approximately July until November. The average was 1.9 mg/L. While the maximum concentration was 3.7 mg/L, typical raw water concentrations ranged from 1.2-2.5 mg/L, indicating that DBP formation potential in filtered water is low. In the 2010 Water Sanitary

Survey, the highest TOC concentrations were noted to occur in June. Average values have remained constant for TOC at the WID Canal since 2010.

Monthly averages in treated water TOC had patterns that tended to follow trends in the raw water TOC. Typically, TOC in treated water was approximately 0.2-0.5 mg/L lower than TOC in raw water. In October 2013, the monthly average treated water TOC concentration was higher than for raw water TOC. The average TOC concentration in finished water was 1.58 mg/L.

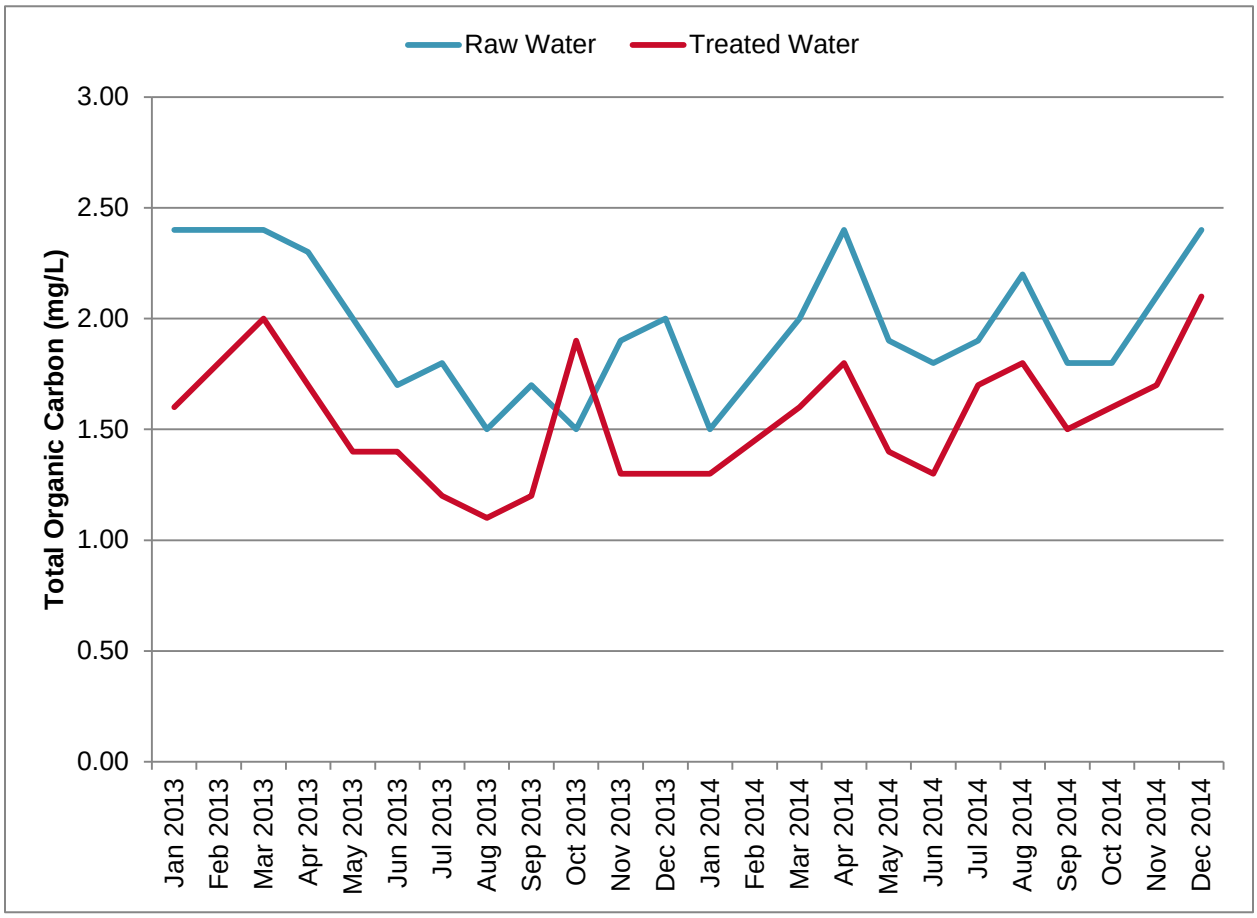

Figure 4-18. Finished and Raw Water Total Organic Carbon Monthly Averages, 2013-2014

4.4.3.6 DISSOLVED OXYGEN

The general dissolved oxygen (DO) Water Quality Objective of 7.0 mg/L applies to the Mokelumne River and its tributaries (CVRWQCB, 1998). Typically, though there is seasonal variation in water temperature, DO tends to be 9.0 mg/L or above, earning an “A” grade based on the San Joaquin River Basin Plan. Figure 4-19 compares DO concentrations measured by SDD at storm water drainage sites along the Mokelumne River.

SDD determined DO concentration at storm water drainage sites along the Mokelumne River. Average DO for all sites was 9.2-9.8 mg/L, considerably higher than the 7.0 mg/L minimum requirement. However, DO concentrations lower than the water quality objective were recorded

in individual sampling events at six of eight test sites. At Sites #1 and #2, DO concentrations fell below 6.0 mg/L only in June 2013; Site #8 also experienced unusually low DO concentrations (6.4 mg/L) in June 2013. At Site #9A, DO concentrations dropped to approximately 3.3 mg/L in January 2010. Site #7A had the greatest proportion of DO concentrations below the water quality objective, with more than 15% of sample DO concentrations falling between 6.0 and 7.0 mg/L. Aside from these episodes, there were few significant occasions of low DO concentration at the sampling sites.

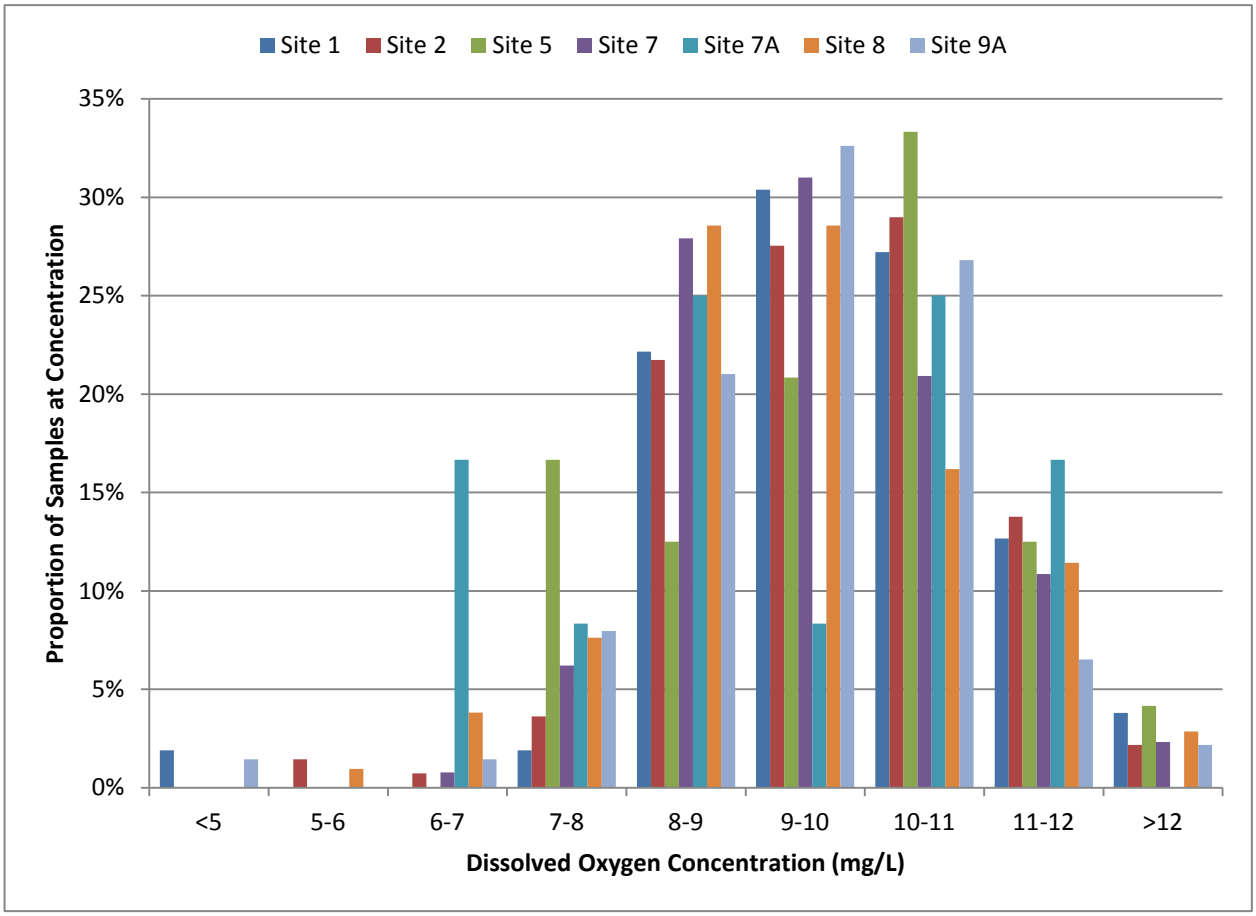

Figure 4-19. Dissolved Oxygen Concentrations at Storm Drain Sites, 2007 - 2014

4.4.3.7 NITROGEN, PHOSPHOROUS, AND SULFUR

The Basin Plan specifies that water shall not contain biostimulatory substances—including nitrogen and phosphorous— which promote aquatic growth in concentrations that cause nuisance or adversely affect designated beneficial uses.

Nitrate concentrations were measured by SDD and at the WID Intake. SDD found nitrate concentrations were highest at Sites #1 and #2, having 0.95 and 1.05 mg/L concentrations of nitrate respectively on April 8, 2015. At Site #8, concentrations of nitrate in the surface water were higher than normal from August to mid-September in 2014, ranging from 0.2-1.1 mg/L. Samples taken by Lodi PWD demonstrated elevated levels of nitrate in December 2010, June 2010, October 2011, and March 2011. Concentrations ranged from 0.3-2.0 mg/L. Possible

sources include storm drain discharge, cattle grazing near the Mokelumne River, and geese fecal matter. Phosphorous was not measured in the samples taken in this survey.

While the elevated nitrate concentrations could be in sufficient quantities to cause nuisance conditions related to algal blooms, WID and the SWTF are unaware of any instances where algal bloom has been reported as a nuisance.

Sulfate is often naturally occurring in water. It currently has a secondary MCL of 250 mg/L, a restriction on water quality due to taste and odor. Although sulfur is the most common pesticide use in the Lower Mokelumne River Watershed, sulfate concentrations were found to be less than 3 mg/L in tests conducted from 2007-2014.

4.4.3.8 COLOR

The Basin Plan includes a narrative Water Quality Objective regarding color, an aesthetic water quality parameter for treated drinking water. Sampling and evaluation for color were performed by PWD and MTL. The MCL for color is 15 color units in drinking water. The maximum value found in the data was 12 color units, with typical values averaging around 5 color units. These values have potential to rise particularly near storm events and when the lake is refilled in February/March.

4.4.3.9 PESTICIDES

The Basin Plan includes extensive discussions related to water quality objectives for pesticides. Significant pesticide use does occur in the Lower Mokelumne River Watershed due to the high amount of land used for agriculture. The Clean Water Act's Section 303(d) provides a list of non-point discharge agricultural pesticides (SWRCB, 2010). While the Mokelumne River is not included in the list of surface water bodies controlled by 303(d), the list provides a general idea of what pesticides are typically monitored in sensitive regions. Agricultural chemicals on the 303(d) list are chlorpyrifos, diazinon, and the Group A Pesticides—aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes, endosulfan, and toxaphene. Many of these chemicals were measured by the City of Lodi in January 2013 and January 2014. The results in both years indicated that all measured values fell below the detectable limit.

In addition, a review of the California Environmental Data Exchange Network (CEDEN) database and data collected for the San Joaquin County Delta Water Quality Coalition Irrigated Lands Regulatory Program found little evidence of pesticides present at above detectable limits in the Mokelumne River in the vicinity of Lodi Lake. Only three instances of pesticides were found at a monitoring location along the Mokelumne near Bruella Rd, all before 2010: Paraquat at 8.68 µg/L in February 2007, Simazine at 0.099 µg/L in January 2008, and DDT at 0.015 µg/L in August 2009.

As agriculture continues to be a significant activity in the watershed, pesticides should continue to be monitored.

4.4.3.10 TASTES AND ODORS

The Basin Plan specifies that waters shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to domestic or municipal water supplies. Taste and odor are aesthetic characteristics in water quality.

Iron is a metal that produces undesirable taste in drinking water. During sampling, iron exceeded its water quality goal (0.05 mg/L) in several events. Typical high ranges for iron concentration at the WID Intake were 0.90-0.160 mg/L. However, iron was in all instances measured at a level less than its secondary MCL of 0.3 mg/L. Secondary MCLs are routinely applied at the point of use (i.e., “at the tap”) and the existing water treatment methods.

Odor was measured at the WID Intake as well. Odor is measured in threshold odor number (T.O.N.), a general measurement that does not discern between sources or types of odor. Algal blooms, humic substances, hydrogen sulfide, and synthetic chemicals can be sources of odor in drinking water. Odor tended to be 1-2 T.O.N. when measured, but occasionally exceeded 10 T.O.N. in certain samples.

Under certain conditions of low river flow and warm water, algae blooms may occur that impart tastes and odors to the water. In July-August, the warmer months of the year, when the river water temperatures rise, taste and odor tests are conducted 2-10 times/month to detect for algae. Historically, the Lower Mokelumne River has not had significant algae concentrations. The 2010 Watershed Sanitary Survey did not indicate observations of noticed algal concentrations in the Lower Mokelumne River.

4.4.3.11 METALS

4.4.4 Summaries of Water Quality Data

Tables 4.13 through 4.15 provide summaries of water quality data from the samples described above. In Table 4.13, data points were taken approximately once monthly in 2010-2014. The averages taken are for sampling results from April 2010-December 2014, excluding data from the 2010 Watershed Sanitary Survey. 2010 and 2007 averages are taken from data compiled in the 2010 Watershed Sanitary Survey. The full set of data from 2006-2007 and 2010 sampling are presented in Appendix H.

Trends and in-depth analysis on the major constituents studied in the survey are provided in Section 4.4.3.

Table 4.13. Summary of Water Quality Data at the WID Intake, 2010 - 2014

Constituent	Units	MCL[2]	Minimum	Maximum	Average[1]	2010 Average (2010 WSS)	2007 Average (2010 WSS)
pH	SU		6.30	9.10	7.77	8.10	7.20
Temp	Deg C		7.90	22.20	14.54		
Turbidity	NTU		1.00	19.38	3.53	2.10	2.40
Total Coliform[3]	col/100ml		30.00	11006.91	2145.78	1250.00	1600.00
E. coli	MPN/100mL		2.00	900.00	121.72	134.00	38.00
Giardia	Cysts/L		ND[4]	1.65	0.24	0.35	0.18
Crypto.	Oocysts/L		ND	0.14	0.02	0.10	0.05

Constituent	Units	MCL[2]	Minimum	Maximum	Average[1]	2010 Average (2010 WSS)	2007 Average (2010 WSS)
Peak TOC	mg/L		1.20	3.70	1.90	1.70	1.80
DOC	mg/l		1.00	4.10	1.85	1.40	1.60
Color	SU		5.00	12.00	7.08	5.00	
Odor	TON		1.00	20.00	4.94	1.00	
Peak Alkalinity	mg/L		12.00	48.00	19.26		20.00
Bicarbonate Alk.	mg/l		16.00	59.00	24.65	20.00	
Carbonate Alk.	mg/l		ND	ND	--[5]	<2.5[6]	
Hydroxide Alk.	mg/l		ND	ND	--	<2.5	
Hardness	mg/l		7.80	18.00	14.49	16.00	15.00
Uranium	pCi/L	20	ND	5.21	0.68		
Gross Alpha	pCi/L	15	ND	1.00	0.25		
Chloride	mg/l	250.00	ND	4.90	2.31		2.60
Fluoride	mg/l	500.00	ND	0.072 (J)7	--		
Nitrite	mg/l	1	ND	ND	--		
Nitrate	mg/l	10	ND	0.96 (J)	--		
Sulfate	mg/l		ND	2.30	1.35		2.40
MBAS	mg/l		ND	ND	ND		
Cyanide	µg/L	0.15	ND	ND	ND		
Aluminum	µg/L	1000.00	36.00	110.00	72.56		
Antimony	µg/L	6.00	ND	0.76 (J)	--		
Arsenic	µg/L	10.00	ND	ND	0.00		
Barium	µg/L	1000.00	15.00	20.00	17.38		
Beryllium	µg/L	4.00	ND	ND	--		
Cadmium	µg/L	5.00	ND	ND	--		
Chromium	µg/L	50.00	ND	0.96 (J)	--		5.00
Copper	µg/L	1300.00	ND	1.8 (J)	--		5.00
Iron	µg/L	50.00	ND	160.00	98.76		120.00
Lead	µg/L	15.00	ND	0.11 (J)	--		
Manganese	µg/L	50.00	ND	18.00	9.74		12.10
Mercury	µg/L	2.00	ND	0.11 (J)	--		

Constituent	Units	MCL[2]	Minimum	Maximum	Average[1]	2010 Average (2010 WSS)	2007 Average (2010 WSS)
Nickel	µg/L	100.00	ND	0.53 (J)	--		
Potassium	mg/l		ND	1.20	0.65 (J)		
Selenium	µg/L	50.00	ND	0.28 (J)	--		
Silver	µg/L	100.00	ND	0.00	--		
Thallium	µg/L	2.00	ND	0.00	--		
Zinc	µg/L	5000.00	ND	4.6 (J)	--		11.00
Perchlorate	µg/L	6	ND	0.00	--		

[1]All data are provided in Appendix H
[2]All applicable MCLs provided
[3]Total Coliform average listed is from 2013-2014 due to measurement technology change
[4]ND Below the detection limit
[5]-- Average does not apply because of imprecision in data below detection limit
[6]< Less than the reporting limit for this analysis
7(J) Estimate of the true value; value fell below reporting limit
µg/L micrograms per Liter
mg/L milligrams per Liter

Table 4.14. Summary of Storm Drain Detective Data

	Upstream									Downstream	
Constituent	Site #1	Site #2	Site #5	Site #6A	Site #6B	Site #7	Site #7A	Site #8	Site #9	Site #9A	Average
Minimum pH	5.5	5.5	5.6	--[2]	--	6.0	6.5	6.3	7.1	5.0	5.9
Maximum pH	9.6	9.3	8.5	--	--	9.3	8.8	9.3	8.1	9.0	9.0
Mean pH[1]	7.7	7.8	7.3	7.6	7.8	7.6	7.5	7.8	7.7	7.6	7.7
Minimum Dissolved Oxygen (mg/L)	4.9	5.4	7.0	--	--	7.4	6.7	5.8	7.7	3.3	6.0
Max. Dissolved Oxygen (mg/L)	13.0	13.8	12.6	--	--	13.4	11.5	13.0	10.5	12.5	12.5
Mean Dissolved Oxygen (mg/L)	9.8	9.7	9.7	9.6	9.4	9.6	9.2	9.4	9.2	9.5	9.5
Minimum Turbidity (NTU)	0.0	0.1	0.0	--	--	0.1	1.5	1.1	0.3	0.6	0.5
Maximum Turbidity (NTU)	50.0	70.0	59.4	--	--	14.8	7.4	23.8	4.9	24.7	31.9
Mean Turbidity (NTU)	3.7	5.3	9.2	3.1	3.2	2.8	3.8	4.5	1.8	3.7	4.1
Min. Total Dissolved Solids (µS)	0.0	0.0	20.0	--	--	20.0	30.0	5.0	30.0	30.0	16.9
Max. Total Dissolved Solids (µS)	90.0	60.0	70.0	--	--	80.0	60.0	1000.0	50.0	70.0	185.0
Mean Total Dissolved Solids (µS)	44.7	42.4	46.7	50.0	50.0	45.8	44.2	83.3	40.0	46.4	49.4
Maximum Nitrate, as mg/L Nitrogen	0.95	1.05	0.0	--	--	0.8	0.0	1.1	0.0	0.9	2.8
Mean Nitrate, as mg/L Nitrogen	0.1	0.1	0.0	--	--	0.0	0.0	0.1	0.0	0.0	0.0

Some data has been omitted to provide accurate averages and trends.
[1]Mean values are provided as arithmetic means for all data points collected. A complete data set for each site can be found in AppendixH.
[2]-- Sites #6A and #6B only had one data point, therefore maximum and minimum values do not apply

Table 4.10. Annual Organic, inorganic, and Metals Data, WID Intake 2013-2014 in Section 4.4.2 summarizes MTL's results for metal concentrations taken from samples collected by the City in January 2013 and 2014, as compared to the respective MCLs for each constituent.

The Basin Plan specifies that waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. The water quality data collected was compared to the aquatic life protective benchmarks from the EPA (2000) California Toxics Rule (CTR) or benchmarks excerpted from Marshack's (2008) *A Compilation of Water Quality Goals*. Metals vary in their level of toxicity to organisms depending on concentration, oxidation state, and the species consuming the metal. All metals tested by MTL had concentrations significantly lower than their MCLs; many were below the detectable limit. If necessary, metals such as iron and manganese can be removed at the SWTF through pre-oxidation, followed by coagulation and filtration. The SWTF uses aluminum chlorohydrate (ACH) as a coagulant to pretreat the raw water.

The Lower Mokelumne River is on the CWA's Section 303(d) list for copper and zinc and is therefore required to abide by regulations that are more stringent than the MCLs for copper and zinc, as mandated by Section 303(d). Control of acid discharge from the Penn Mine in the Upper Mokelumne River Watershed has reduced copper and zinc concentrations in the Mokelumne River since 1999. Copper and zinc pose health risks to humans when consumed at high doses, and are extremely toxic to fish and other aquatic life at lower doses. Concentrations of copper and zinc were found to be below the detection limit in all samples taken by PWD from 2010-2014.

Mercury is a legacy contaminant of the gold mining era (SWRCB, 2010). Mercury can affect the nervous system of higher trophic organisms and is bioaccumulated and transferred to higher trophic organisms through the food-web. In particular, Cal EPA has issued several warnings of the danger of consuming fish with elevated mercury levels. In 2010, the CVWB issued amendments to the Water Quality Control Plan for the Sacramento-San Joaquin Delta Estuary to control of methylmercury and total mercury. Several tributaries to the delta were placed on the Section 303(d) list as impaired for methylmercury and mercury. The segment of the Lower Mokelumne River between Camanche Dam and Woodbridge Dam is not listed as impaired for mercury.

The MCL for mercury is 2 µg/L. In the watershed, mercury was below the detection limit for all samples taken by PWD from 2010-2014.

4.4.4.1 TOTAL PETROLEUM HYDROCARBONS (MTBE AND BTEX)

Methyl tert-butyl ether (MTBE) is a member of a group of chemicals commonly known as fuel oxygenates. Oxygenates are added to fuel to increase its oxygen content. MTBE was used in gasoline throughout the United States to reduce carbon monoxide and ozone levels caused by auto emissions. However, since 1999, MTBE has been phased out in California because of groundwater contamination. Releases of MTBE to ground and surface water can occur through leaking underground storage tanks and pipelines, spills, emissions from marine engines into lakes and reservoirs, and to some extent from air deposition. The US EPA has not set a national standard for MTBE. DDW has an MCL of 13 µg/L and secondary standard of 5 µg/L.

BTEX is a collection of compounds consisting of benzene, toluene, ethylbenzene, and xylene. While DDW does not have a combined BTEX MCL, it regulates the individual organic compounds that make up BTEX, which have the following MCLs: benzene – 1 µg/L; toluene – 150 µg/L; ethylbenzene – 300 µg/L and xylene – 1750 µg/L. The full suite samples in 2013 and 2014 included data for MTBE and BTEX. In both sample dates, MTBE and BTEX concentrations were below the detection limit at the WID Intake.

4.5 Summary of Raw Water Quality

There are few constituents in the source water that exceeded treated water MCLs. Table 4.15 summarizes water quality information on the major classes of water quality constituents.

Table 4.15. Summary of Water Quality Data

Constituent	Water Quality Comments
pH, Temperature, Alkalinity	pH varied from approximately 6-9 units; water temperatures ranged from 9-22 ^{O}C; alkalinity remained constant with an average of 16.4 mg/L
Turbidity	Turbidity varied widely across sampling sites; precipitation events correlated to turbidity spikes; finished water data indicated that treatment removed substantial amounts of turbidity
Microbial Content	Total coliform, E. coli, and Giardia are found in concentrations at or above Basin Plan Water Quality Objectives; Cryptosporidium counts are low
Sediments	Sediments varied across storm water discharge sitesLodi Lake has higher levels of total dissolved solids during winter months (during lake refill), compared to other locations along the Mokelumne River.
Total Organic Carbon	TOC was relatively constant, typically ranging from 1.2-2.5 mg/L; low TOC concentrations indicate low DBP formation potential
Dissolved Oxygen	Dissolved oxygen remained constant with typical values above 9.0 mg/L; occasional dips in D.O. content to below WQCB's water quality objective of 7.0 mg/L
Nitrates	Nitrate concentrations tended to be low, with some spike events
Color	The MCL for drinking water is 15 color units; recorded color values ranged from 5-12 color units
Pesticides	While pesticide use is significant in the watershed, water quality did not indicate significant seepage into the water supply
Taste, Odor	Taste can be impacted by elevated iron concentrations, but iron can be removed in treatment; algae has not been observed historically
Metals	All metal concentrations were significantly lower than their MCLs; copper and zinc (Section 303(d) contaminants) were below the detection limit
MTBE, BTEX	MTBE, BTEX, and other petroleum products were not found in detectable quantities in the raw water

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5 Conclusions

This section presents a summary of significant potential contaminant sources and the management practices that control contaminant concentrations in the water supply. Additionally, this section summarizes and analyzes completion of the management practices recommended in the 2010 Watershed Sanitary Survey.

Urban Runoff and Industrial Runoff

Urban runoff can contain a variety of contaminants ranging from VOCs, solvents, nutrients, inorganics, metals, trash, and coliform bacteria. High levels of these contaminants would indicate that urban runoff is negatively impacting water quality in the Mokelumne River. Total coliform was found in high concentration in the river during water quality sampling, however, these high counts could be contributed from a variety of sources. Other typical contaminants from urban runoff were often found below their respective MCLs. Urban and industrial runoff may contribute to these high bacterial counts because storm water drains in Lodi direct some of the city's runoff to the Mokelumne River.

The City of Lodi has a Stormwater Management Program and a Stormwater Management Plan for the prevention of contaminants entering the Mokelumne River through the storm drain system. Education and outreach have been primary focuses of the City to control urban runoff from significantly impacting water quality. Continuing education, outreach, testing, and stormwater management should help continue to engage the public in proactive stormwater practice.

Agriculture

Because much of the land in the watershed is used for agriculture, it has a high potential to impact the water quality in the Lower Mokelumne River. Indicators of agriculture-based contamination are turbidity from erosion, pesticides, and herbicides in the water. The most common pesticide used in the watershed is sulfur. Concentrations of sulfate in the water have typically fallen under 3 mg/L, which is significantly less than the secondary MCL for sulfate, 250 mg/L. This suggests that pesticides may not be significantly impacting water quality.

Agriculture has remained constant in the watershed without significant growth. Water quality parameters indicating agricultural contamination should continue to be monitored.

Grazing Animals & Concentrated Animal Facilities

Grazing animals have potential to increase turbidity, total dissolved solids, and bacterial content in the water. The few concentrated animal facilities in the watershed are not close to the river and do not discharge waste into the Mokelumne River. Cattle have been seen to approach the Mokelumne River in two sites when grazing, and sometimes enter the river on county land. Controlling their entry into the river by building fences would prevent cattle feces from directly entering the water.

Water quality testing conducted by PWD indicates that *Cryptosporidium* and *Giardia* contamination are low. Implementing and exercising cattle grazing BMPs can minimize potential

contamination. Many successful BMP models have been implemented to protect watersheds across the state. Watershed protection and the use of sodium hypochlorite as a primary disinfectant, in conjunction with free available chlorine to maintain a disinfectant residual, provides multiple barriers of defense against pathogenic protozoa in drinking water.

Wild Animals

Wild animals can contribute to erosion in the watershed, and their feces may increase the bacterial content of the water in the Mokelumne River. The most concentrated population of wildlife in the watershed are the geese flocks residing at Lodi Lake and the Mokelumne River near the WID Canal and WID Dam. While other wildlife are sparse in comparison, the geese have high potential to impact water quality. The feces directly enter the water supply just upstream of the intake. Additionally, the emptying and refilling of Lodi Lake in February can lead to spikes in surface water bacterial content, due to the accumulation of geese fecal matter on the dry surface of the lake that is stirred up and released into the water when the lake is refilled.

The City of Lodi has engaged in goose egg addling to control geese populations in the watershed. Ongoing organized efforts have not been established into City plans, but discussion has started among City leaders.

Mine Runoff

Abandoned mine sites in the Upper Mokelumne River Watershed may have potential impacts on surface waters via wet weather runoff. The Lower Mokelumne River is listed on the 303(d) list for copper and zinc contamination associated with historic resource extraction activities upstream, although there are no currently active copper or zinc sites. Copper and zinc were detected at all locations at concentrations far less than both of their MCLs.

The Clements Rock Plant, which is on the Lower Mokelumne River near the unincorporated community of Clements, does not have a permit to discharge into surface water. However, materials can still leach into the surface water. It appears that there are no spikes in constituent concentrations that would clearly indicate an effect on water quality. CA SWRCB oversees NPDES permitting to allow mines including Clements Rock Plant to discharge onto land and water.

The raw water data from Lodi's PWD sampling efforts in 2010-2014 indicate that iron samples have surpassed the MCL for treated water (0.05 mg/L). Averages over the five years of testing conducted by PWD approached 0.1 mg/L. The SWTF treatment processes include pre-oxidation followed by coagulation and filtration which can function as a mechanism for the removal of iron. Iron primarily impacts only the aesthetic quality of water at low doses.

All available data for other metal concentrations were below the MCLs or other more stringent surface water quality criteria. The California Office of Mine Reclamation develops a list of mines regulated under the Surface Mining and Reclamation Act and a list of Principal Areas of Mine Pollution. The CVRWQCB maintains a list of active mines in the Sacramento and San Joaquin River Basins that pose a risk to water quality.

Recreational Use

Recreational activities in Lodi Lake and the Lower Mokelumne River include fishing, boating, swimming, kayaking, hiking, and camping, attracting hundreds of thousands of visitors per year. Annual visitor counts have increased, and recreational areas including Stillman Magee Park are expanding. The City plans to construct another boat launch in Lodi Lake, which can increase traffic in the watershed. Recreational areas are managed by the City of Lodi, San Joaquin County, and EBMUD.

Bacterial samples conducted at the WID Intake indicate that there is significant microbial contamination in the watershed. *E. coli* counts in particular approached the Basin Plan's water quality objective of 126 MPN/100 mL, and often exceeded this benchmark. *E. coli* has appeared to increase in concentration by 300% since 2007. The increase in *E. coli* may be caused by cattle grazing, the resident geese, or increased recreational activity in the watershed. To counteract *E. coli*, turbidity, and coliform in Lodi Lake, the City closes the beach area at Lodi Lake two times per week and after *E. coli* spikes that may occur during the summer months.

Recreational use of waters close to the WID Intake poses a significant concern to water quality. The swimming beach at Lodi Lake Park is upstream of the WID Intake and often has to be closed in summer due to high *E. coli* and coliform counts. In addition, recreational boating in the Mokelumne River can contribute trace metals from boat hull paints, petroleum hydrocarbons from fueling, spills, and pathogens from boat sewage discharges.

Unauthorized Activity

Unauthorized activities continue to be present in the watershed, including illegal dumping and illegal camping. Potential contamination from unauthorized activities is difficult to quantify and is dependent on the nature of the activity and the type of waste discarded. Although unauthorized activities have neither increased nor decreased since the last sanitary survey, these activities remain a potential threat to water quality.

The City of Lodi and San Joaquin County monitor and clean up dump sites, depending on land ownership. San Joaquin County has the authority to levy fines, although perpetrators are difficult to identify and, even if caught, are typically given warnings and an opportunity to cleanup. The homeless camp underneath the CA-99 Bridge presents a potential contaminant site along the Mokelumne River. While efforts to temporarily clean up the homeless camp have occurred in the past, no permanent solution has been found.

Invasive Species

To date, no invasive mussel species have yet been found in the Mokelumne River. However, the potential for these species to become introduced remains a concern. Lodi Lake is the only location where boats can enter the water, and it does not have a mussel prevention program. EBMUD, which manages reservoirs and boat launches upstream of the Lower Mokelumne River, does conduct boat inspections, encourage self-inspections, and lead education to prevent mussel invasion in its reservoirs.

Completion of Recommendations from 2010 Watershed Sanitary Survey

The 2010 Watershed Sanitary Survey concluded with recommendations regarding watershed management measures to help control potential contaminant sources. An update to the recommendations is presented in Table 5.1.

Table 5.1. Updated of 2010 Watershed Sanitary Survey Recommendations

Recommendation	Completed (Y/N)? Action Taken
Continue to monitor turbidity levels and concentrations of TOC, pathogens, and pesticides along the Mokelumne River in the City of Lodi to determine the impact of stormwater discharges, recreation, and urban and agricultural runoff.	Yes. The Storm Drain Detectives program has continued to sample water at storm drainage sites along the river to monitor turbidity, nitrates, TDS, and other parameters. The impact of stormwater discharge has not been analyzed. Constituent data has remained constant.
Continue to monitor at the WID Intake to establish baseline water quality data and identify constituents of concern. Regulated chemicals should be monitored at least yearly. Sampling for pesticides and herbicides should occur during periods of application in the watershed.	Yes. Baseline water quality data has been established through regular testing. In 2013 and 2014, a laboratory conducted a sampling test at the intake to test a suite of VOCs and SVOCs not typically measured during the year. All results have met primary drinking water standards.
Collect coliform data more frequently at the WID Intake to evaluate treatment requirements and identify source control needs.	Yes. Coliform data is collected five times per week (Monday-Friday) when the plant is in operation.
Continue monthly sampling of Cryptosporidium over a two year period to comply with the LT2ESWTR at the WID Intake.	Yes. Cryptosporidium has been sampled at least monthly from 2010-2014. The SWTF was classified as a schedule 2 system. The City will begin second round source monitoring in October 2015 to re-evaluate bin classification.
Initiate routine field surveys of the watershed to monitor for any activity that may impact water quality.	Routine field surveys of the watershed are conducted twice monthly by high school students, volunteers and city employees participating in the Storm Drain Detective program. Monitoring teams are established each year and trained by an Environmental Compliance Inspector for the City.
Develop an emergency response plan for dealing with any chemical spills or other episodes that could affect water quality.	Yes. An emergency response plan has been developed and is located in the Operations and Maintenance Manual, Chapter 18-Plant Safety, updated March 2015.
Continue with proposed design for the SWTF using Pall membranes and chlorine disinfection with the ability to achieve 4.0-Log Giardia and Cryptosporidium inactivation and 0.5-Log Giardia and 4.5-Log virus removal.	Yes. The SWTF has used chlorine disinfection to achieve the desired inactivation and removal of viruses and bacteria. Pall membranes have been included in the proposed design.

6 Recommendations

This section provides a prioritized list of recommendations regarding watershed management measures that the City of Lodi may take to help control potential contaminant sources, and to identify water quality constituents of concern.

The list of recommendations is described below.

1. Continue to monitor turbidity levels and concentrations of TOC, pathogens, and pesticides along the Mokelumne River in the City of Lodi to determine the impact of stormwater discharges, recreation, and urban and agricultural runoff.

2. Determine potential sources of bacterial and other contamination by:

    a. Continuing to monitor water quality at the WID intake to establish baseline water quality data and identify constituents of concern. Regulated chemicals should be monitored at least yearly.
    b. Continuing to monitor water quality at Lodi Lake beach.
    c. Closely monitoring water quality data after annual lake refilling activities for one week.
    d. Initiating a water quality sampling at point upstream of lake near cattle grazing activities.

    Coordinate sampling at the intake with sampling at other locations to observe correlations or trends between potential sources and at the intake. Use the sampling results to focus on future contaminant mitigation or prevention efforts.

3. Consider conducting the annual sampling in the summer rather than winter months to obtain information on contaminants which have summer seasonal usage. For example, sampling for pesticides and herbicides should occur during periods of application in the watershed.

4. Continue to use the Storm Drain Detective program to conduct routine field surveys of the watershed and to monitor for any activity that may impact water quality.

5. Collaborate with the Lodi Parks Department on development of a comprehensive invasive species program including mussel prevention focused on education and stewardship.

6. Increase awareness of potential water quality impacts in the vicinity of homeless encampments by providing the WSS to the City's homeless task force. Coordinate with Caltrans and other agencies, as necessary, to improve conditions at homeless camps with the goal of lowering potential impacts on water quality. (For example, cleanups and trash removal could be conducted regularly, or prior to the rainy season or large rain events).

7. Work with the Lodi Parks Department to mitigate the goose problem at Lodi Lake, including continued monitoring of the goose population to determine if current control efforts are effective and representative of need.

8. Follow LT2ESWTR monitoring plan and complete monthly sampling of Cryptosporidium and related constituents over a two year period at the WID Intake beginning October 2015.

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8 Limitations

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